

Feeding Raw

Ensuring:

Enough Calories

Amino Acid Balance

All Essential Fatty Acids

Enough Fiber Content

Enough Calcium & Minerals

HUMAN / Animal Safety

Water and Fat Soluble Vit.

Avoiding Overfeeding

Managing Cost

Articles curated
by Dr Erik Johnson
Not Copyright Holder

[UPDATED] Raw Feeding Primer: 10 Simple Rules To Get Started



By: [Dana Scott](#) -

Reading Time: 15 minutes

21k4.9kSHARES26k

Twenty-something years ago, I loved going to the pet store and dissecting bags of dog food and choosing the very best bag money could buy.

I'd take my expensive bag of food, complete with pictures of winning show dogs and plates of meats and vegetables, to the check-out counter thinking "what lucky dogs I have."

I can't remember exactly why I started feeding a raw dog food diet, but I did all the same. There were certainly enough compelling reasons to take that leap of faith. After just a few months of feeding my dogs kibble, I didn't see how food in a bag with an ingredient list that I couldn't even pronounce was the best choice for my dogs. And I wondered if those big companies with big marketing budgets really had my dogs' best interests at heart.

But you probably don't need the details of why I switched to raw because I'm assuming that, if you've read this far, you're ready to do the same. (And if you want a reason, check out this post: [Why Feed Raw.](#))

But if you're thinking of switching to raw ... you're probably a bit scared. You might be worried your dog will choke on bones or that his diet won't be balanced. And those are very valid concerns ...

I was really (like really) frightened feeding real bones to my dogs ... especially back then when nobody else was. I'll never forget lying on the floor, feeding my dog a raw chicken wing and thinking "This is it ... this is how I kill my dog."

I remember what it was like to start out and if you're scared, you have every right to be ... change is scary and you probably love your dog a lot (otherwise you'd just be tossing some Ol' Roy in a bowl instead of reading this post).

But I'm here to tell you, it will be the best change you can ever make for your dog. If you ask any dog owner who has fed raw for more than a few weeks if they would ever go back to kibble, 100% of them would say NEVER!

If you ask any dog owner who has fed raw for more than a few weeks if they would ever go back to kibble, 100% of them would say NEVER!

What that means is that the health benefits are so noticeable and you'll honestly feel so good about knowing what goes into your dog that you'll forget all about your scary first moments feeding the raw diet.

So if you're thinking of maybe switching to raw, then I applaud you and I want to make it as easy and not-so-scary as possible for you. I'll summarize what I've learned from feeding dozens of dogs and puppies a raw diet over the last twenty years and make it as easy as possible for you to get started.

Just be sure to read all ten of the rules right to the end ... while they're easy to follow, each one is important and will make sure your dog's raw diet is balanced and safe.

The Raw Dog Food Diet Primer

What I'm going to share with you is the result of successfully feeding and raising a lot of dogs ... and my job means I'm friends with a lot of really smart PhD veterinarians who've helped me along the way and know a thing or two about raw feeding. My dogs are lucky to have this kind of team behind them ... and I want to give you the same veterinary-approved plan for your own dog.

That doesn't mean that my way is the only way to feed raw ... but it's the result of a lot of research and it's as scientifically sound as I can make it (because we really know so little about nutrition).

What follows is what I hope is a very simple explanation of some very complicated science and math. Let's jump right in!

The 10 Simple Raw Feeding Rules

Let's break the raw diet into some simple rules. If you get these rules right, you'll get the raw diet right (I promise ... just follow these rules and your dog will do just fine).

Rule # 1: The Raw Dog Food Diet Must Have Calcium

Dogs, and especially puppies, need a solid source of minerals, especially calcium and phosphorus. Your dog wouldn't survive without them.

To get enough calcium and keep a healthy balance of minerals, your dog's raw diet needs to contain about 12% to 15% bone.

If you feed your dog bones, you'll mostly get the minerals right. The most important ones to worry about are calcium and phosphorus. Both dogs and growing puppies need enough calcium in their diet. And they need some phosphorus to go with it because these minerals work closely together. Bones contain both calcium and phosphorus.

On the other hand, meat is high in phosphorus and too low in calcium. An all-meat diet will certainly cause bone and nervous system issues in your dog and severe bone issues in growing puppies. So you need bone in the diet ...

To get enough calcium and keep a healthy balance of minerals, your dog's raw diet needs to contain about 12% to 15% bone. To make things simpler, this means about 1/3 of his diet should be nice meaty bones. Here are some good choices for meaty bones:

- Chicken wings, necks, legs or thighs
- Turkey necks (other bones are large)
- Beef tail bones (great for larger dogs)
- Lamb or goat necks or ribs

You can also feed your dog whole animals such as whole fish, whole rabbit and whole poultry. These contain just the right amount of bone. Raw eggs with the shell on also contain the right ratio of calcium and phosphorus (just be sure they're from the farm ... grocery store eggs have a toxic spray in their shells).

Rule #2: Organs Are the Multi-Vitamins

I think the number two mistake raw feeders make with a raw dog food diet (I'll talk about the #1 mistake soon) is not feeding enough organs. Organs are the nutrient-rich parts of the animal and without them, your dog could be missing some important vitamins.

Organs are the nutrient-rich parts of the animal and without them, your dog could be missing some important vitamins.

Overall, you'll want to feed anywhere from 10% to 30% organ meats. But this depends on how much you can get. If you can only find liver, just feed 10% organs. If you're lucky and you can find kidney, spleen, pancreas, brain and other delicious, nutritious organs, then feed them as a third of your dog's diet. But never feed that much liver ... limit it to 10% because it's really high in vitamin A and can give your dog some messy diarrhea if you give too much. The same applies to any organ ... no one organ should be more than 5% to 10% of your dog's diet, but if you have a few different ones, they can be 1/3 of your dog's total meals.

Organs would include:

- Liver
- Kidney
- Spleen
- Pancreas*
- Thymus*
- Brain

- Lung
- Testicles

* Pancreas and thymus are both sold under the name sweetbreads.

Just go easy on the organ meat at first because it can cause loose stools until your dog is used to it. If your dog doesn't like the taste at first, try frying it for a minute or so first.

Rule #3: Muscle Meat Is the Foundation

Once you get your meaty bones and organs in place, the rest of your dog's diet should be nice lean meats. That means half to a third of his total food, depending on how much organ meat you can get your hands on. These are the protein-rich component of your dog's diet and he needs proteins to build strong tissues, as well as the hormones and enzymes he needs to survive and thrive.

Good choices for muscle meat include:

- Beef (ground beef, cheek meat, stewing beef)
- Beef heart (but not more than 5% of the diet as it's very rich)
- Bison (ground bison, stewing bison meat)
- Turkey (ground turkey, boneless thighs, breast meat, tenderloin)
- Lamb (stewing lamb, ground lamb, shoulder or breast meat)
- Pork (pork shoulder or butt, cushion meat, boneless rib meat, loin)
- Chicken (boneless thighs, breast meat)

Rule #4: Watch The Fat

If your dog's diet is too high in fat, I guarantee he won't be getting enough vitamins and minerals.

Fat is healthy for your dog ... it helps with nerve and immune function and is critical for skin health. But fat carries a downside ... fat contains

twice the number of calories as protein and it contains very few vitamins and minerals.

Remember I said I'd mention the #1 mistake when it comes to raw diets? It's feeding too much fat. If your dog's diet is too high in fat, I guarantee he won't be getting enough vitamins and minerals. The calories from the vitamin and mineral deficient fat will add up before your dog gets enough and you might start to see some long-term health issues if the fat is too high.

The main reason why so many raw feeders give their dogs too much fat is because cheaper meats contain a lot of fat. But if you watch for sales, you can get low fat meats at a good price.

Overall, you don't want fat to be much more than 10% and certainly no more than 20% of the diet. This doesn't mean no fat! Your dog needs fat, but just not so much of it that it robs him of other important nutrients.

Here are some examples of some high fat meats you'll want to avoid and low fat meats that are easy to find:

High

- Chicken necks with skin
- Chicken or turkey dark meat with skin
- Ground beef (85% lean or less)
- Pork belly
- Domestic duck

Low

- Chicken necks with no skin
- Chicken or turkey light meat with no skin
- Lean ground beef
- Pork loin
- Rabbit
- Most fish
- Most wild game (except duck)

Note: If you're able to feed your dog whole fish, whole rabbit, or other whole animals with the bone in, they're already balanced and you don't need to add extra meat. But if the carcass doesn't have organs, be sure to add those back in.

10 RAW FEEDING RULES FOR DOGS



1

The Raw Diet Must Have Calcium



2

Organs Are The Multi-vitamins



3

Muscle Meat Is The Foundation



4

Watch The Fat



5

Don't Get Hung Up On Fruit And Veg



6

Keep It Starch-free



7

Variety Counts



8

Balance Over Time



9

Feed Fish Once A Week



10

Relax

Rule #5: Don't Get Hung Up On Fruit and Veg

Should you add fruits and vegetables to your dog's raw diet? The short answer is it's really up to you. If you stick to the first four rules, your dog will get a nicely balanced raw diet with enough vitamins and minerals to do well.

But why end there?

Fruits and vegetables carry some unique benefits your dog can't get from animal products. And in the wild, your dog's ancestors ate a reasonable amount of grasses and berries ... and I like to think that they ate them for a reason (because animals are very good at sourcing out the foods their bodies need).

What benefits do fruits and vegetables offer that can't be found in meat?

Prebiotics (fiber) are indigestible plant fibers that feed important little bugs that live in your dog's gut (called probiotics).

Chlorophyll is the green pigment in plants that makes your dog's cells healthy detoxifies his liver and digestive system. It can also protect against cancer.

Carotenoids are important antioxidants that protect your dog from aging and disease. Carotenoids are found in yellow, orange and red colored fruits and vegetables like squash, carrots, papaya, cantaloupe.

Lycopene is another powerful antioxidant that can play a role in preventing and slowing cancer. Lycopene gives many vegetables their red color and it's found in tomatoes, carrots, red cabbage, watermelon.

Lutein is another antioxidant that's known to protect the eyes, skin and heart. It's found in dark leafy greens and in yellow plants, including kale, broccoli, oranges and papaya.

Flavonoids or bioflavonoids can regulate cell signaling and have antioxidant, anti-inflammatory and anti-cancer properties. In general, the more colorful the plant food, the higher it is in bioflavonoids.

My dogs love eating fruits and veggies and I like giving them for the above reasons. And to get the most out of their fruits and vegetables, I suggest you either run them through a juicer or mulcher or lightly steam them first. Fruits and veggies can be pricey, so help your dog get the most out of them. And always buy organic if you can afford it.

Rule #6: Keep It Starch-Free

Starchy foods like grains, peas and potatoes aren't suitable for your dog (or for you for that matter). Dogs do have the ability to digest some grain content and it might not be too harmful to include a small amount of grains in training treats ... but try as much as possible to limit their use.

Starchy foods cause your dog to continually produce a hormone called insulin. This causes him to store a lot of his food as fat, so if your dog is on the chubby side, avoiding grains will help. This can also lead to insulin resistance and diabetes.

Don't overlook the importance of cutting that starch out of your dog's life ... this is the main reason people see so many healthy changes when they switch their dog to a raw diet.

But the biggest reason to ditch the starch is because it only adds calories to your dog's diet. While your dog would die without protein or fat, he has no need for starch (or carbohydrate). And eating too much can start to disrupt the delicate colonies of microbes that live in his digestive tract. These little bugs make up most of your dog's immune

system and even help him produce vitamins ... and when they're disrupted, your dog can suffer from allergies, yeast and inflammatory health issues.

In a nutshell, if your dog doesn't need them, why would you feed them? There's no benefit to starch and the risks outweigh the benefits (and the only benefit to starch is it keeps costs down for you ... they add no benefit to your dog whatsoever).

Most of the healthy benefits of the raw diet aren't necessarily because it's raw ... it's because every other diet is high in starch! Don't overlook the importance of cutting that starch out of your dog's life ... this is the main reason people see so many healthy changes when they switch their dog to a raw diet.

Rule #7: Variety Counts

Just like us, dogs need a variety of wholesome foods to provide them with a wide range of nutrients ... not to mention the fact that it's boring to eat the same foods every day!

Feed a wide variety of different foods, including different sources of meat. Don't forget to feed some of the "weird and icky things" such as chicken, duck or turkey feet, beef trachea, tails, lung, testicles and pizzles. Parts like beef trachea and poultry feet are loaded with natural chondroitin and glucosamine, which help to build healthy joints and they're reasonably priced. Adding the icky parts is a win-win.

Rule #8: Balance over Time

One common concern with raw feeding is that it's not "complete and balanced." This isn't true for two reasons.

First, nobody knows what complete and balanced is, so it's difficult to make this claim.

Second, balance can occur over time ... every meal doesn't need to be completely balanced. As long as your dog's nutritional needs are met over the course of a few days or weeks, you're good.

You don't calculate the exact percentages of protein and carbohydrates or the exact amount of vitamins and minerals in each of your family's meals. You don't have to do it with your dog's meals either. So, you don't have to follow these rules for every meal.

Let me show you what I fed my dogs this week to give you an idea of balance over time.

Real Life Raw Meal Examples

Here's what my dogs ate this week ...

Monday: Big veal tails

Tuesday am: Beef (95% lean) mixed with 50% organ meats (containing brain, lung, spleen, kidney, reproductive organs, liver, pancreas and some green tripe) and 5% fruit and veggie mix

Tuesday pm: Beef (95% lean) mixed with 50% organ meats

Wednesday am: Lamb ribs

Wednesday pm: Beef (95% lean) mixed with 50% organ meats and 5% fruits and veggies

Thursday am: Whole mackerel

Thursday pm: Ground goat with 40% organ meats and 5% fruits and veggies

Friday: Whole rabbit

Saturday am: Lamb ribs

Saturday pm: Ground goat with 40% organ meats and 5% fruits and veggies

Sunday am: Beef neck bone

Sunday pm: Fruit and veggies

You probably noticed that some days I didn't feed very balanced meals. And that's OK! At the end of the week, my dogs will have averaged out to about 12% bone and 30% organ meat. That's balance over time!

As a side note, I don't feed poultry to my dogs. The reason I don't is an advanced idea that will get in your way of learning. If you're starting out, poultry is just fine ... but once you get the hang of raw feeding, and if you can afford to, you might want to reduce the amount of poultry in your dog's diet. But for now, it's just fine.

Rule #9: Feed Fish Once A Week

Although a lot of raw feeders do, I never give my dogs fish oil. It can easily turn rancid (even high quality oil) and cause inflammation in your dog. It's not environmentally friendly and it's a heated, processed product. I feed my dogs to avoid the unhealthy consequences of heating and processing. And I don't want to undo all that hard work and extra expense by slathering fish oil all over my dogs' meals. And if you're feeding poultry, your dog's diet will be much too high in polyunsaturated fats if you add fish oil.

Instead of fish oil, you can feed whole fish (like sardines, smelts, herring, and mackerel) once or twice a week. Or you can add a little fish to several meals. At the end of the week, you'll want whole fish to be about 5% of your dog's total diet. This will balance out his fats.

Rule # 10: Relax

If you follow rules 1 through 9, you'll be feeding your dog a fresh, whole food diet that's safe and balanced. It really is that easy to feed raw. The only step left is to start doing it! But before you do, here are just a couple of things to keep in mind ...

When To Feed

Most people feed their dogs twice per day. I feed once a day, twice a day and some days not at all.

I like to fast my dogs once every week or two because most immune function is in the gut. If the dog's digestive system is continually digesting meals, there's no time for house cleaning. The dog's immune system will suffer. Once a week, I turn my dogs out with a nice beef neck bone to chew. Or I'll give them some fruit and that's their fast day. The exception is puppies under six months of age who eat three times a day in my house.

How Much To Feed

As a starting point, feed your dog about two to three percent of his ideal adult weight. So, if he weighs 50 pounds, feed him one pound of food or a bit more.

If your dog is very active, you may need to feed a little more and if your dog is more of a couch potato, you may need to feed a little less.

The best way to tell if you're feeding the right amount is to run your hands over your dog's ribs. If you can feel the ribs, but not see them, your dog is at a good weight.

Puppies need more calories and nutrition ... so they should also receive about two to three percent of their ideal **adult** weight. When puppies are four to six months old, they will need a lot of food and a good amount of calcium because they're building their adult teeth. If

they don't get enough calcium in their diet at this critical stage, they'll pull the calcium from their bones and either develop bone or dental deformities. So, throw a few extra bones at your puppies at this age, just for a little extra insurance.

So, there you have it! Overall, raw feeding is quite easy and you only need to follow those simple rules to be safe and successful.

With time, you will become more comfortable with your dog's new diet and you will start to see the results in the form of better coats, cleaner teeth, fresher breath and fewer health issues.

Good luck with your dog's diet. Feel confident that when you feed your last bag of kibble, you'll be joining the ranks of thousands of people who have safely and effectively made the jump to raw feeding and have never looked back!

FOOD AND NUTRITION (/CONTENT/FOOD-AND-NUTRITION)

10 Myths And Misperceptions About Homemade Dog Food

Nutritionwise

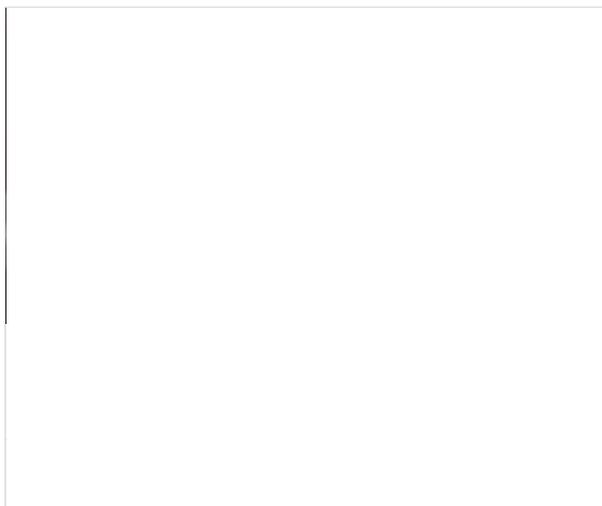
By Catherine Lane (/category/author/catherine-lane), May 2009, Updated February 2015



More images > ● ●

It's been two years since the first melamine-related pet food recall, and during that time, more dog lovers than ever have decided to turn to homemade diets—cooked or raw—as insurance against potential problems with commercial products. Is a homemade diet really insurance? Yes, it can be, assuming it's nutritionally balanced and takes into account your dog's breed, age, weight, activity and overall physiology.

As a consulting canine nutrition specialist, I analyze hundreds of diets annually, and see firsthand what people are actually feeding their dogs. Here are a few common misperceptions I've encountered and my responses to them, which I hope will help Bark readers in their own efforts to improve their dogs' nutrition. (The following applies to adult dogs in good health; if your dog is a puppy, a senior or has health issues, be sure to consult with your veterinarian before making dietary changes.)



1. “Using fresh, wholesome foods will, over time, meet my dog’s needs if I vary the diet enough.”

There is some basis for this point of view; fresh foods are indeed more bioavailable than those made with highly processed ingredients. In addition, when an owner prepares food at home, she knows exactly what’s going into it. However, when analyzed, even diets based on wholesome, fresh ingredients can still come up low in various vitamins and minerals.

Bone up on your dog’s actual nutrient requirements by doing a bit of research; this means reading widely, speaking with nutritionists and vets (holistic, conventional and specialists), and starting to think in terms of both ingredients and nutrient needs. (See sidebar for a short “starter list” of online information sources.)

2. “A multivitamin added to the food will cover any gaps.”

The question here is this: Which multi, and with which diet? Any unsupplemented home-prepared diet will be low in some nutrients and adequate or high in others. But because there is no standard formulation for human multivitamins and they can vary greatly in what they include, just tossing one in the dish is not the answer.

Choosing an all-purpose multi made specifically for dogs doesn't necessarily solve the problem either. These usually contain very low levels of nutrients because it's assumed they will be added to commercial food, and so are unlikely to provide enough supplementation to round out a homemade diet. This is why "balanced" is not just a buzzword; it's a valid and essential aspect of proper nutrition. Once you understand your dog's nutritional needs, work out what her diet actually contains and then add what's missing.

3. "I'm adding yogurt to my dog's food daily so she's getting enough calcium."

Dogs require fairly high levels of calcium, and yogurt absolutely won't cut it. Here's a quick example: My own 75-pound dog has a daily requirement of 1,840 mgs of calcium, and since I use quite a bit of fiber in his diet in the form of brown rice, I want to offset any absorption issues and ensure that he gets about 2,000 mgs per day, or 14,000 mgs per week. His weekly diet alone—turkey, liver, sardines, brown rice, ground lamb and acorn squash—only provides 1,750 mgs. That means I need to add over 12,000 mgs of calcium; in other words, more than 40 cups of plain yogurt.

Calcium supplementation is always necessary unless you are feeding raw bones. I recommend using a commercial carbonate or citrate form of calcium, or an eggshell crushed into a fine powder—one teaspoon of this powder (about 5.5 grams) equals roughly 2,200 mgs of calcium carbonate. To use eggshells, rinse them well and then bake for about 10 minutes at 300 degrees; use a small grinder to make the powder. Bone meal can be used if there is also a need to add phosphorus, but many homemade diets supply plenty of this

mineral.

4. “I eat carefully and read human nutrition books—I just follow similar principles with my dog.”

This is a very common assumption but unfortunately, it isn't accurate. Current nutritional guidelines for humans—who are omnivores—emphasize foods and ratios that may not be ideal for dogs. Ensure dietary balance by aiming for about 30 to 35 percent of total calories from fats, 30 percent from protein and the balance from complex carbohydrates.

(Percentages are guidelines, but are not as accurate as evaluating the gram content of a diet; this is another place where it pays to do the math.)

5. “My dog had some loose stools, so cutting way down on fiber will correct that.”

Fiber is an important dietary component, and the type of fiber you use counts as much or more than the amount (fiber is commonly used to address both constipation and diarrhea problems).

If your dog has loose stools on a homemade diet, switch to bland meals or cut back on the amount of food by about 30 percent for a day or so, and watch for other symptoms that might indicate an illness or parasites. If the problem doesn't clear up within a few days, consult your veterinarian.

6. “I use a lot of fresh veggies in my dog's diet because they offer so many health benefits.”

Vegetables' role in the canine diet has been a topic of considerable discussion. One school of thought holds that adding them is inappropriate, since dogs are carnivores and do not need plant matter. Others emphasize the need for both veggies and fruit to boost not only essential nutrients but also phytochemicals that may provide protection from disease.

Unlike cats, who are obligate carnivores (animals who must get their primary nutrition from meat), dogs' systems are more accommodating, and vegetables offer a lot in the way of health benefits. But here again, we are faced with the all-important questions, “How much

and what type?” Some vegetables have elements that may interfere with the absorption of minerals, and others, such as those in the nightshade family—tomatoes, white potatoes, eggplants and peppers—contain solanine, an alkaloid that some theorize aggravates inflammation. Use veggies judiciously: Limit dark leafy greens—which contain high levels of oxalate and may contribute to bladder stones in dogs who are prone to them—and be conservative with nightshades. Green beans and carrots are usually safe bets, and pumpkin and sweet potatoes are well tolerated (unlike white potatoes, sweet potatoes are not in the nightshade family, but are high in calories and starch).

7. “Dogs don’t require carbs, and grains are bad for them.”

This is one of the most often-quoted—and misunderstood!—of all the ideas here. It seems to come from National Research Council studies, which conclude that dogs have no strict requirement for dietary carbohydrates. Briefly put, canines can metabolize adequate glucose (blood sugar) from a diet consisting of fat and protein alone.

All this means is that lack of carbohydrates will not lead to an identifiable deficiency in the way that a lack of Vitamin C in humans will produce scurvy. It does not, however, mean that a carb-free diet is a good idea. To complicate this issue, many people use the terms “carbohydrate” and “grain” interchangeably, thinking they’re following a no-carb diet because they have eliminated grains.

Complex carbohydrates provide energy and aid in healthy gastrointestinal function, and some portion of your dog’s homemade food should consist of brown rice, wild rice, quinoa, legumes (which also add protein) or starchy vegetables. Try to keep levels consistent so if need be, you can make adjustments.

8. “A raw diet is always superior to one that’s cooked—dogs fed raw do not get sick.”

Raw diets vary in type; some seek nutrient balance while others utilize a “prey model” approach, which mimics the diet of wolves or wild dogs as closely as possible. These diets have become hugely popular over the past decade, and to be sure, there are dogs who absolutely thrive on them. But some do not. As with a cooked diet, it’s essential to ensure proper formulation. Raw diets have drawbacks as well as benefits, and may not be suitable for every dog.

If you are planning to try a raw approach, do your homework. Research both within and outside the various raw communities that exist on the Internet. Talk to veterinarians and nutritionists, read widely, and take your time.

9. “Raw diets are a dangerous fad. I’d be scared to try it.”

For every home feeder who sings the praises of a raw diet, I hear another one say she wouldn’t dare use foods that aren’t cooked. It’s as much a mistake to assume that raw is uniformly dangerous as it is to insist it’s a viable solution for every dog. I often use raw diets for dogs with allergies, or proactively where there are no problems and the owner has expressed an interest. One great advantage of this approach is ease of preparation. Consider your own needs and lifestyle as well as your dog’s when making this all-important decision about feeding.

10. “Dogs of all ages can be fed a similar diet, as long as it’s made up of whole foods.”

This can be a dangerous misconception. Puppies’ diets need to have at least twice, and in some cases, as much as five times the nutrient content of an adult dog’s. But although they require more nutrients, hyper-nutrition can be a serious problem, particularly in giant breeds. At the other end of the age range, though it was long thought that reducing dietary protein was in the best interest of seniors, current findings suggest they may actually require more protein than adult dogs.

If you are new to home feeding, learn as much as you can about canine nutrition before introducing your puppy or senior to a homemade diet. Better yet, work with an experienced nutrition consultant who can help you formulate and adjust the diet according to your dog’s growth needs. For seniors in particular, have a full geriatric screening run at least semi-annually to ensure that liver and kidney values are within normal range; aberrations in these numbers often indicate a need for changes in dietary management. Though poor nutrition causes problems no matter what the dog’s age, growing dogs and seniors pose greater challenges to the novice home feeder than do adult dogs, and mistakes made here can have serious consequences.

So, here's the take-away message: A homemade diet remains a popular and potentially very healthy alternative or complement to the many premium foods on the market. However, research and planning are essential. Gather information from a wide range of sources, exercise a little caution, start slowly and don't forget to check in with your vet or nutrition specialist regularly to be sure the diet hasn't inadvertently drifted out of balance. Any diet on which your dog fails to thrive is a poor choice. If you see that your dog is not doing well on what you're feeding him, consider a change. He will thank you for it.

--

Important: Many veterinarians, while acknowledging that pet food recalls and the poor quality of some pet foods are causes for concern, still feel that homemade diets, when fed exclusively, may result in nutritional imbalances and vitamin/mineral deficiencies that may pose threats to canine health. Therefore, if you choose to feed your dog a homemade diet, it is important that you understand and provide what your dog needs to stay healthy; veterinary nutritionists can assist in developing suitable homemade diets. While caution was taken to give safe recommendations and accurate instructions in this article, it is impossible to predict an individual dog's reaction to any food or ingredient. Readers should consult their vets and use personal judgment when applying this information to their own dogs' diets.

Starting Points

[National Research Council \(http://dels.nas.edu/banr/petdoor.html\)](http://dels.nas.edu/banr/petdoor.html)

Nutrient Requirements of Dogs

A pamphlet with basic information on canine nutrition can be downloaded for free, and the full report is available for purchase.

[Nutritiondata \(http://nutritiondata.com\)](http://nutritiondata.com)

Analyze a recipe's nutritional value; enter it in the database and see what it contains.

[USDA Nutrient Database \(http://nal.usda.gov/fnic/foodcomp/search\)](http://nal.usda.gov/fnic/foodcomp/search)

Become familiar with nutrient content. Enter one word that best describes the food item; if you don't get a match, check your spelling or try a related term.

Tags: [food & nutrition \(/category/tags/food-nutrition\)](/category/tags/food-nutrition)

Illustration by Vivienne Flesher

Article first appeared in *The Bark*, Issue 53: Mar/Apr 2009 (</content/issue-53-marapr-2009>).



View Comments

60% protein

30% fat

10% carbohydrate

Another 'idea' unsubstantiated:

Raw Dog Food Recipe Proportions

80% meat with fat

10% organs

5% vegetables/fruits

5% dairy/supplements

Dairy/supplements: Whole eggs (shell and all) are a great source of calcium. I'll also use some plain yogurt to help bind the patties.

Vegetables

Carrots

Broccoli

Spinach

Green beans

Collards

Kale

Regarding fat:

A starting point - discussing the kinds of fats

There are five essential fatty acids (EFAs) for dogs. They're all polyunsaturated fats and they're essential because your dog can't make them himself. They must be included in her diet. These are:

Alpha Linolenic Acid – an omega-3 fat found in flaxseeds and hempseeds

Linoleic Acid – an omega-6 fat found in things like hempseeds and sunflower seeds

Arachidonic Acid – an omega-6 fat found in meat, poultry and eggs

Docosahexaenoic Acid – an omega-3 fat found in oily fish like sardines

Eicosapentaenoic Acid – an omega-3 also found in oily fish

Feeding rate:

To start, feed your dog about one to three percent of her ideal weight. So, if your dog's ideal weight is 50 lbs, one pound of food a day (or a little more) is good.

Good things to add to a home diet

Almonds, Blueberries, Yogurt, Multivitamins, Omega 3,6,9 FA's, Calcium, FOS / inulin

Homemade raw dog food

PREP TIME

30 minutes

TOTAL TIME

30 minutes

Ingredients

2 1/2 pounds ground beef

4 ounces chicken livers

1 carrot, chopped

1 small apple, cored

1/2 cup baby spinach

2 whole eggs (including shell)

1/2 cup plain yogurt

1 tablespoon ground flaxseed

1 tablespoon olive oil

Instructions

Add the carrot, apple and spinach to a food processor and process until finely chopped.

Add the remaining ingredients except the ground beef and process again until well combined.

Transfer the mixture into a large bowl. Add the ground beef and mix together with a spatula or your hands.

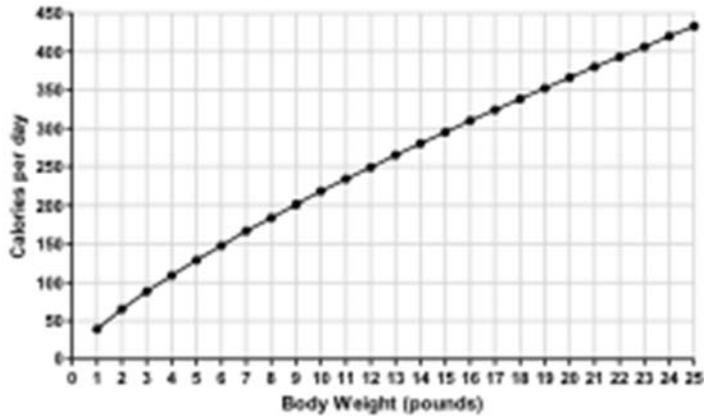
Form into patties about the size of your palm and place on a parchment lined baking sheet.

Freeze patties until solid, transfer to a storage container or plastic bag and keep frozen.

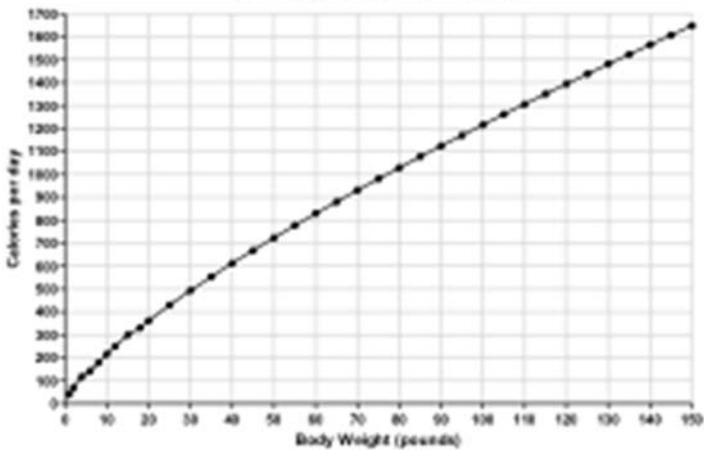
Remove one day's worth of patties from the freezer the night before and place in the refrigerator to thaw before serving.

Pets' energy (Calorie) needs to maintain a healthy weight for their life stage depends upon several factors. First, the energy to perform essential body functions like digestion, respiration, heart functions, brain functions, etc. (Resting Energy Requirements or RER), which can be calculated by multiplying the animal's body weight in kilograms raised to the $\frac{3}{4}$ power by 70, for example, a 10kg (22lb) adult neutered dog of healthy weight needs $RER = 70(10\text{kg})^{3/4} \approx 400$ Calories/day. One also can use the charts below to estimate resting calorie needs.

Resting Calorie Needs for Adult Cats



Resting Calorie Needs for Adult Dogs



The RER is then multiplied by factors to estimate the pet's total daily energy needs. (See Table 1). Individual pet needs can vary by as much as 50% from calculated values however, so these are only starting points for estimating the amount of food to be provided daily. The amount is then adjusted up or down as needed to maintain a healthy body condition score.

Table 1. Known life stages and corresponding factors used to estimate daily energy needs for dogs.	
Neutered adult	=1.6 x RER
Intact adult	=1.8 x RER
Inactive/obese prone	=1.2-1.4 x RER
Weight loss	=1.0 x RER for ideal weight
Weight gain	=1.2-1.8 x RER for ideal weight
Active, working dogs	=2.0-5.0 x RER
Puppy 0-4 months	=3.0 x RER
Puppy 4 months to adult	= 2.0 x RER

As mentioned, these calculations can only give crude, “zip-code” level estimates of your pet's Calorie needs (and so how much to feed), which can change with time and circumstances.

For example, some dog breeds also require more or less energy by the inherent nature of their breed. For example, an active Jack Russell Terrier versus a miniature poodle. Although both are about the same size, the highly active nature of the Jack Russell Terrier compared to the slower pace of the miniature poodle can result in very different energy intakes to maintain a healthy body condition.

Bibliography: <https://vet.osu.edu/vmc/companion/our-services/nutrition-support-service/basic-calorie-calculator>



Calorie Needs for an Average Healthy Adult Dog in Ideal Body Condition*

Weight (kg)	Weight (lb)	Kilocalories/day	Weight (kg)	Weight (lb)	Kilocalories/day
2	4.4	140	26	57.2	970
3	6.6	190	27	59.4	1000
4	8.8	240	28	61.6	1020
5	11	280	29	63.8	1050
6	13.2	320	30	66	1080
7	15.4	360	31	68.2	1100
8	17.6	400	32	70.4	1130
9	19.8	440	33	72.6	1160
10	22	470	34	74.8	1180
11	24.2	510	35	77	1210
12	26.4	540	36	79.2	1240
13	28.6	580	37	81.4	1260
14	30.8	610	38	83.6	1290
15	33	640	39	85.8	1310
16	35.2	670	40	88	1340
17	37.4	700	41	90.2	1360
18	39.6	730	42	92.4	1390
19	41.8	760	43	94.6	1410
20	44	790	44	96.8	1440
21	46.2	820	45	99	1460
22	48.4	850	46	101.2	1480
23	50.6	880	47	103.4	1510
24	52.8	910	48	105.6	1530
25	55	940	49	107.8	1560

Note: These recommendations are for guidance only. Dogs are individuals and some may have higher or lower caloric requirements in order to maintain an ideal, trim body condition.

**If the dog is overweight, these estimates may be too high and further calorie restriction will be required.*

YOUR DOG'S NUTRITIONAL NEEDS

A Science-Based Guide For Pet Owners



NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

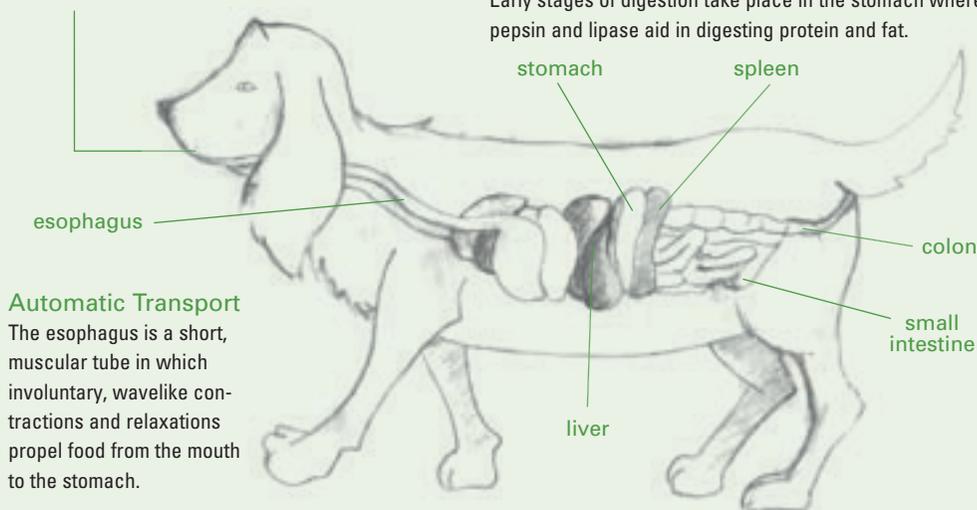
THE DIGESTIVE TRACT

Point of Departure

The mechanical breakdown of food begins in the mouth, where food is ingested, chewed, and swallowed.

Storage and Processing

The stomach acts as a temporary storage and processing facility before emptying its contents into the small intestine. Early stages of digestion take place in the stomach where pepsin and lipase aid in digesting protein and fat.



Automatic Transport

The esophagus is a short, muscular tube in which involuntary, wavelike contractions and relaxations propel food from the mouth to the stomach.

Treatment Facilities

In the small intestine, enzymes break down large, complex food molecules into simpler units that can be absorbed into the bloodstream. The pancreas is an organ that does double duty, secreting digestive enzymes into the gut and hormones, including insulin and glucagon, into the blood. Important for fat metabolism, the liver produces bile and partially stores it in the gall bladder between meals.

End of the Line

The primary function of the large intestine is to absorb electrolytes and water. Also, this is where microbes ferment nutrients that have so far escaped digestion and absorption.

COMMITTEE ON NUTRIENT REQUIREMENTS OF DOGS AND CATS

DONALD C. BEITZ, *Chair*, Iowa State University

JOHN E. BAUER, Texas A&M University

KEITH C. BEHNKE, Kansas State University

DAVID A. DZANIS, Dzanis Consulting & Collaborations

GEORGE C. FAHEY, University Of Illinois

RICHARD C. HILL, University Of Florida

FRANCIS A. KALLFELZ, Cornell University

ELLEN KIENZLE, Zentrum Für Lebensmittel Und Tierernährung, Oberschleissheim, Germany

JAMES G. MORRIS, University Of California, Davis

QUINTON R. ROGERS, University Of California, Davis

Support for this pamphlet was provided by the President's Circle Communications Initiative of the National Academies. The pamphlet was written by Dale Feuer based on a report by the Committee on Nutrient Requirements of Dogs and Cats. Illustration and design by Van Nguyen.

Copies of *Nutrient Requirements of Dogs and Cats* are available from the National Academies Press, 500 Fifth Street, N.W., Washington, DC 20001; 800-624-6242 or 202-334-3313 (in the Washington area); <http://www.nap.edu>.

Copyright 2006 by the National Academy of Sciences. All rights reserved.

CONTENTS

Introduction	1
Proteins and Amino Acids	2
Fats and Fatty Acids	2
Energy Needs	3
Vitamins	6
Minerals	8
Feeding Practices	11
Food Choices	12

INTRODUCTION

How much should I feed my dog? Does the food I'm providing meet my dog's nutritional needs? As our knowledge of the relationship between diet and health continues to advance and as the range of foods available for dogs continues to expand, it's more important than ever to base feeding choices on good information.

The information in this pamphlet is based on *Nutrient Requirements of Dogs and Cats*, a technical report issued by the National Research Council as part of its Animal Nutrition Series. The Food and Drug Administration relies on information in the report to regulate and ensure the safety of pet foods. Other reports in the series address the nutritional needs of horses, dairy cattle, beef cattle, nonhuman primates, swine, and small ruminants. Scientists who study the nutritional needs of animals use the Animal Nutrition Series to guide future research. The series is also used by animal owners, caretakers, and veterinarians to develop specialized diets for individual animals. Links to reports in the series can be found at <http://dels.nas.edu/banr>.

Dogs need several different kinds of nutrients to survive: **amino acids from proteins, fatty acids and carbohydrates, vitamins, minerals, and water.** The tables in this pamphlet provide recommended daily allowances for dietary nutrients based on the minimum amount required to maintain good health in normal dogs. Your dog's unique nutritional requirements will depend on its size, its breed, and its stage in life, among other factors. A better understanding of how dogs use the various nutrients in food and how much of them they need can help you choose a healthier diet for your pet.

PROTEINS AND AMINO ACIDS

Dogs cannot survive without protein in their diets. Dietary protein contains 10 specific amino acids that dogs cannot make on their own. Known as essential amino acids, they provide the building blocks for many important biologically active compounds and proteins. In addition, they donate the carbon chains needed to make glucose for energy. High-quality proteins have a good balance of all of the essential amino acids. Studies show that dogs can tell when their food lacks a single amino acid and will avoid such a meal.

Dogs are known to selectively choose foods that are high in protein. Whether this is simply a matter of taste or a complex response to their biological needs for all 10 essential amino acids is not known. However, dogs can survive on a vegetarian diet as long as it contains sufficient protein and is supplemented with vitamin D.

FATS AND FATTY ACIDS

Dietary fats, mainly derived from animal fats and the seed oils of various plants, provide the most concentrated source of energy in the diet. They supply essential fatty acids that cannot be synthesized in the body and serve as carriers for important fat-soluble vitamins. Fatty acids play a role in cell structure and function. Food fats tend to enhance the taste and texture of the dog's food as well.

Essential fatty acids are necessary to keep your dog's skin and coat healthy. Puppies fed ultralow-fat diets develop dry, coarse hair and skin lesions that become increasingly vulnerable to infections. Deficiencies in the so-called "omega-3" family of essential fatty acids may be associated with vision problems and impaired learning ability. Another family of essential fatty acids called "omega-6" has been shown to have important physiologic effects in the body.



DAILY RECOMMENDED ALLOWANCES FOR PROTEIN AND FATS

	PUPPIES (Weighing 12 lb, 33 lb at maturity)	ADULT DOGS (Weighing 33 lb)	PREGNANT/NURSING DOGS (Weighing 33 lb with 6 puppies)
Crude Protein	56 g	25 g	69 g/158 g
Total Fat	21 g	14 g	29 g/67 g

Determining Grams of Essential Nutrients from Petfood Labels

Petfood labels do not generally list amounts of essential nutrients in grams. However, all pet food labels must state guarantees for the minimum percentages of crude* protein and crude fat, and the maximum percentages of crude fiber and moisture. To convert these percentages to grams, simply multiply the crude percentages times the weight of your dog's daily portion. For example, if you feed your dog a 1-lb (454-gram) can of food per day, and the food contains 8% crude protein, the grams of protein would be $0.08 \times 454 = 36$ grams.

*"Crude" refers to the specific method of testing the product, not to the quality of the nutrient itself.

TIDBIT

Scientific research has shown that an adult dog's daily diet can contain up to 50% carbohydrates by weight, including 2.5–4.5% from fiber. A minimum of approximately 5.5% of the diet should come from fats and 10% from protein.

ENERGY NEEDS

Dogs need a certain amount of energy to sustain the normal activities of their daily lives. Growth, pregnancy, lactation, and exercise all increase these normal energy requirements. Generally measured in terms of calories, energy comes from three major dietary components: **carbohydrates, protein, and fats**.

Omnivorous animals get some of their energy from carbohydrates, which include sugars, starches, and dietary fibers. The major sources of carbohydrates in commercial dog foods are cereals, legumes, and other plant foodstuffs. So-called absorbable carbohydrates, including glucose and fructose, can be directly absorbed and do not need to be digested by enzymes. Digestible carbohydrates are readily broken down by intestinal tract enzymes. Fermentable carbohydrates include certain starches and dietary fibers that pass undigested through the small intestine to the colon, where they are fermented by microbes into short-chain fatty acids and gases. Some studies suggest that fermentable fibers may aid in the regulation of blood glucose concentrations and enhance immune function. Nonfermentable fibers, such as cellulose and wheat bran, contribute little in terms of energy or nutrition and are primarily used to decrease caloric intake of the overweight animal.

AVERAGE DAILY ENERGY NEEDS

TYPE OF DOG	CALORIES PER DAY (Kilocalories per day*)				
	10 lb	30 lb	50 lb	70 lb	90 lb
PUPPIES (10 lb puppy growing to 33 lb at maturity)	990	—	—	—	—
INACTIVE DOGS —dogs with little stimulus or opportunity to exercise.	296	674	989	1,272	1,540
ADULT ACTIVE DOGS —dogs with strong stimulus and ample opportunity to exercise, such as dogs in households with more than one dog, in the country or with a large yard.	404	922	1,353	1,740	2,100
PREGNANT DOGS —from 4 weeks after mating until delivery.	518	1,274	1,940	2,570	3,170
YOUNG ADULT ACTIVE DOGS	436	993	1,451	1,876	2,264
OLDER ACTIVE DOGS	327	745	1,093	1,407	1,700

*1 Calorie = 1 kilocalorie = 1,000 calories. The term Calorie that is used on food nutrition labels is really a “food calorie” sometimes called a “large calorie.” It is equivalent to 1,000 calories (or 1 kilocalorie) as calories are defined scientifically (the amount of energy needed to warm 1 gram of water 1°C). In Nutrient Requirements of Dogs and Cats, energy needs are expressed in terms of kilocalories, which are equivalent to Calories in this document.

Number of Puppies	ENERGY NEEDS IN CALORIES (Calories per Day for a 33 lb and 50 lb Nursing Dog)							
	Weeks into Lactation							
	1		2		3 (peak)		4	
	33 lb	50 lb	33 lb	50 lb	33 lb	50 lb	33 lb	50 lb
2	1,645	2,328	1,789	2,546	1,897	2,709	1,969	2,818
4	2,185	3,146	2,473	3,581	2,689	3,909	2,833	4,127
6	2,455	3,555	2,815	4,100	3,084	4,509	3,265	4,782
8	2,725	3,964	3,157	4,618	3,481	5,109	3,697	5,437

TIDBIT

Severe illness or trauma may increase a dog's energy needs. Whenever your dog becomes ill, please consult with your veterinarian or dog nutritionist for your dog's changed nutritional needs.

ENERGY NEEDS OF GROWING PUPPIES

The growing puppy starts out needing about twice as many calories per pound of body weight as an adult dog of the same breed. Owners should start feeding puppies food at approximately 4 weeks after birth, because mother's milk is no longer sufficient. Food is best offered to puppies in multiple, well-spaced meals.

ENERGY NEEDS OF OLDER DOGS

Because of decreased physical activity and slowed metabolism, older dogs need 20% fewer total calories than do middle-aged adult dogs. As dogs age, they tend to become overweight. It may take obese dogs longer for their blood glucose concentrations to return to normal. This disrupted carbohydrate metabolism can lead to diabetes.

ENERGY NEEDS OF LACTATING DOGS

New mothers generally suckle their puppies for at least 6 weeks. The mother's need for calories increase with the number of puppies and the week of lactation, up to 4 weeks. Giant breeds (like Great Danes) have proportionately smaller digestive tracts and may not be able to eat enough to sustain themselves during lactation. Owners of such dogs may need to start feeding puppies supplemental food at an early age.



VITAMINS

Vitamins are organic compounds that take part in a wide range of metabolic activities. Dogs require vitamins in their food, albeit at low concentrations. First noticed in dogs some 75 years ago, vitamin deficiencies can cause a variety of health problems. Clinical signs of vitamin A deficiency, one of the first deficiencies studied in dogs, include motor and vision impairment, skin lesions, respiratory ailments, and increased susceptibility to infections. Dogs fed diets lacking vitamin E show signs of skeletal muscle breakdown, reproductive failure, and retinal degeneration. Thiamin deficiency can lead to brain lesions and other neurological abnormalities if the deprivation is sudden and to heart damage and death if it is chronic. Some vitamins, such as vitamin D, are not only essential in small doses, but also toxic in excess amounts.



DAILY RECOMMENDED ALLOWANCES FOR VITAMINS

	FUNCTIONS	RECOMMENDED ALLOWANCE*	SIGNS OF DEFICIENCY/EXCESS
Vitamin A	Vision; growth; immune function; fetal development; cellular differentiation; transmembrane protein transfer	379 µg	Anorexia; body weight loss; ataxia; conjunctivitis; corneal disorders; skin lesions; respiratory ailments; increased susceptibility to infection Imbalance in bone remodeling processes; artery and vein degeneration; dehydration; central nervous system depression; joint pain
Vitamin D	Maintenance of mineral status; phosphorous balance	3.4 µg	Rickets; lethargy; loss of muscle tone; bone swelling and bending Anorexia; weakness; diarrhea; vomiting; calcification of soft tissue; excessive mineralization of long bones; dehydration; dry and brittle hair; muscle atrophy
Vitamin E	Defense against oxidative damage	8 mg	Degeneration of skeletal muscle; reproductive failure; retinal degeneration

Vitamin K	Activation of clotting factors, bone proteins, and other proteins	0.41 mg	No reports of naturally occurring deficiencies in normal dogs
Vitamin B₁ (Thiamin)	Energy and carbohydrate metabolism; activation of ion channels in neural tissue	0.56 mg	Failure to grow, weight loss and neurological abnormalities in puppies; damage to the nervous system and to the heart in adult dogs
Riboflavin	Enzyme functions	1.3 mg	Anorexia; weight loss; muscular weakness; flaking dermatitis; eye lesions
Vitamin B₆	Glucose generation; red blood cell function; niacin synthesis; nervous system function; immune response; hormone regulation; gene activation	0.4 mg	Anorexia and weight loss in puppies; convulsions, muscle twitching, and anemia in adult dogs Impairment of motor control and balance ; muscle weakness
Niacin	Enzyme functions	4 mg	Anorexia; weight loss; inflammation of the lips, cheeks, and throat; profuse salivation; bloody diarrhea Bloody feces ; convulsions
Pantothenic Acid	Energy metabolism	4 mg	Erratic food intake; sudden prostration or coma; rapid respiratory and heart rates; convulsions; gastrointestinal symptoms; reduced antibody production
Vitamin B₁₂	Enzyme functions	9 µg	Appetite loss; lack of white blood cells; anemia; bone marrow changes
Folic Acid	Amino acid and nucleotide metabolism; mitochondrial protein synthesis	68 µg	Weight loss; decline in hemoglobin concentration
Choline	Phospholipid cell membrane component	425 mg	Loss of body weight; fatty liver

**Daily needs for an adult dog weighing 33 pounds, consuming 1,000 Calories per day.
g = grams; mg = milligrams; µg = micrograms*



MINERALS

Twelve minerals in the table are known to be essential nutrients for dogs. Calcium and phosphorus are crucial to strong bones and teeth. Dogs need magnesium, potassium, and sodium for nerve impulse transmission, muscle contraction, and cell signaling. Many minerals that are present only in minute amounts in the body, including selenium, copper, and molybdenum, act as helpers in a wide variety of enzymatic reactions.

Dogs can get too much or too little of a specific mineral in their diets. A deficiency of dietary calcium, for instance, causes a condition known as secondary hyperparathyroidism.

Recognized clinically for many years in dogs fed meals consisting mainly of meat, this disease results in major bone loss, skeletal abnormalities, and pathological fractures. An excess of calcium, on the other hand, may also cause skeletal abnormalities, especially in growing large-breed puppies.

DAILY RECOMMENDED ALLOWANCES FOR MINERALS

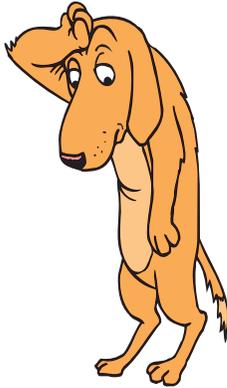
	FUNCTIONS	DAILY RECOMMENDED ALLOWANCE*	SIGNS OF DEFICIENCY/EXCESS
Calcium	Formation of bones and teeth; blood coagulation; nerve impulse transmission; muscle contraction; cell signaling	1 g	Nutritional secondary hyperparathyroidism; significant decreases in bone mineral content, which can result in major skeletal abnormalities Different types of skeletal aberrations, especially in growing puppies of large breeds
Phosphorus	Skeletal structure; DNA and RNA structure; energy metabolism; locomotion; acid-base balance	0.75 g	Reduced weight gain; poor appetite; bowing and swelling of forelimbs in puppies
Magnesium	Enzyme functions; muscle and nerve-cell membrane stability; hormone secretion and function; mineral structure of bones and teeth	150 mg	Reduction in weight gain, irritability, and convulsions in puppies; hyperextension of carpal joints and hind-leg paralysis later in life

Sodium	Acid-base balance; regulation of osmotic pressure; nerve impulse generation and transmission	200 mg	Restlessness; increased heart rate, water intake, and hemoglobin concentration; dry and tacky mucous membranes
Potassium	Acid-base balance; nerve-impulse transmission; enzymatic reactions; transport functions	1 g	Poor growth in puppies; paralysis of neck muscles and rear legs and general weakness later in life
Chlorine	Acid-base balance; transfer of extracellular fluids across cell membranes	300 mg	Reduced weight gain and weakness in puppies
Iron	Synthesis of blood components; energy metabolism	7.5 mg	Poor growth; pale mucous membranes; lethargy; weakness; diarrhea <i>At acute levels, dangerous oxidative reactions that lead to gastrointestinal and other tissue damage</i>
Copper	Connective tissue formation; iron metabolism; blood cell formation; melanin pigment formation; myelin formation; defense against oxidative damage	1.5 mg	Loss of hair pigmentation in puppies; anemia
Zinc	Enzyme reactions; cell replication; protein and carbohydrate metabolism; skin function; wound healing	15 mg	Poor weight gain; vomiting; skin lesions
Manganese	Enzyme functions; bone development; neurological function	1.2 mg	No studies of deficiency in dogs
Selenium	Defense against oxidative damage; immune response	90 µg	Anorexia; depression; breathing discomfort; coma; muscular degeneration
Iodine	Thyroid hormone synthesis; cell differentiation; growth and development of puppies; regulation of metabolic rate	220 µg	Enlargement of thyroid glands; dry, sparse hair coat; weight gain <i>Excessive tearing, salivation, and nasal discharge; dandruff</i>

**Daily needs for an adult dog weighing 33 pounds, consuming 1,000 Calories per day.
g = grams; mg = milligrams; µg = micrograms*

UNDERWEIGHT OR OVERWEIGHT?

UNDERWEIGHT



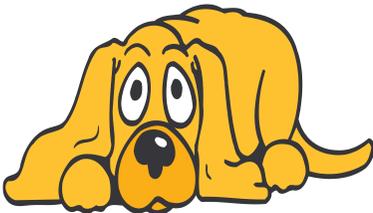
Your dog is not getting enough to eat if you can easily see its ribs, vertebrae, and pelvic bones, feel no fat on the bones, and possibly notice some loss of muscle mass. If chronically underfed, adult dogs may experience impaired ability to nurse young and perform work, and increased susceptibility to bacterial infections and parasites; puppies may be stunted in their growth; adult dogs may develop osteoporosis.

IDEAL



Your dog is at an ideal weight if you can easily feel its ribs. The waist should be easily observed behind the ribs when viewed from above. An abdominal tuck is evident when viewed from the side.

OVERWEIGHT



Your dog is overweight if you cannot feel its ribs, see fat deposits over its back and the base of its tail, discern no waist behind the ribs when viewed from above, and see no abdominal tuck in profile. Obesity occurs in one out of four dogs in western societies. Its incidence increases with age and is more common in neutered animals. Health risks include diabetes and osteoarthritis.

FEEDING PRACTICES

Q: Does my dog need to eat meat?

A: Because dogs are descended from omnivores, they are not strict meat eaters. They are remarkably adaptable to a wide range of ingredients, texture, and form in terms of what they will eat. Though many dogs may prefer animal-based protein, they can thrive on a vegetarian diet. Regardless of whether the protein comes from plant or animal sources, normal adult dogs should get at least 10% of their total calories from protein. Older dogs appear to require somewhat more protein to maintain their protein reserves, perhaps as much as 50% more.

Q: How much fiber is good for my dog?

A: Fiber in the diet is probably good for overall gastrointestinal health and may help some dogs keep their weight down. The typical diet of normal adult dogs contains between 2.5 and 4.5% fiber. However, the fiber content of some “diet” dog foods may be higher. This may allow the dog to feel full without consuming too many calories for effective weight control. Diets high in fiber also may help in the management of hyperglycemia (high blood sugar), and may improve large intestine function.

On the other hand, too much fiber in the diet can decrease the digestibility of other important nutrients and result in loose stools, frequent defecation, and reduced palatability of the dog food. Wheat bran and barley products are high in fiber. Conversely, dog food ingredients high in starch, including rice and dried potatoes, have less fiber.

Q: How often should I feed my dog?

A: Dogs eat larger, less frequent meals than do cats. It is fine to feed an adult dog one or two times per day. Puppies, however, need two to three daily meals.

Q: How can I help my overweight dog trim down?

A: The most obvious answer is to feed your dog smaller amounts on the same feeding schedule. Some dog owners offer less tasty food or allow less time to eat. Another option is to feed your dog one of the low-calorie dog foods on the market. It's also important to remember to keep your dog from sampling the dog-next-door's food and to refrain from giving your dog table scraps.

Q: How do heat and exercise affect the amount of water my dog needs?

A: Fresh water should be available to your dog at all times to reduce the risk of becoming overheated. A dog's need for water increases in keeping with the amount of energy he expends during exercise, and this need may more than double in warm conditions. Ideally, you should actively offer your dog water during exercise.



TIDBIT

Exposure to certain flavors and textures of food early in life can shape strong preferences later on.

FOOD CHOICES

Commercial dog foods come in a variety of forms. The most common types are **dry, semimoist, and canned**. The moisture content of these foods ranges from 6 to 10 % for dry, 15 to 30% for semimoist, and 75% for canned. Most canned food has relatively more fat and protein and fewer carbohydrates than does dry and semi-moist food, and generally contains much higher levels of animal products.

Pet food labels must list the percentage of protein, fat, fiber, and water in the food. When reading labels, it is important to remember that what may appear to be a big difference in the amount of a nutrient—for example, 8% protein in a canned dog food vs. 27% protein in a dry dog food—reflects the fact that there is more water in the canned food.

PET FOOD ADDITIVES

Some other substances that might be found in pet foods, which are not required nutrients, are described below:

Chondroprotective agents are used by the body to make cartilage and joint tissues. Although, use of chondroprotective agents may be indicated for selected clinical conditions, widespread inclusion in the diets of healthy populations may not be warranted at this time.

Antioxidants work to prevent oxidative damage to nutrients and other compounds in the body and inhibit or quench the formation of free radicals. At this time, data are lacking to make specific recommendations beyond those for the essential vitamins and minerals that are components of antioxidants.



Herbs and botanicals are used in pet foods either to provide flavor or, more often, to have a medicinal effect on the body. This is especially true in the case of extracts, where the classical nutritive components of the plant may be separated from the extract in the process. Because the intended functions are more pharmacologic versus nutritional in nature, discussion of potential benefit is beyond the scope of this publication.

Flavors and extracts derived from animal tissues such as poultry or fish are considered “natural” flavors. A wide variety of flavors can be derived from other animal and plant materials, including dairy products, eggs, herbs, and spices. Acceptable processing methods include roasting, extraction, and fermentation. Except for artificial smoke and bacon flavors, synthetic substances are rarely used in most dog and cat foods.

Colors are synthetic compounds used to replace or accentuate the inherent color of the food. Only certified colors approved for use in human foods are allowed in pet foods. Iron oxide is a synthetic but noncertified color that can be used at levels not to exceed 0.25% of the pet food product to give dog and cat food a red, meaty appearance. Titanium dioxide is another common color additive in human and pet foods because it can induce a “brightness” in foods by complementing other color additives. Its use is limited to 1% of the food by weight.



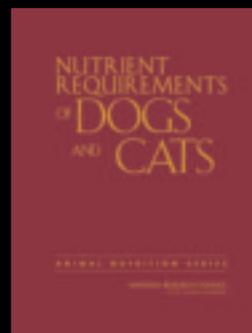
TIDBIT

Pet foods marketed as “snacks” are not required to have nutritional adequacy labels.



For more than 80 years, the National Academies has fostered improved understanding of the nutritional needs of pets, wildlife, laboratory-research species, and food-producing animals through its Nutrient Requirements of Domestic Animals series—a series that is considered the “gold standard” for animal nutrition in the United States and worldwide.

This pamphlet is based on recommendations from the 2006 release of *Nutrient Requirements of Dogs and Cats*. The report contains useful information for companion animal nutritionists, veterinarians, scientists in industry and academe, regulators, pet owners and anyone with an interest in the health and welfare of these important animals. To order the report, contact the National Academies Press, 500 Fifth Street NW, Washington, DC 20001; (800) 624-6242 or <http://www.nap.edu>.



For more information, contact the Board on Agriculture and Natural Resources (BANR) at **202-334-3062** or visit <http://dels.nas.edu/banr>. BANR is part of the National Academies' Division on Earth and Life Studies. Sign up for the division's free e-mail notifications of new reports, projects, committees, and events at <http://dels.nas.edu>.

THE NATIONAL ACADEMIES™ *Advisers to the Nation on Science, Engineering, and Medicine*

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org

YOUR CAT'S NUTRITIONAL NEEDS

A Science-Based Guide For Pet Owners



NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE DIGESTIVE TRACT

Point of Departure

The mechanical breakdown of food begins in the mouth, where food is ingested, chewed, and swallowed. Chemical breakdown starts here as well, with the secretion of enzyme-laden saliva.

Automatic Transport

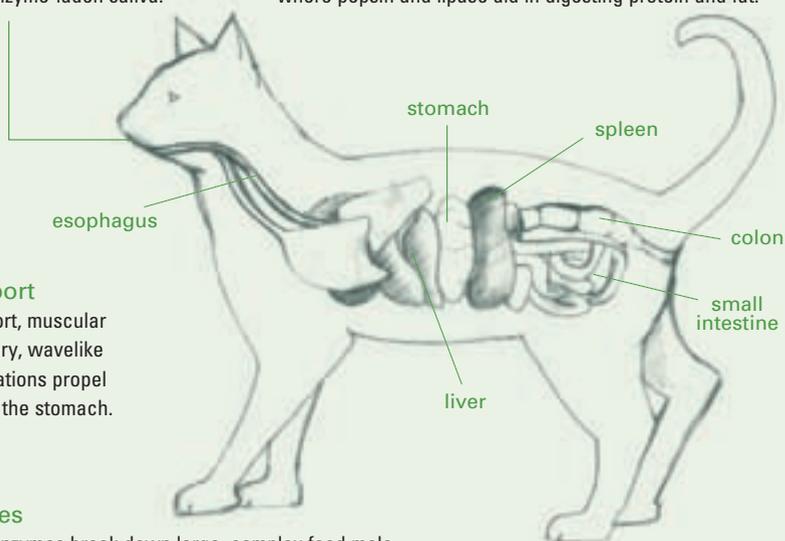
The esophagus is a short, muscular tube in which involuntary, wavelike contractions and relaxations propel food from the mouth to the stomach.

Treatment Facilities

In the small intestine, enzymes break down large, complex food molecules into simpler units that can be absorbed into the bloodstream. The pancreas is an organ that does double duty secreting digestive enzymes into the gut and hormones, including insulin and glucagon, into the blood. Important for fat metabolism, the liver produces bile and partially stores it in the gall bladder between meals.

Storage and Processing

The stomach acts as a temporary storage and processing facility before emptying its contents into the small intestine. Early stages of digestion take place in the stomach, where pepsin and lipase aid in digesting protein and fat.



End of the Line

The primary function of the large intestine is to absorb electrolytes and water. Also, this is where microbes ferment nutrients that have so far escaped digestion and absorption.

COMMITTEE ON NUTRIENT REQUIREMENTS OF DOGS AND CATS

DONALD C. BEITZ, *Chair*, Iowa State University
 JOHN E. BAUER, Texas A&M University
 KEITH C. BEHNKE, Kansas State University
 DAVID A. DZANIS, Dzanis Consulting & Collaborations
 GEORGE C. FAHEY, University Of Illinois
 RICHARD C. HILL, University Of Florida
 FRANCIS A. KALLFELZ, Cornell University
 ELLEN KIENZLE, Zentrum Für Lebensmittel Und Tierernährung, Oberschleissheim, Germany
 JAMES G. MORRIS, University Of California, Davis
 QUINTON R. ROGERS, University Of California, Davis

Support for the development of this pamphlet was provided by the President's Circle Communications Initiative of the National Academies. The pamphlet was written by Dale Feuer based on a report by the Committee on Nutrient Requirements of Dogs and Cats. Illustration and design by Van Nguyen.

Copies of *Nutrient Requirements of Dogs and Cats* are available from the National Academies Press, 500 Fifth Street, NW, Washington, DC, 20001; 800-624-6242 or 202-334-3313 (in the Washington area); <http://www.nap.edu>.

Copyright 2006 by the National Academy of Sciences. All rights reserved.

CONTENTS

Introduction	1
Proteins and Amino Acids	2
Fats and Fatty Acids	3
Energy Needs	4
Vitamins	6
Minerals	8
Feeding Practices	10
Food Choices	12

INTRODUCTION

How much should I feed my cat? Does the food I'm providing meet my cat's nutritional needs? As our knowledge of the relationship between diet and health continues to advance and as the range of foods available for cats continues to expand, it's more important than ever to base feeding choices on good information.

The information in this pamphlet is based on *Nutrient Requirements of Dogs and Cats*, a technical report issued by the National Research Council as part of its Animal Nutrition Series. The Food and Drug Administration relies on information in the report to regulate and ensure the safety of pet foods. Other reports in the series address the nutritional needs of horses, dairy cattle, beef cattle, nonhuman primates, swine, poultry, fish, and small ruminants. Scientists who study the nutritional needs of animals use the Animal Nutrition Series to guide future research. The series is also used by animal owners, caretakers, and veterinarians to develop specialized diets for individual animals. Links to reports in the series can be found at <http://dels.nas.edu/banr>.

Cats need several different kinds of nutrients to survive: **amino acids from protein, fatty acids and carbohydrates, vitamins, minerals, and water.** The tables in this pamphlet provide recommended daily allowances for nutrients based on the amount required to maintain good health in normal cats. Your cat's unique nutritional requirements will depend on its size and its stage in life, among other factors. A better understanding of how cats use the various nutrients in food and how much of them they need can help you choose a healthy diet for your pet.

PROTEINS AND AMINO ACIDS

As carnivorous animals, cats derive most of their protein from meat, fish, and other animal products. Some animal-based protein is easier to digest than plant-based protein and is better suited to the cat's digestive system.

Dietary protein contains 10 specific amino acids that neither cats nor dogs can make on their own. Known as essential amino acids, they provide the building blocks for many important biologically active compounds and proteins. In addition, they provide the carbon chains needed to make glucose for energy. High-quality proteins have a good balance of all of the essential amino acids.

Deficiencies of single essential amino acids can lead to serious health problems. Arginine, for example, is critical to the removal of ammonia from the body through urine. Without sufficient arginine in the diet, cats may suffer from a toxic buildup of ammonia in the bloodstream. Although not the case for dogs, the amino acid taurine is a dietary essential for cats. Taurine deficiency in cats causes a host of metabolic and clinical problems, including feline central retinal degeneration and blindness, deafness, cardiomyopathy and heart failure, inadequate immune response, poor neonatal growth, reproductive failure, and congenital defects. Found abundantly in many fish, birds, and small rodents, taurine is either absent or present only in trace amounts in plants. Strict vegetarian diets are not appropriate for cats unless supplemented with nutrients essential for cats that are not found in plants.



FATS AND FATTY ACIDS

Dietary fats, mainly derived from animal fats and the seed oils of various plants, provide the most concentrated source of energy in the diet. Fats contain more than twice as much energy as protein and carbohydrates per gram. Dietary fats supply essential fatty acids that cannot be synthesized in the body and serve as carriers for important fat-soluble vitamins. Fatty acids play an important role in cell structure and function. Additionally, food fats tend to enhance the taste and texture of a cat's food.

The maximum amount of fat in the cat's diet can be reasonably high without any known adverse effects. In many cat foods, 50% or more of the energy comes from fat. Studies indicate that cat foods containing even higher amounts of fat are safe. At a minimum, cat foods should have a fat content of about 9% of dry matter.

Essential fatty acids are necessary to keep your cat's skin and coat healthy. Deficiencies in the so-called omega-3 family of essential fatty acids can lead to a host abnormalities of the nervous system, ranging from vision problems to impaired learning ability. Another family of essential fatty acids, known as omega-6, has been shown to have important physiological effects in the body. Tissues that perform such functions as storage (fat), metabolism (liver), mechanical work (muscle), and excretion (kidney) tend to have cell membranes in which omega-6 fatty acids predominate.

DAILY RECOMMENDED ALLOWANCES FOR PROTEIN AND FATS

	KITTENS Weighing 1.8 lb	ADULT CAT Weighing 9 lb, consuming 250 Calories	NURSING CATS Weighing 9 lb with 4 kittens
Crude Protein	10 g	12.5 g	41 g
Total Fat	4 g	5.5 g	12 g

Determining Grams of Essential Nutrients from Petfood Labels

Petfood labels do not generally list amounts of essential nutrients in grams. However, all pet food labels must state guarantees for the minimum percentages of crude* protein and crude fat, and the maximum percentages of crude fiber and moisture. To convert these percentages to grams, simply multiply the crude percentages times the weight of your cat's daily portion. For example, if you feed your cat one 6-oz (170-gram) can of food per day, and the food contains 8% crude protein, the grams of protein would be $0.08 \times 170 = 13.6$ grams.

*"Crude" refers to the specific method of testing the product, not to the quality of the nutrient itself.



ENERGY NEEDS

Cats need a certain amount of energy to sustain the normal activities of their daily lives. Growth, pregnancy, lactation, and exercise all increase these normal energy requirements. Generally measured in terms of calories, energy comes from three major dietary components: **carbohydrates, protein, and fats.**

While not essential in the diet, carbohydrates provide an abundant source of energy. The major sources of carbohydrates in commercial cat foods are cereals, legumes, and other plant foodstuffs. Because cats are carnivores, the short length of their long intestines limits their ability to ferment fibers that are found in many carbohydrates.

TIDBIT

Severe illness or trauma may increase a cat's energy needs. Whenever your cat becomes ill, please consult with your veterinarian or cat nutritionist about your cat's changed nutritional needs.

AVERAGE DAILY ENERGY NEEDS

	CALORIES PER DAY (Kilocalories per day*)			
	5 lb	10 lb	15 lb	20 lb
Kittens (after weaning)	200	—	—	—
Lean Domestic Cat	170	280	360	440
Overweight Domestic Cats	180	240	280	310
Exotic (wild) Cats	100–480	170–810	230–1,100	200–1,360
Pregnant/Nursing Cat (4 kittens/4 kittens at peak lactation)	336	603	851	1,091

*1 Calorie = 1 kilocalorie = 1,000 calories. The term Calorie that is used on food nutrition labels is really a “food calorie” sometimes called a “large calorie.” It is equivalent to 1,000 calories (or 1 kilocalorie) as calories are defined scientifically (the amount of energy needed to warm 1 gram of water 1°C). In Nutrient Requirements of Cats and Dogs, energy needs are expressed in terms of kilocalories, which are equivalent to Calories in this document.

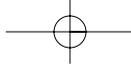
ENERGY NEEDS OF KITTENS

Before weaning, kittens need 20–25 Calories for every 100 grams of body weight. Cat owners should start supplemental feedings from 2.5 to 4 weeks after birth, because mother’s milk is no longer sufficient.

ENERGY NEEDS OF PREGNANT AND LACTATING CATS

New mothers typically suckle their kittens for 7 to 9 weeks and will lose weight while nursing no matter what you feed them. That is why it is important to feed your pregnant cat enough to allow her to increase her body weight by 40–50% by the end of her pregnancy. The energy needs of nursing cats generally increase with litter size and through the fourth week of nursing. As a rule of thumb, nursing mothers with more than two kittens need between 2 and 2.5 times the calories they needed at the time of mating. Lactating cats should be given free access to a highly palatable, high-calorie food.





UNDERWEIGHT



Your cat is not getting enough to eat if it feels “bony” to the touch, has little or no fat on the ribs, and appears to “cave in” just behind the ribs. If chronically underfed, adult cats may experience damage to internal organs, impaired ability to nurse young, and increased susceptibility to bacterial infections and parasites; kittens may be stunted in their growth; adult cats may develop osteoporosis.

IDEAL



Your cat is at an ideal weight if it appears well-proportioned, shows a moderate waistline behind the ribs, and has a thin covering of fat over the ribs and abdomen.

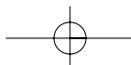
OVERWEIGHT



Your cat is overweight if it has heavy fat deposits over the lumbar area, face, and limbs and if there is an obvious rounding or distension of the abdomen. Obesity occurs in one out of four cats in westernized societies and is more common in older and neutered animals. Health risks include diabetes and osteoarthritis.

VITAMINS

Vitamins are organic compounds that take part in a wide range of metabolic activities. Vitamin deficiencies can cause a variety of health problems. Cats cannot synthesize some vitamins from precursors (pre-vitamin structures) in the diet. For example, they must get all of the vitamin A and niacin they need directly from the food they eat. Deficiencies in vitamin A can adversely affect the health of the eyes. Adult cats deprived of niacin in the diet will lose weight and may die as a result. The diets fed to many cats, especially canned food containing fat-laden fish products, make them more susceptible to deficiencies of certain vitamins, such as vitamin E. Vitamin E, an antioxidant, provides protection against oxidative damage. Some vitamins are not only essential in small doses, but are also toxic in excess amounts. Too much vitamin A, a natural consequence of feeding large amounts of liver to growing kittens, can cause hypervitaminosis A, a condition characterized by a variety of skeletal lesions.



DAILY RECOMMENDED ALLOWANCES FOR VITAMINS

	Functions	Daily Recommended Allowance*	Signs of Deficiency/Excess
Vitamin A	Vision; growth; immune function; fetal development; cellular differentiation	63 µg	Conjunctivitis; cataracts, retinal degeneration and other eye problems; weight loss; muscle weakness; reproductive and developmental disorders Skeletal lesions in kittens, particularly outgrowths of the cervical vertebrae; osteoporosis
Vitamin D	Maintenance of mineral status; skeletal structure; phosphorous balance	0.4 µg	Rickets; abnormalities in skeletal development; progressive paralysis; ataxia; lack of grooming; reduction in body weight and food intake Anorexia; vomiting; lethargy; calcification of soft tissues
Vitamin E	Defense against oxidative damage	2.5 mg	Anorexia; depression; pain sensitivity in abdomen; fat tissue pathology
Vitamin K	Activation of clotting factors, bone proteins, and other proteins	82 µg	Prolonged blood clotting times; hemorrhaging
Vitamin B₁ (thiamin)	Energy and carbohydrate metabolism	0.33 mg	Neurological impairments including altered reflexes and convulsive seizures; heart-rate disorders; pathological changes in the central nervous system; severe learning deficits
Riboflavin	Enzyme functions	0.27 mg	Cataracts; fatty livers; testicular atrophy
Vitamin B₆	Glucose generation; red blood cell function; niacin synthesis; nervous system function; immune response; hormone regulation; gene activation	0.16 mg	Stunted growth; convulsive seizures; kidney lesions
Niacin	Enzyme functions	2.5 mg	Anorexia; weight loss; elevated body temperature; fiery red tongue, with ulceration and congestion
Pantothenic Acid	Energy metabolism	0.4 mg	Stunted growth; fatty changes in liver; small bowel lesions
Vitamin B₁₂	Enzyme functions	1.4 µg	Weight loss; vomiting; diarrhea; intestinal disorders
Folic Acid	Amino acid and nucleotide metabolism; mitochondrial protein synthesis	47 µg	Decreased growth rate; increased iron levels in blood

*Daily needs for an adult cat weighing 9 pounds, consuming 250 Calories per day.
mg = milligram µg = microgram



MINERALS

Twelve minerals are known to be essential nutrients for cats. Calcium and phosphorus are crucial to strong bones and teeth. Cats need other minerals, such as magnesium, potassium, and sodium, for nerve impulse transmission, muscle contraction, and cell signaling. Many minerals that are present only in minute amounts in the body, including selenium, copper, and molybdenum, act as helpers in a wide variety of enzymatic reactions. The requirements for certain minerals may change as your cat ages.

Cats can get too much or too little of a specific mineral in their diets. An excess of dietary magnesium, for instance, has been implicated in the formation of stones in the urinary tract. Foods that maintain relatively low urinary pH levels, however, have been shown to prevent these stones.

DAILY RECOMMENDED ALLOWANCES FOR MINERALS

	Functions	Daily Recommended Allowance*	Signs of Deficiency/Excess
Calcium	Formation of bones and teeth; blood coagulation; nerve impulse transmission; muscle contraction; cell signaling	0.18 g	Nutritional secondary hyperparathyroidism; loss of bone mineral content, which can lead to collapse and curvature of lumbar vertebrae and pelvic bones; bone pain, which can progress to pathological fractures Depressed food intake; decreased growth; increased bone mineral density; increased need for magnesium
Phosphorus	Skeletal structure; DNA and RNA structure; energy metabolism; locomotion; acid-base balance	0.16 g	Hemolytic anemia; locomotor disturbances; metabolic acidosis

Magnesium	Enzyme functions; muscle and nerve-cell membrane stability; hormone secretion and function; mineral structure of bones and teeth	25 mg	Poor growth; overextension of the carpal joints; muscle twitching; convulsions Urinary tract stone formation in the presence of high pH
Sodium	Acid-base balance; regulation of osmotic pressure; nerve impulse generation and transmission	42 mg	Anorexia; impaired growth; excessive thirst and drinking; excessive urination
Potassium	Acid-base balance; nerve-impulse transmission; enzymatic reactions; transport functions	0.33 g	Anorexia; retarded growth; neurological disorders, including ataxia and severe muscle weakness
Chlorine	Acid-base balance; osmolarity of extracellular fluids	60 mg	Increased sodium concentration in renal fluid; excess potassium excretion
Iron	Hemoglobin and myoglobin synthesis; energy metabolism	5 mg	Poor growth; pale mucous membranes; lethargy; weakness; diarrhea Vomiting and diarrhea
Copper	Connective tissue formation; iron metabolism; blood cell formation; melanin pigment formation; myelin formation; defense against oxidative damage	0.3 mg	Reduced weight gain; longer time to conceive
Zinc	Enzyme reactions; cell replication; protein and carbohydrate metabolism; skin function; wound healing	4.6 mg	Skin lesions; growth retardation; testicular atrophy
Manganese	Enzyme functions; bone development; neurological function	0.3 mg	No studies of deficiency in cats
Selenium	Defense against oxidative damage; immune response	19 µg	No studies of deficiency in cats
Iodine	Thyroid hormone synthesis; cell differentiation; growth and development of puppies; regulation of metabolic rate	88 µg	Enlargement of thyroid glands Excessive tearing, salivation, and nasal discharge; dandruff

**Daily needs for an adult cat weighing 9 pounds at maturity, consuming 250 Calories per day.*

FEEDING PRACTICES

Q: Does my cat need to have meat and/or fish products in its diet?

A: Domestic cats are descended from strict meat-eaters, and their behavior reveals their carnivorous nature. When hunting, domestic cats will seek small prey such as mice, birds, and insects. They may even kill and eat a rabbit. They will stop eating a meal of commercial cat food and go off hunting if distracted by potential prey. The particular chemistry and structure of the cat's gastrointestinal system is well-suited to digesting and absorbing nutrients from animal-based proteins and fats. Unsupplemented vegetarian diets can result in harmful deficiencies of certain essential amino acids, fatty acids, and vitamins.

Q: How much fiber is good for my cat?

A: Fiber in the diet is probably good for overall gastrointestinal health and may help overweight cats trim down. Dietary fiber is thought to help maintain proper weight by diluting the caloric density of the food and through physical effects and hormonal interactions. For reasons not yet understood, dietary fiber also seems to help in the management of mild hyperglycemia (high blood sugar), a relatively common problem in older cats.

On the other hand, too much fiber in the diet can decrease the digestibility of other important nutrients. Also, certain features of the cat's intestinal tract, including a relatively small colon and nonfunctional cecum, suggest that cats may not be able to utilize dietary fibers as well as other animals. Meals should not have more than 10% fiber.

Q: How often should I feed and water my cat?

A: If given free access to food, cats will eat between 12 and 20 meals a day, evenly spread out over the 24-hour light–dark cycle. Cats should be fed more than once a day.

Fresh water should be available at all times, but the amount needed varies with the type of diet and the environmental conditions. Cats don't drink as much per kilogram of body weight as do dogs, perhaps because of their evolution as desert animals. Cats will drink approximately 2 milliliters of water for every gram of dry food they eat. Whereas dogs will drink enough water to replace 6% of their body weight in one hour, cats will take 24 hours to do the same. The weak thirst drive of cats puts some cats at higher risk of developing urinary tract stones. While



TIDBIT

Exposure to certain flavors and textures of food early in life can shape strong preferences later on, as can meal temperature, odor, texture, and taste. It's important to gradually mix the familiar food with the new food before switching completely.

they may be better off eating canned cat food, which contains 78–82% water, simply adding water to dry food will also help to protect against stone formation.

Q: How can I help my overweight cat trim down?

A: The most obvious answer is to put less of the same type of food in its bowl each day, still allowing it to eat at all times of the day. This is not the same as letting it eat as much as it wants at all times. About 30 to 40% of cats will overeat and become fat if given this latitude. Some cat owners offer less appealing food. Another option is to feed one of the low-calorie cat foods on the market. It's also important to remember to keep your cat from sampling the cat-next-door's food and to refrain from giving it table scraps.

Q: Is it true that cats are finicky eaters?

A: It is true that taste, texture, and moisture content of food is more important to cats than it is to dogs. Cats will choose foods on the basis of these features rather than nutritional adequacy. That is why it is important for cat owners to make sure their pets are getting the recommended amounts and mix of all of the essential vitamins, minerals, and other nutrients.

In contrast to dogs, cats will not eat a powdered, commercial diet. They will, however, eat the same diet if it is provided as pellets, in a mash, or in gel form. Typically, they like the gel form the best. They are more sensitive to bitter taste than dogs and prefer warm to cold food.



TIDBIT

Cats don't drink as much water as dogs do, perhaps because of their evolution as desert animals.

FOOD CHOICES

Commercial cat foods come in a variety of forms. The most common types are **dry, semimoist, and canned**. The moisture content of these foods ranges from 6 to 10% for dry, 15 to 30% for semi-moist, and 75% for canned. Most canned food has relatively more fat and protein and fewer carbohydrates than dry and semi-moist food, and generally contains much

higher levels of animal products.

Pet food labels must list the percentage of protein, fat, fiber, and water in the food. When reading labels, it is important to remember that what may appear to be a big difference in the amount of a nutrient—for example, 8% protein in a canned cat food vs. 27% protein in a dry cat food—reflects the fact that there is more water in the canned food.

PET FOOD ADDITIVES

Some other substances that might be found in pet foods, which are not required nutrients, are described below:

Chondroprotective agents are used by the body to make cartilage and joint tissues. Although chondroprotective agents may be indicated for selected clinical conditions, widespread inclusion in the diets of healthy populations may not be warranted at this time.

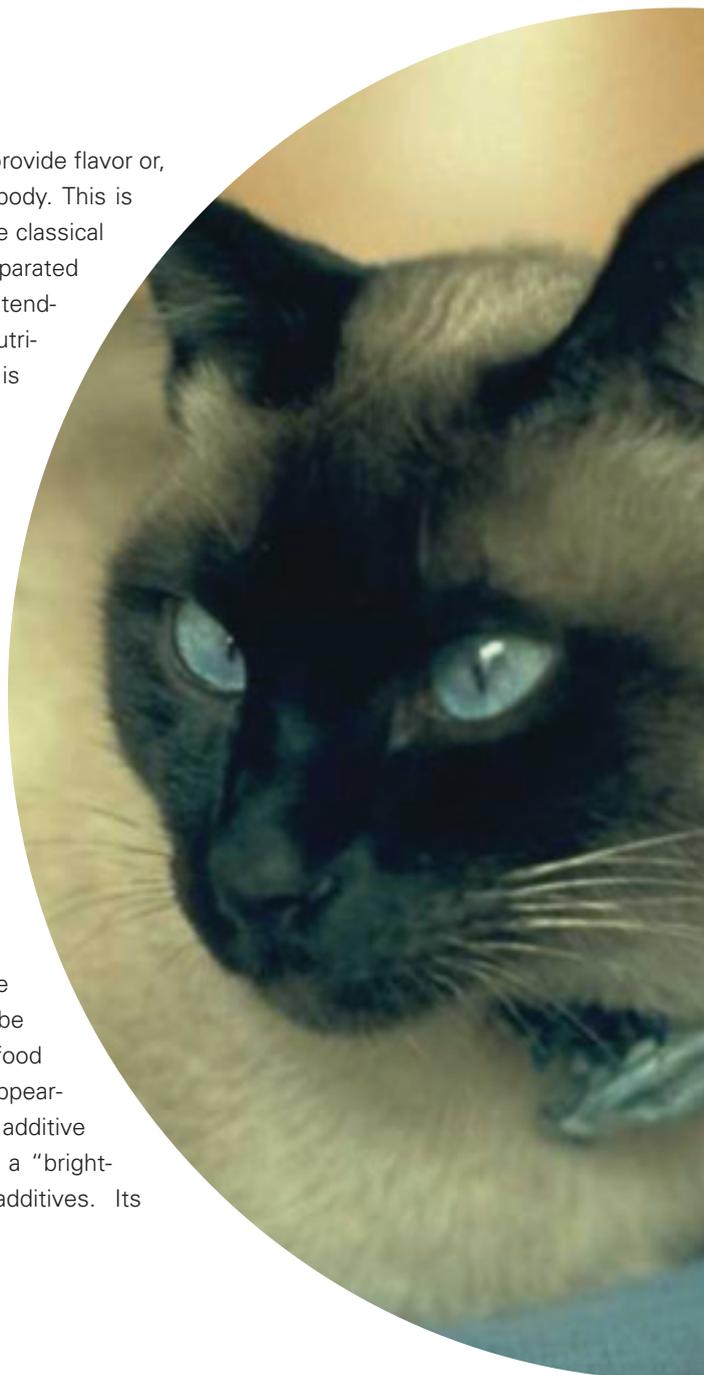
Antioxidants work to prevent oxidative damage to nutrients and other compounds in the body and inhibit or quench the formation of free radicals. At this time, data are lacking to make specific recommendations beyond those for the essential vitamins and minerals that are components of antioxidants.



Herbs and botanicals are used in pet foods to provide flavor or, more often, to have a medicinal effect on the body. This is especially true in the case of extracts, where the classical nutritive components of the plant may be separated from the extract in the process. Because the intended functions are more pharmacologic versus nutritional in nature, discussion of potential benefit is beyond the scope of this publication.

Flavors and extracts derived from animal tissues such as poultry or fish are considered “natural” flavors. A wide variety of flavors can be derived from other animal and plant materials, including dairy products, eggs, herbs, and spices. Acceptable processing methods include roasting, extraction, and fermentation. Except for artificial smoke and bacon flavors, synthetic substances are rarely used in most dog and cat foods.

Colors are synthetic compounds used to replace or accentuate the inherent color of the food. Only certified colors approved for use in human foods are allowed in pet foods. Iron oxide is a synthetic but noncertified color that can be used at levels not to exceed 0.25% of the pet food product to give dog and cat food a red, meaty appearance. Titanium dioxide is another common color additive in human and pet foods because it can induce a “brightness” in foods by complementing other color additives. Its use is limited to 1% of the food by weight.



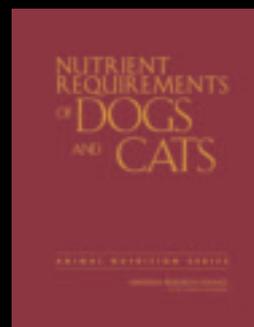
TIDBIT

Pet foods marketed as “snacks” are not required to have nutritional adequacy labels.



For more than 80 years, the National Academies has fostered improved understanding of the nutritional needs of pets, wildlife, laboratory-research species, and food-producing animals through its Nutrient Requirements of Domestic Animals series—a series that is considered the “gold standard” for animal nutrition in the United States and worldwide.

This pamphlet is based on recommendations from the 2006 release of *Nutrient Requirements of Dogs and Cats*. The report contains useful information for companion animal nutritionists, veterinarians, scientists in industry and academe, regulators, pet owners and anyone with an interest in the health and welfare of these important animals. To order the report, contact the National Academies Press, 500 Fifth Street NW, Washington, DC 20001; (800) 624-6242 or <http://www.nap.edu>.



For more information, contact the Board on Agriculture and Natural Resources (BANR) at **202-334-3062** or visit <http://dels.nas.edu/banr>. BANR is part of the National Academies' Division on Earth and Life Studies. Sign up for the division's free e-mail notifications of new reports, projects, committees, and events at <http://dels.nas.edu>.

THE NATIONAL ACADEMIES™

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org



Fédération européenne de l'industrie
des aliments pour animaux familiers

The European Pet Food Industry Federation



Nutritional Guidelines

For Complete and Complementary Pet Food
for Cats and Dogs



TABLE OF CONTENTS

I. Glossary		V. Analytical methods	
1. Definitions.....	05	1. Non-exhaustive list of analytical methods.....	38
II. Introduction		VI. Feeding test protocols	
1. Objectives	09	1. Indicator method	41
2. Scope.....	09	1.1 Introduction	
III. Complete pet food		1.2. Protocol	
1. Guidance.....	11	1.2.1 Animals	
1.1 Minimum recommended nutrient levels in cat and dog foods		1.2.2 Feeding procedures	
1.2 Energy contents of pet foods		1.2.3 Food	
1.3 Maximum levels of certain substances in pet food for cats and dogs		1.2.4 Food allowances	
1.4 Product validation		1.2.5 Times of feeding	
1.5 Repeat analyses		1.2.6 Pre-trial termination	
1.6 Directions for use/feeding instructions		1.2.7 Collection	
		1.2.8 Sample preparation	
		1.2.9 Analytical determination	
		1.2.10 Calculation of digestible energy and digestible nutrients	
		1.2.11 Calculation of metabolizable energy	
2. Tables with nutrient recommendations	14	2. Quantitative collection method	44
2.1 How to read the tables		2.1 Introduction	
2.2 Recommended nutrient levels for dogs		2.2. Protocol	
2.3 Recommended nutrient levels for cats		2.2.1 Animals	
		2.2.2 Feeding procedures	
		2.2.3 Food	
		2.2.4 Food allowances	
		2.2.5 Times of feeding	
		2.2.6 Pre-trial termination	
		2.2.7 Faeces collection	
		2.2.8 Sample preparation	
		2.2.9 Analytical determination	
		2.2.10 Calculation of digestible energy and .. digestible nutrients	
		2.2.11 Calculation of metabolizable energy	
		3. References	48
IV. Complementary pet food			
1. Recommended allowances	37		
2. Validation procedure.....	37		
3. Repeat analyses	37		

VII. Annexes

1. Body Condition Score	49
1.1 Introduction	
1.2 Validated Body Condition Score	
1.3 Practical use and interpretation	
1.4 Conclusion	
1.5 References	
2. Energy	56
2.1 Introduction	
2.2 Energy density of the food	
2.2.1 Gross energy	
2.2.2 Metabolizable energy	
2.3 Literature	
2.3.1 Maintenance Energy Requirements (MER) of adult dogs	
2.3.2 Activity	
2.3.3 Age	
2.3.4 Breed & type	
2.3.5 Thermoregulation and housing	
2.4 Practical recommendations for daily energy intake by dogs and cats in different physiological states	
2.4.1 Dogs	
2.4.2 Cats	
2.5 Impact of energy requirement on product formulation	
2.6 References	
3. Taurine	72
3.1 Introduction	
3.2 Cat	
3.3 Dog	
3.4 Conclusion	
3.5 References	
4. Arginine	75
5. Vitamins.....	76
5.1 Chemical compounds	
5.2 References	
6. Adverse Reactions to Food.....	77
6.1 Introduction	
6.2 Definitions	
6.2.1 Adverse reactions to food	
6.2.2 Food allergy	
6.2.3 Non-allergic food hypersensitivity	
6.2.4 All individuals susceptible if sufficient quantity eaten	
6.3 Food allergy in humans	
6.4 Adverse reactions to food in cats and dogs	
6.5 Conclusions	
6.6 References	

7. Risk of some human foods regularly given to pets.....	81
7.1 Grape and raisin toxicity in dogs	
7.1.1 Background	
7.1.2 Clinical signs and pathology	
7.1.3 Toxic agent	
7.1.4 Treatment	
7.1.5 References	
7.2 Chocolate toxicity	
7.2.1 Background	
7.2.2 Toxic agent	
7.2.3 Clinical signs	
7.2.4 Treatment	
7.2.5 References	
7.3 Toxicity of onions and garlic in cats & dogs	
7.3.1 Background	
7.3.2 Clinical signs and pathology	
7.3.3 Toxic agent	
7.3.4 Treatment	
7.3.5 References	
8. Product families	88
9. Recommended nutrient levels by lifestage and maintenance energy requirement.....	89

VIII. Changes versus previous versions

1. Adaptions in the Nutritional Guidelines 2011	97
2. Adaptions in the Nutritional Guidelines 2012	97
3. Adaptions in the Nutritional Guidelines 2013	98
4. Adaptions in the Nutritional Guidelines 2014.....	99
5. Adaptions in the Nutritional Guidelines 2016.....	100
6. Adaptions in the Nutritional Guidelines 2017.....	101

Disclaimer:

The official document is written in English and the English version of the Web Site is the only version endorsed by FEDIAF. The information contained in this document may be translated to other languages for the convenience of member associations. FEDIAF shall not be responsible for any errors or omissions contained in the translations.

Preface

Nutrition of dogs and cats is central for health and wellbeing. Scientific knowledge about nutrient requirements, digestion of feed and metabolism of nutrients are the guidelines for formulating appropriate diets for dogs and cats. It is therefore important that the composition and nutrient profiles of pet food corresponds to the specific nutritional requirements of dogs and cats in the different life cycles.

The European pet food industry has taken up the task of adapting the recommendations for nutrient levels in pet food in close cooperation with independent scientists. A significant step was initiated in the year 2010, when a Scientific Advisory Board (SAB) with scientists from European countries was installed. The SAB will ensure to maintain the scientific standards of the recommended nutrient levels and it will advise FEDIAF so that latest research results are transferred into the guidelines and the current feeding practice.

Proper nutrition ensuring adequate intakes of energy, protein, minerals and vitamins is essential for dogs and cats to ensure health and longevity. By now these revised nutrient recommendations take the current state of knowledge into account. The recommended values are based on scientific principles and take into account the requirements for practical feeding. This enables the pet food industry to adjust the quality of complete diets for dogs and cats according to the scientific state of the art.

Through ongoing communication, research and critical evaluation of new findings FEDIAF and the SAB work on the adaptation of these recommendations in a continuous process. The scientific SAB has set itself the task to accompany this development and to assist FEDIAF in its commitment to safe and healthy pet food.

Prof. Jürgen Zentek, Chairman of the SAB

Acknowledgement

FEDIAF thanks everyone who has contributed to the quality of these Nutritional Guidelines, especially the Scientific Advisory Board members for reviewing the

Guidelines and for the continuing scientific support to the group.

Scientific Advisory Board:

- Prof. Biagi, Giacomo.....Bologna (IT)
- Dr. Chandler, Marge.....Edinburgh (UK)
- Dr. Dobenecker, BrittaMünchen (DE)
- Prof. Hendriks, WouterWageningen/Utrecht (NL)
- Dr. Hervera, Marta Nantes (FR)
- Prof. Hesta, Myriam.....Gent (BE)
- Prof. Iben, Christine.....Wien (AT)
- Prof. Nguyen, PatrickNantes (FR)
- Prof. Paragon, Bernard.....Maisons-Alfort (FR)
- Dr. Villaverde, Cecilia.....Barcelona (ES)
- Prof. Zentek, Jürgen.....Berlin (DE)

I Glossary

DEFINITIONS

The glossary contains definitions of key words used in this Guideline followed by the source of the

definition. Whenever appropriate, definitions are adapted to pet food.

A

Allowance An Allowance or Recommendation for daily intake (RDI) is the level of intake of a nutrient or food component that appears to be adequate to meet the known nutritional needs of practically all healthy individuals. It reflects the minimum requirement plus a safety margin for differences in availability between individual animals and for nutrient interactions. In practice this would be translated as the levels of essential nutrients that healthy individuals should consume over time to ensure adequate and safe nutrition.^{a, b}

^a *Food and Nutrition Board How should the Recommended Dietary Allowances be Revised? A concept paper from the Food and Nutrition Board Nutrition Reviews 1994; 216-219.*

^b *Uauy-Dagach R, Hertrampf E. Chapter 56 Food-based dietary recommendations: possibilities and limitations. In: Present Knowledge in Nutrition 8th Edit. Bowman BA, Russell RM edits. ILSI Press Washington, DC. 2001 636-649.*

Anaphylaxis Anaphylaxis is an acute life-threatening multi-system allergic reaction resulting from exposure to an offending agent. In people, foods, insect stings, and medication are the most common causes.^{a, b, c}

^a *Tang AW. A practical guide to anaphylaxis. Am Fam Physician 2003; 68 (7): 1325-1332.*

^b *Oswalt M, Kemp SF. Anaphylaxis: office management and prevention Immunol Allergy Clin North Am 2007; 27 (2): 177-191.*

^c *Wang J, Sampson HA. Food Anaphylaxis. Clin Exp Allergy. 2007; 37 (5): 651-660.*

B

Basal metabolic rate (BMR) Is the energy required to maintain homeostasis in an animal in a post-absorptive state (ideally after an overnight fast) that is lying down but awake in a thermo-neutral environment to which it has been acclimatised

Blaxter KL, The minimal metabolism. In: Energy metabolism in animals and man. Cambridge University Press. Cambridge, UK. 1989; 120-146.

Bioavailability The degree to which a nutrient is absorbed and becomes available at the site of action in the body.

Adapted from: Hoag SW, Hussain AS. The impact of formulation on bioavailability: Summary of workshop discussion. J. Nutr. 2001; 131: 1389S-1391S.

C

Complementary pet food Pet food which has a high content of certain substances but which, by

Regulation (EU) No 767/2009 on the placing on the market and use of feed (art. 3 (2.)) adapted to pet food.

reason of its composition, is sufficient for a daily ration only if used in combination with other pet foods.

See also FEDIAF explanation (see chapter IV)

Complete pet food Pet food which, by reason of its composition, is sufficient for a daily ration.

Regulation (EU) No 767/2009 on the placing on the market and use of feed (art. 3 (2.i)) adapted to pet food.

D

Daily ration The average total quantity of feedingstuffs, calculated on a moisture content of 12%, required daily by an animal of a given species, age category and yield, to satisfy all its needs.

Regulation (EU) No 1831/2003 (art. 2 (2.f)).

FEDIAF Explanation

The above-mentioned legal definition means the average total quantity of a specific pet food that is needed daily by a pet of a given species, age category and life style or activity to satisfy all its energy and nutrient requirements

Dietary indiscretion An adverse reaction resulting from such behaviour as gluttony, pica, or ingestion of various indigestible materials or garbage.

Guilford WG. Adverse reactions to foods: A gastrointestinal perspective Compend Contin Educ Pract Vet 1994; 16 (8): 957-969.

Digestible energy (DE) Is the gross energy less the gross energy of faeces resulting from the consumption of that pet food

McDonald P, Edwards RA, Greenhalgh JFD, et al. Digestible energy (DE). In: Animal Nutrition. 7th Edition Pearson Education Ltd. Harlow, England. 2011: 257.

DM Dry Matter

-

Dry pet food Pet food with a moisture content of less than 14%.

Hygienische productie en handel Huisdiervoeders 1997.

E

Extrusion The process by which feed materials are transformed in a tube by a combination of moisture, pressure, heat, and mechanical shear, and which is widely used to produce dry pet food.

Adapted from: Hauck B, Rokey G, Smith O, et al. Extrusion cooking systems. In: Feed Manufacturing Technology IV. McElhiney edit. American Feed Industry Association, Inc. 1994: 131-139.

F

Food allergy Immune-mediated reaction caused by the ingestion of a food or food additive and resulting in one or more of the clinical signs described in ANNEX 5 "Adverse reactions to food".

Halliwel REW Comparative aspects of food intolerance Veterinary Medicine 1992; 87: 893-899.

G

Gross energy Is the total energy arising from complete combustion of a food in a bomb calorimeter.

McDonald P, Edwards RA, Greenhalgh JFD, et al. Gross energy (GE). In: Animal Nutrition. 7th Edition Pearson Education Ltd. Harlow, England. 2011: 255-256.

M

Maintenance energy requirement (MER) Is the energy required to support energy equilibrium, (where ME equals heat production), over a long period of time.

Blaxter k. L., 1989. Energy Metabolism in Animals and Man. Cambridge University Press.

Metabolizable energy (ME) Is the digestible energy less the energy lost in urine and combustible gases.

McDonald P, Edwards RA, Greenhalgh JFD, et al. Metabolisable energy (ME). In: Animal Nutrition. 7th Edition Pearson Education Ltd. Harlow, England. 2011: 258.

Minimum recommended level See allowance for definition

-

N

NRC National Research Council (USA) is a council organised by the US National Academy of Sciences. The NRC ad hoc Committee on dog and cat nutrition has compiled the nutritional requirements for dogs and cats 2006.

www.national-academies.org

Nutrient requirement Is the quantity of a nutrient that must be supplied to an animal in order to satisfy its metabolic needs. It reflects the minimum average level of intake of a nutrient, which, over time, is sufficient to maintain the desired biochemical or physiological functions in a population.

Food and Nutrition Board USA How should the Recommended Dietary Allowances be Revised? A concept paper from the Food and Nutrition Board. Nutrition Reviews, 1994; 52: 216-219.

Nutritional maximum limit This is the maximum level of a nutrient in a complete pet food that, based on scientific data, has not been associated with adverse effects in healthy dogs and cats. Levels exceeding the nutritional maximum may still be safe, however, no scientific data are currently known to FEDIAF.

FEDIAF 2011

P

Pet food Any product produced by a pet food manufacturer, whether processed, partially processed or unprocessed, intended to be ingested by pet animals after placing on the market.

Adapted from Regulation (EC) No. 767/2009.

Pet food safety Is the assurance that, when eaten according to its intended use, the pet food will not cause harm to the pet animal.

EN ISO 22000:2005(E) adapted to pet food.

Pharmacologic reaction An adverse reaction to food as a result of a naturally derived or added chemical that produces a drug-like or pharmacological effect in the host; e.g. methylxanthines in chocolate or a pseudo-allergic reaction caused by high histamine levels in not well-preserved scombroid fish such as tuna.

Guilford WG. Adverse reactions to foods: A gastrointestinal perspective Compend Contin Educ Pract Vet 1994; 16 (8): 957-969.
Halliwell REW Comparative aspects of food intolerance Veterinary Medicine 1992; 87: 893-899.

R

RA Recommended Allowance. See allowance for definition

S

Semi-moist pet food Pet food with a moisture content of 14% or more and less than 60%.

Arnaud P. Actualités technologiques dans l'industrie des aliments pour chiens. Rec. Méd. Vét. 1989; 165 (6-7): 527-535.

W

Wet pet food Pet food with a moisture content of 60% or more.

Hygiënische productie en handel Huisdiervoeders 1997.

II Introduction

FEDIAF represents the national pet food industry associations in the EU and from Bosnia-Herzegovina, Norway, Russia, Serbia and Switzerland, representing in the region of 650 pet food factories across Europe.

One of FEDIAF's main objectives is to ascertain the well-being of pets by providing well balanced and nutritionally sound pet food through its member companies. Therefore FEDIAF has compiled the present **“Nutritional Guidelines for Complete and**

Complementary Pet Food for Cats and Dogs”, which is based on the state of the art knowledge on cat and dog nutrition, providing pet food manufacturers with nutritional recommendations to ensure the production of well balanced and nutritionally sound pet food.

This document is reviewed yearly and updated whenever there are new relevant technological, scientific or legislative developments in pet nutrition.

1. OBJECTIVES

The objectives of FEDIAF's Guidelines for Complete and Complementary Pet Foods for Cats and Dogs are:

- a. To contribute to the production of nutritionally balanced pet food, while complying with relevant EU legislation on animal nutrition. To achieve this objective, the guidelines incorporate up-to-date scientific knowledge on cat and dog nutrition to:
 - Provide practical nutrient recommendations for pet food manufacturers when formulating their products for adult maintenance, growth and reproduction.
 - Help pet food manufacturers to assess the nutritional value of practical pet foods for healthy animals.
- b. To be the reference document on pet nutrition in Europe for EU and local authorities, consumer organisations, professionals, and customers.
- c. To enhance cooperation between pet food manufacturers, pet care professionals and competent authorities by providing scientifically sound information on the formulation and assessment of pet foods.
- d. To complement FEDIAF's Guide to Good Practice for the Manufacture of Safe Pet Foods and the FEDIAF's Guide to Good Practice for Communication on Pet Food.

2. SCOPE

FEDIAF's Nutritional Guidelines provide:

- a. Recommendations for minimum and maximum nutrient levels in commercial pet foods for healthy dogs and cats, to ensure adequate and safe nutrition.
- b. Guidance for the assessment of the nutritional value of pet foods.
- c. Recommendations for energy intake.
- d. Annexes with advice on specific topics:
 - The levels in this guide reflect the amounts of essential nutrients in commercial products that are required to ensure adequate and safe nutrition in healthy individuals when consumed over time.
 - The recommended minimum levels include a safety margin to prevent deficiencies due to animal variations and nutrient interactions.

- These guidelines relate to dog and cat foods manufactured from ingredients with normal digestibility (i.e. $\geq 70\%$ DM digestibility; $\geq 80\%$ protein digestibility) and average bioavailability.
- The maximum recommended nutrient levels are based on EU legal limits (L) or levels that are considered nutritionally safe (N) based on research data.
- Pet foods can be adequate and safe when nutrient levels are outside the recommendations

in this guide, based on the manufacturer's substantiation of nutritional adequacy and safety.

Excluded from the FEDIAF's Nutritional Guidelines are pet foods for particular nutritional purposes and some other specialised foods such as for sporting dogs etc. Therefore specific products may have nutrient levels that are different from those stated in these guidelines.

III Complete Pet Food

1. GUIDANCE

Complete pet food means pet food which, by reason of its composition, is sufficient for a daily ration (Regulation EU No. 767/2009 adapted). When a complete pet food is fed for an extended period (i.e. covering the whole period of the life stage) as the only source of nutrients, it will provide all the nutritional needs of the particular animals of the given species and physiological state for which it is intended.

If a manufacturer labels a product as a complete pet food without specification of a determined life stage, it is assumed to be complete for all life stages, and should be formulated according to the levels recommended for early growth and reproduction. If the product is designed for a specific life stage, then the label must clearly state this. For example “Bloggo” is a complete pet food for breeding cats, or “Bloggo” is a complete pet food for growing puppies.

FEDIAF recommends to all members of each National Association that before a complete pet food is placed on the market:

- a. It should be formulated to take account of current nutritional knowledge and using the data compiled in this guide.
- b. If certain nutrient levels are outside the values stated in this guide, manufacturers should be able to prove that the product provides adequate and safe intakes of all required nutrients.
- c. Each family of products (ANNEX 8) should be validated by chemical analysis of the finished product. It is recommended to use an officially recognised method (Chapter V).

1.1 Minimum recommended nutrient levels in cat and dog foods

The nutrient requirements of cats and dogs are the subject of ongoing research. When formulating pet foods, manufacturers should not use a reference to minimum requirements but minimum recommended levels ensuring adequate nutrient intake as contained in this guide. The nutritional tables are provided in

“units/100g DM” (Tables A1 & B1), “units/1000kcal ME” (Tables A2 & B2) and “units/MJ ME” (Tables A3 & B3).

This FEDIAF Guide is based on published scientific studies (including NRC 2006) and unpublished data from experts in the field.

1.2 Energy contents of pet foods

Feeding trials are the most accurate way to measure the energy density of a cat and dog food (see Chapter VI for the different methods).

A feeding trial normally measures digestible energy. By subtracting the energy lost in the urine, the same trials allow also for determining the metabolizable energy. The energy lost in the urine can be measured if urine is collected or, if urine is not collected, be calculated using the following correction factors: 1.25kcal (5.23kJ)g⁻¹ digestible crude protein for dogs

and 0.86kcal (3.60kJ)g⁻¹ digestible protein for cats (Chapter VI).

Alternatively, formulae given in ANNEX 1 can be used by manufacturers to calculate the energy content of practical diets.

In addition, a bibliographic survey for calculating the energy needs of dogs and cats, in relation to body weight, physiological state and specific activities, is reported in ANNEX 1.

1.3 Maximum levels of certain substances in pet food for cats and dogs

For certain nutrients, FEDIAF has defined a nutritional maximum level in these guidelines. This is the maximum level of a nutrient in a complete pet food that, based on scientific data, has not been associated with adverse effects in healthy dogs and cats. Levels exceeding the nutritional maximum may still be safe, however, no scientific data are currently known to FEDIAF.

Until further scientific data are available FEDIAF recommends that commercial pet foods should not exceed this nutritional maximum.

In addition, maximum permitted levels have been determined by the legislator for several nutrients if added as a nutritional additive (i.e. trace elements & vitamin D) (legal maximum). They are laid down in the Community Register of Feed Additives pursuant to Regulation 1831/2003/EC of the Parliament and the Council, concerning additives in feeding stuffs. The legal maximum levels apply to all life stages

(EU Regulation 1831/2003 in conjunction with EU register of feed additives). A legal maximum only applies when the particular trace-element or vitamin is added to the recipe as an additive, but relates to the 'total' amount present in the finished product [amount coming from the additive + amount from feed materials (ingredients)]. If the nutrient comes exclusively from feed materials, the legal maximum does not apply, instead the nutritional maximum, when included in the relevant tables, should be taken into account.

Both groups of maximum values are reported in the FEDIAF tables III-3_{a-c} and III-4_{a-c} and tables VII-18_{a-d} and VII19_{a-c}. EU legal limits are reported on dry matter basis only to comply with Regulation 1831/2003/EC.

A non-exhaustive list of scientifically recognised analytical methods that can be used to assess the nutrient levels in pet food is available in chapter V.

1.4 Product validation

Before a product is placed on the market, it should have undergone the necessary procedures to ensure its adequacy.

The following nutrients should be taken into consideration for evaluation of nutritional adequacy.

Table III-1. Nutrients

Major nutrients	Protein		
	Fat		
Fatty acids	Linoleic acid	Arachidonic acid (cats)	
	Alpha-linolenic acid	Eicosapentaenoic acid (EPA)	
		Docosahexaenoic acid (DHA)	
Amino acids	Arginine	Histidine	Isoleucine
	Cystine	Tyrosine	Lysine
	Phenylalanine	Threonine	Tryptophan
	Leucine	Methionine	Valine
Minerals	Calcium	Phosphorus	Potassium
	Sodium	Copper	Iron
	Chloride	Magnesium	Iodine
	Manganese	Zinc	Selenium
Vitamins	Vitamin A	Vitamin D	Vitamin E
	Thiamine	Riboflavin	Pantothenic acid
	Niacin	Vitamin B6 (Pyridoxine)	Biotin
	Cobalamin	Folic acid	Vitamin K
Vitamin-like substances	Taurine (cats)	Choline	
Remarks	See section on analytical method pp. for the appropriate method and other details.		
	Routine analysis for energy calculation includes moisture, crude protein, crude fat, crude ash, crude fibre (Weende analysis)		

1.5 Repeat analyses

Once a product has been passed and the formula remains essentially unchanged, continued analyses are recommended to make sure that the product still meets the appropriate nutritional standards and/or truly satisfies its claim of belonging to a family. Deviations may occur due to fluctuations in

raw materials. The frequency of testing is the responsibility of the manufacturer.

If the manufacturer makes a major change in the formulation or processing, complete re-analysis is recommended.

1.6 Directions for use / feeding instructions

The manufacturer is required to provide, as part of the statutory statement, directions for the proper use of a pet food indicating the purpose for which it is intended. The **feeding instructions** should be clear and complete, and give an indication of the daily

amounts to be fed. Feeding instructions could also provide information about the frequency of feeding, the need to have water available, and possible need to adapt the amount according to activity. ANNEX 1 can be used as basis to calculate the amounts to feed.

2. TABLES WITH NUTRIENT RECOMMENDATIONS

2.1 How to read the tables

Values are expressed as follows: recommended minimum value. These values are based on an average daily energy intake of either 95kcal/kg^{0.75} (398kJ/kg^{0.75}) or 110kcal/kg^{0.75} (460kJ/kg^{0.75}) for dogs and either 75kcal/kg^{0.67} (314kJ/kg^{0.67}) or 100kcal/kg^{0.67} (418kJ/kg^{0.67}) for cats.

The maximum nutrient levels are listed in a separate column on the right and are indicated by (N) for nutritional maximum and (L) for legal maximum. Legal maxima in EU legislation are expressed on 12% moisture content and they do not account for energy density. Therefore in these guidelines they are only provided on a dry matter basis.

For commercial dog and cat foods it is recommended that the nutrient levels are at or above the levels listed in the tables and do not exceed the nutritional or legal maximum. If the protein digestibility of $\geq 80\%$ (mentioned in the scope on page 8) cannot be guaranteed, it is recommended to increase the essential amino acid levels by a minimum of 10%.

An asterisk (*) indicates that there is further information in the substantiation section which follows the nutrient recommendations.

The nutritional tables provide nutrient allowances in “units/100g dry matter (DM)”, “units/1000kcal ME” and “units/MJ ME”.

Specific recommendations for nutrient intake during reproduction are only available for a few nutrients. Hence, until more data become available, recommendations in the tables combine early growth and reproduction for dogs, and growth and reproduction for cats. Where there are proven differences between the two life stages both values are stated.

They are declared as follows: **value for growth/ value for reproduction**.

Table III-2. Conversion factors

Units/100g DM	x 2.5	=	units/1000kcal
Units/100g DM	x 0.598	=	units/MJ
Units/1000kcal	x 0.4	=	units/100g DM
Units/1000kcal	x 0.239	=	units/MJ
Units/MJ	x 1.6736	=	units/100g DM
Units/MJ	x 4.184	=	units/1000kcal

These conversions assume an energy density of 16.7kJ (4.0kcal) ME/g DM. For foods with energy densities different from this value, the recommendations should be corrected for energy density.

Tables III-3_{a,b,c}. Recommended nutrient levels for dogs

3 _a	Recommended nutrient levels for dogs: unit per 100g of dry matter (DM)
3 _b	Recommended nutrient levels for dogs: unit per 1000kcal of metabolizable energy (ME)
3 _c	Recommended nutrient levels for dogs: unit per MJ of metabolizable energy (ME)

Tables III-4_{a,b,c}. Recommended nutrient levels for cats

4 _a	Recommended nutrient levels for cats: unit per 100g of dry matter (DM)
4 _b	Recommended nutrient levels for cats: unit per 1000kcal of metabolizable energy (ME)
4 _c	Recommended nutrient levels for cats: unit per MJ of metabolizable energy (ME)

- The nutrient levels in the tables are minimum recommended allowances for commercial pet food, not **minimum** requirements or optimal intake levels
- The right column indicates the maximum recommended value
- The legal **maximum** (L) is mandatory and always applies to all life stages.
- The nutritional maximum (N) is the highest level that is not supposed to cause any harmful effect. Unless the life stage is indicated it applies to all life stages.
- Values for adult cats and dogs in the tables are calculated from NRC (2006) recommendations by assuming a moderate-sized lean adult dog of 15kg bodyweight and a moderate-sized lean adult cat of 4kg bodyweight including a correction for lower energy intake.
- When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter III. 3. 1 and 3.2.

2.2 Recommended nutrient levels for dogs

TABLE III-3_a. Recommended nutrient levels for dogs -
Unit per 100 g dry matter (DM)

Nutrient	UNIT	Minimum Recommended				Maximum	
		Adult - based on MER of		Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	(L) = EU legal limit	
		95 kcal/kg ^{0.75}	110 kcal/kg ^{0.75}			(N) = nutritional	
Protein*	g	21.00	18.00	25.00	20.00	-	
Arginine*	g	0.60	0.52	0.82	0.74	-	
Histidine	g	0.27	0.23	0.39	0.25	-	
Isoleucine	g	0.53	0.46	0.65	0.50	-	
Leucine	g	0.95	0.82	1.29	0.80	-	
Lysine*	g	0.46	0.42	0.88	0.70	Growth:	2.80 (N)
Methionine*	g	0.46	0.40	0.35	0.26	-	
Methionine + cystine*	g	0.88	0.76	0.70	0.53	-	
Phenylalanine	g	0.63	0.54	0.65	0.50	-	
Phenylalanine + tyrosine*	g	1.03	0.89	1.30	1.00	-	
Threonine	g	0.60	0.52	0.81	0.64	-	
Tryptophan	g	0.20	0.17	0.23	0.21	-	
Valine	g	0.68	0.59	0.68	0.56	-	
Fat*	g	5.50	5.50	8.50	8.50	-	
Linoleic acid (ω-6) *	g	1.53	1.32	1.30	1.30	Early Growth:	6.50 (N)
Arachidonic acid (ω-6)	mg	-	-	30.0	30.0	-	
Alpha-linolenic acid (ω-3) *	g	-	-	0.08	0.08	-	
EPA + DHA (ω-3) *	g	-	-	0.05	0.05	-	
Minerals							
Calcium*	g	0.58	0.50	1.00	0.80 ^a 1.00 ^b	Adult:	2.50 (N)
						Early growth:	1.60 (N)
						Late growth:	1.80 (N)
Phosphorus	g	0.46	0.40	0.90	0.70	Adult:	1.60 (N)
Ca / P ratio		1/1				Adult:	2/1 (N)
						Early growth & reprod.:	1.6/1 (N)
						Late growth:	1.8/1 ^a (N) or 1.6/1 ^b (N)
Potassium	g	0.58	0.50	0.44	0.44	-	
Sodium*	g	0.12	0.10	0.22	0.22	c	
Chloride	g	0.17	0.15	0.33	0.33	c	
Magnesium	g	0.08	0.07	0.04	0.04	-	
Trace elements*							
Copper*	mg	0.83	0.72	1.10	1.10	2.80 (L)	
Iodine*	mg	0.12	0.11	0.15	0.15	1.10 (L)	
Iron*	mg	4.17	3.60	8.80	8.80	142.00 (L)	
Manganese	mg	0.67	0.58	0.56	0.56	17.00 (L)	
Selenium*	µg	35.00	30.00	40.00	40.00	56.80 (L) ^d	
Zinc*	mg	8.34	7.20	10.00	10.00	22.70 (L)	
Vitamins							
Vitamin A*	IU	702.00	606.00	500.00	500.00	40 000.00 (N)	
Vitamin D*	IU	63.90	55.20	55.20	50.00	227.00 (L) 320.00 (N)	
Vitamin E*	IU	4.17	3.60	5.00	5.00	-	
Thiamine	mg	0.25	0.21	0.18	0.18	-	
Riboflavin*	mg	0.69	0.60	0.42	0.42	-	
Pantothenic acid	mg	1.64	1.42	1.20	1.20	-	
Vitamin B6 (Pyridoxine)	mg	0.17	0.15	0.12	0.12	-	
Vitamin B12	µg	3.87	3.35	2.80	2.80	-	
Niacin	mg	1.89	1.64	1.36	1.36	-	
Folic acid	µg	29.90	25.80	21.60	21.60	-	
Biotin*	µg	-	-	-	-	-	
Choline	mg	189.00	164.00	209.00	170.00	-	
Vitamin K*	µg	-	-	-	-	-	

a. For puppies of dog breeds with adult body weight up to 15kg, during the whole late growth phase (≥14 weeks)

b. For puppies of breeds with adult body weight over 15kg, until the age of about 6 months. Only after that time, calcium can be reduced to 0.8% DM (2g/1000 kcal or 0.48g/MJ) and the calcium-phosphorus ratio can be increased to 1.8/1.

c. Scientific data show that sodium levels up to 1.5% DM and chloride levels up to 2.35% DM are safe for healthy dogs. Higher levels may still be safe, but no scientific data are available.

d. For organic selenium a maximum supplementation level of 22.73 µg organic Se/100g DM (0.20mg organic Se/kg complete feed with a moisture content of 12%) applies.

TABLE III-3_b.

Recommended nutrient levels for dogs - Unit per 1000kcal of metabolizable energy (ME)

Nutrient	UNIT	Minimum Recommended				Maximum	
		Adult based on MER of		Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	(L) = EU legal limit (given only on DM basis, see table III-3 _a) (N) = nutritional	
		95 kcal/kg ^{0.75}	110 kcal/kg ^{0.75}				
Protein*	g	52.10	45.00	62.50	50.00	-	
Arginine*	g	1.51	1.30	2.04	1.84	-	
Histidine	g	0.67	0.58	0.98	0.63	-	
Isoleucine	g	1.33	1.15	1.63	1.25	-	
Leucine	g	2.37	2.05	3.23	2.00	-	
Lysine*	g	1.22	1.05	2.20	1.75	Growth:	7.00 (N)
Methionine*	g	1.16	1.00	0.88	0.65	-	
Methionine + cystine*	g	2.21	1.91	1.75	1.33	-	
Phenylalanine	g	1.56	1.35	1.63	1.25	-	
Phenylalanine + tyrosine*	g	2.58	2.23	3.25	2.50	-	
Threonine	g	1.51	1.30	2.03	1.60	-	
Tryptophan	g	0.49	0.43	0.58	0.53	-	
Valine	g	1.71	1.48	1.70	1.40	-	
Fat*	g	13.75	13.75	21.25	21.25	-	
Linoleic acid (ω-6) *	g	3.82	3.27	3.25	3.25	Early Growth:	16.25 (N)
Arachidonic acid (ω-6)	mg	-	-	75.00	75.00	-	
Alpha-linolenic acid (ω-3) *	g	-	-	0.20	0.20	-	
EPA + DHA (ω-3) *	g	-	-	0.13	0.13	-	
Minerals							
Calcium*	g	1.45	1.25	2.50	2.00 ^a 2.50 ^b	Adult: Early growth: Late growth:	6.25 (N) 4.00 (N) 4.50 (N)
Phosphorus	g	1.16	1.00	2.25	1.75	Adult:	4.00 (N)
Ca / P ratio		1/1				Adult: Early growth & reprod.: Late growth:	2/1 (N) 1.6/1 (N) 1.8/1 ^a (N) or 1.6/1 ^b (N)
Potassium	g	1.45	1.25	1.10	1.10	-	
Sodium*	g	0.29	0.25	0.55	0.55	c	
Chloride	g	0.43	0.38	0.83	0.83	c	
Magnesium	g	0.20	0.18	0.10	0.10	-	
Trace elements*							
Copper*	mg	2.08	1.80	2.75	2.75	(L)	
Iodine*	mg	0.30	0.26	0.38	0.38	(L)	
Iron*	mg	10.40	9.00	22.00	22.00	(L)	
Manganese	mg	1.67	1.44	1.40	1.40	(L)	
Selenium*	µg	87.00	75.00	100.00	100.00	(L)	
Zinc*	mg	20.80	18.00	25.00	25.00	(L)	
Vitamins							
Vitamin A*	IU	1 754.00	1 515.00	1 250.00	1 250.00	100 000.00 (N)	
Vitamin D*	IU	159.00	138.00	138.00	125.00	(L) 800.00 (N)	
Vitamin E*	IU	10.40	9.00	12.50	12.50	-	
Thiamine	mg	0.62	0.54	0.45	0.45	-	
Riboflavin*	mg	1.74	1.50	1.05	1.05	-	
Pantothenic acid	mg	4.11	3.55	3.00	3.00	-	
Vitamin B6 (Pyridoxine)	mg	0.42	0.36	0.30	0.30	-	
Vitamin B12	µg	9.68	8.36	7.00	7.00	-	
Niacin	mg	4.74	4.09	3.40	3.40	-	
Folic acid	µg	74.70	64.50	54.00	54.00	-	
Biotin*	µg	-	-	-	-	-	
Choline	mg	474.00	409.00	425.00	425.00	-	
Vitamin K*	µg	-	-	-	-	-	

a. For puppies of dog breeds with adult body weight up to 15kg, during the whole late growth phase (≥14 weeks)

b. For puppies of breeds with adult body weight over 15kg, until the age of about 6 months. Only after that time, calcium can be reduced to 0.8% DM (2g/1000 kcal or 0.48g/MJ) and the calcium-phosphorus ratio can be increased to 1.8/1.

c. Scientific data show that sodium levels up to 3.75g/1000kcal and chloride levels up to 5.87g/1000kcal are safe for healthy dogs. Higher levels may still be safe, but no scientific data are available.

TABLE III-3_c.

Recommended nutrient levels for dogs - Unit per MJ of metabolizable energy (ME)

Nutrient	UNIT	Minimum Recommended				Maximum
		Adult based on MER of		Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	(L) = EU legal limit (given only on DM basis, see table III-3 _a) (N) = nutritional
		95 kcal/kg ^{0.75}	110 kcal/kg ^{0.75}			
Protein*	g	12.50	10.80	14.94	11.95	-
Arginine*	g	0.36	0.31	0.49	0.44	-
Histidine	g	0.16	0.14	0.23	0.15	-
Isoleucine	g	0.32	0.27	0.39	0.30	-
Leucine	g	0.57	0.49	0.77	0.48	-
Lysine*	g	0.29	0.25	0.53	0.42	Growth: 1.67 (N)
Methionine*	g	0.28	0.24	0.21	0.16	-
Methionine + cystine*	g	0.53	0.46	0.42	0.32	-
Phenylalanine	g	0.37	0.32	0.39	0.30	-
Phenylalanine + tyrosine*	g	0.62	0.53	0.78	0.60	-
Threonine	g	0.36	0.31	0.48	0.38	-
Tryptophan	g	0.12	0.10	0.14	0.13	-
Valine	g	0.41	0.35	0.41	0.33	-
Fat*	g	3.29	3.29	5.08	5.08	-
Linoleic acid (ω-6) *	g	0.91	0.79	0.78	0.78	Early Growth: 3.88 (N)
Arachidonic acid (ω-6)	mg	-	-	17.90	17.90	-
Alpha-linolenic acid (ω-3) *	g	-	-	0.05	0.05	-
EPA + DHA (ω-3) *	g	-	-	0.03	0.03	-
Minerals						
Calcium*	g	0.35	0.30	0.60	0.48 ^a 0.60 ^b	Adult: 1.49 (N) Early growth: 0.96 (N) Late growth: 1.08 (N)
Phosphorus	g	0.28	0.24	0.54	0.42	Adult: 0.96 (N)
Ca / P ratio		1/1				Adult: 2/1 (N) Early growth & reprod.: 1.6/1 (N) Late growth: 1.8/1 ^a (N) or 1.6/1 ^b (N)
Potassium	g	0.35	0.30	0.26	0.26	-
Sodium*	g	0.07	0.06	0.13	0.13	^c
Chloride	g	0.10	0.09	0.20	0.20	^c
Magnesium	g	0.05	0.04	0.02	0.02	-
Trace elements*						
Copper*	mg	0.50	0.43	0.66	0.66	(L)
Iodine*	mg	0.07	0.06	0.09	0.09	(L)
Iron*	mg	2.49	2.15	5.26	5.26	(L)
Manganese	mg	0.40	0.34	0.33	0.33	(L)
Selenium*	µg	21.00	17.90	23.90	23.90	(L)
Zinc*	mg	4.98	4.30	5.98	5.98	(L)
Vitamins						
Vitamin A*	IU	419.00	362.00	299.00	299.00	23 900 (N)
Vitamin D*	IU	38.20	33.00	33.00	29.90	(L) 191.00 (N)
Vitamin E*	IU	2.49	2.20	3.00	3.00	-
Thiamine	mg	0.15	0.13	0.11	0.11	-
Riboflavin*	mg	0.42	0.36	0.25	0.25	-
Pantothenic acid	mg	0.98	0.85	0.72	0.72	-
Vitamin B6 (Pyridoxine)	mg	0.10	0.09	0.07	0.07	-
Vitamin B12	µg	2.31	2.00	1.67	1.67	-
Niacin	mg	1.13	0.98	0.81	0.81	-
Folic acid	µg	17.90	15.40	12.90	12.90	-
Biotin*	µg	-	-	-	-	-
Choline	mg	113.00	97.80	102.00	102.00	-
Vitamin K*	µg	-	-	-	-	-

a. For puppies of dog breeds with adult body weight up to 15kg, during the whole late growth phase (≥14 weeks)

b. For puppies of breeds with adult body weight over 15kg, until the age of about 6 months. Only after that time, calcium can be reduced to 0.8% DM (2g/1000 kcal or 0.48g/MJ) and the calcium-phosphorus ratio can be increased to 1.8/1.

c. Scientific data show that sodium levels up to 0.89g/MJ and chloride levels up to 1.40g/MJ are safe for healthy dogs. Higher levels may still be safe, but no scientific data are available.

2.3 Recommended nutrient levels for cats

TABLE III-4_a Recommended nutrient levels for cats - Unit per 100g dry matter (DM)

Nutrient	UNIT	Minimum Recommended			Maximum	
		Adult based on MER of		Growth & Reproduction	(L) = EU legal limit	
		75 kcal/kg ^{0.67}	100 kcal/kg ^{0.67}		(N) = nutritional	
Protein*	g	33.30	25.00	28.00 / 30.00	-	
Arginine*	g	1.30	1.00	1.07 / 1.11	Growth:	3.50 (N)
Histidine	g	0.35	0.26	0.33	-	
Isoleucine	g	0.57	0.43	0.54		
Leucine	g	1.36	1.02	1.28		
Lysine*	g	0.45	0.34	0.85		
Methionine*	g	0.23	0.17	0.44	Growth:	1.30 (N)
Methionine + cystine*	g	0.45	0.34	0.88		
Phenylalanine	g	0.53	0.40	0.50		
Phenylalanine + tyrosine*	g	2.04	1.53	1.91		
Threonine	g	0.69	0.52	0.65		
Tryptophan*	g	0.17	0.13	0.16	Growth:	1.70 (N)
Valine	g	0.68	0.51	0.64		
Taurine (canned pet food)*	g	0.27	0.20	0.25		
Taurine (dry pet food)*	g	0.13	0.10	0.10		
Fat*	g	9.00	9.00	9.00		
Linoleic acid (ω-6) *	g	0.67	0.50	0.55		
Arachidonic acid (ω-6)	mg	8.00	6.00	20.00		
Alpha-linolenic acid (ω-3) *	g	-	-	0.02		
EPA + DHA (ω-3) *	g	-	-	0.01		
Minerals						
Calcium*	g	0.79	0.59	1.00		
Phosphorus	g	0.67	0.50	0.84		
Ca / P ratio			1/1		Growth:	1.5/1 (N)
					Adult:	2/1 (N)
Potassium	g	0.80	0.60	0.60		
Sodium*	g	0.10 ^a	0.08 ^a	0.16 ^a		
Chloride	g	0.15	0.11	0.24	2.25 (N)	
Magnesium	g	0.05	0.04	0.05		
Trace elements*						
Copper*	mg	0.67	0.50	1.00	2.80 (L)	
Iodine*	mg	0.17	0.13	0.18	1.10 (L)	
Iron*	mg	10.70	8.00	8.00	142.00 (L)	
Manganese	mg	0.67	0.50	1.00	17.00 (L)	
Selenium	µg	40.00	30.00	30.00	56.80 (L) ^b	
Zinc	mg	10.00	7.50	7.50	22.70 (L)	
Vitamins						
Vitamin A*	IU	444.00	333.00	900.00	Adult & Growth:	40 000.00 (N)
					Reproduction:	33 333.00 (N)
Vitamin D*	IU	33.30	25.00	28.00	227.00 (L)	
					3 000.00 (N)	
Vitamin E*	IU	5.07	3.80	3.80		
Thiamine	mg	0.59	0.44	0.55		
Riboflavin*	mg	0.42	0.32	0.32		
Pantothenic acid	mg	0.77	0.58	0.57		
Vitamin B6 (Pyridoxine)*	mg	0.33	0.25	0.25		
Vitamin B12	µg	2.35	1.76	1.80		
Niacin	mg	4.21	3.20	3.20		
Folic acid	µg	101.00	75.00	75.00		
Biotin*	µg	8.00	6.00	7.00		
Choline	mg	320.00	240.00	240.00		
Vitamin K*	µg	-	-	-		

a Scientific data show that sodium levels up to 1.5% DM are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.

b. For organic selenium a maximum supplementation level of 22.73 µg organic Se/100g DM (0.20mg organic Se/kg complete feed with a moisture content of 12%) applies.

TABLE III-4_b. Recommended nutrient levels for cats - Unit per 1000kcal of metabolizable energy (ME)

Nutrient	UNIT	Minimum Recommended			Maximum	
		Adult based on MER of		Growth & Reproduction	(L) = EU legal limit (given only on DM basis, see table III-4 _a) (N) = nutritional	
		75 kcal/kg ^{0.67}	100 kcal/kg ^{0.67}			
Protein*	g	83.30	62.50	70.00 / 75.00	-	
Arginine*	g	3.30	2.50	2.68 / 2.78	Growth:	8.75 (N)
Histidine	g	0.87	0.65	0.83	-	
Isoleucine	g	1.44	1.08	1.35		
Leucine	g	3.40	2.55	3.20		
Lysine*	g	1.13	0.85	2.13		
Methionine*	g	0.57	0.43	1.10	Growth:	3.25 (N)
Methionine + cystine*	g	1.13	0.85	2.20		
Phenylalanine	g	1.33	1.00	1.25		
Phenylalanine + tyrosine*	g	5.11	3.83	4.78		
Threonine	g	1.73	1.30	1.63		
Tryptophan*	g	0.44	0.33	0.40	Growth:	4.25 (N)
Valine	g	1.70	1.28	1.60		
Taurine (canned pet food)*	g	0.67	0.50	0.63		
Taurine (dry pet food)*	g	0.33	0.25	0.25		
Fat*	g	22.50	22.50	22.50		
Linoleic acid (ω-6) *	g	1.67	1.25	1.38		
Arachidonic acid (ω-6)	mg	20.00	15.00	50.00		
Alpha-linolenic acid (ω-3) *	g	-	-	0.05		
EPA + DHA (ω-3) *	g	-	-	0.03		
Minerals						
Calcium*	g	1.97	1.48	2.50		
Phosphorus	g	1.67	1.25	2.10		
Ca / P ratio			1/1		Growth:	1.5/1 (N)
					Adult:	2/1 (N)
Potassium	g	2.00	1.50	1.50		
Sodium*	g	0.25 ^a	0.19 ^a	0.40 ^a		
Chloride	g	0.39	0.29	0.60		
Magnesium	g	0.13	0.10	0.13		
Trace elements*						
Copper*	mg	1.67	1.25	2.50	(L)	
Iodine*	mg	0.43	0.33	0.45	(L)	
Iron*	mg	26.70	20.00	20.00	(L)	
Manganese	mg	1.67	1.25	2.50	(L)	
Selenium	µg	100.00	75.00	75.00	(L)	
Zinc	mg	25.00	18.80	18.80	(L)	
Vitamins						
Vitamin A*	IU	1111.00	833.00	2250.00	Adult & Growth: Reproduction:	100 000 (N) 83 325 (N)
Vitamin D*	IU	83.30	62.50	70.00	(L) 7 500 (N)	
Vitamin E*	IU	12.70	9.50	9.50		
Thiamine	mg	1.47	1.10	1.40		
Riboflavin*	mg	1.05	0.80	0.80		
Pantothenic acid	mg	1.92	1.44	1.43		
Vitamin B6 (Pyridoxine)*	mg	0.83	0.63	0.63		
Vitamin B12	µg	5.87	4.40	4.50		
Niacin	mg	10.50	8.00	8.00		
Folic acid	µg	253.00	188.00	188.00		
Biotin*	µg	20.00	15.00	17.50		
Choline	mg	800.00	600.00	600.00		
Vitamin K*	µg	-	-	-		

^a Scientific data show that sodium levels up to 3.75g/1000kcal ME are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.

TABLE III-4_c. Minimum recommended nutrient levels for cats –
Unit per MJ of metabolizable energy (ME)

Nutrient	UNIT	Minimum Recommended			Maximum	
		Adult based on MER of		Growth & Reproduction	(L) = EU legal limit (given only on DM basis, see table III-4 _a) (N) = nutritional	
		75 kcal/kg ^{0.67}	100 kcal/kg ^{0.67}			
Protein*	g	19.92	14.94	16.73 / 17.93	-	
Arginine*	g	0.80	0.60	0.64/1.00	Growth:	2.09 (N)
Histidine	g	0.21	0.16	0.20	-	
Isoleucine	g	0.35	0.26	0.32		
Leucine	g	0.81	0.61	0.76		
Lysine*	g	0.27	0.20	0.51		
Methionine*	g	0.14	0.10	0.26	Growth:	0.78 (N)
Methionine + cystine*	g	0.27	0.20	0.53		
Phenylalanine	g	0.32	0.24	0.30		
Phenylalanine + tyrosine*	g	1.23	0.92	1.14		
Threonine	g	0.41	0.31	0.39		
Tryptophan*	g	0.11	0.08	0.10	Growth:	1.02 (N)
Valine	g	0.41	0.31	0.38		
Taurine (canned pet food)*	g	0.16	0.12	0.15		
Taurine (dry pet food)*	g	0.08	0.06	0.06		
Fat*	g	5.38	5.38	5.38		
Linoleic acid (ω-6) *	g	0.40	0.30	0.33		
Arachidonic acid (ω-6)	mg	4.78	3.59	11.95		
Alpha-linolenic acid (ω-3) *	g	-	-	0.01		
EPA + DHA (ω-3) *	g	-	-	0.01		
Minerals						
Calcium*	g	0.47	0.35	0.60		
Phosphorus	g	0.40	0.30	0.50		
Ca / P ratio			1/1		Growth:	1.5/1 (N)
					Adult:	2/1 (N)
Potassium	g	0.48	0.36	0.36		
Sodium*	g	0.06 ^a	0.05 ^a	0.10 ^a		
Chloride	g	0.09	0.07	0.14		
Magnesium	g	0.03	0.02	0.03		
Trace elements*						
Copper*	mg	0.40	0.30	0.60		(L)
Iodine*	mg	0.10	0.078	0.11		(L)
Iron*	mg	6.37	4.78	4.78		(L)
Manganese	mg	0.40	0.30	0.60		(L)
Selenium	µg	23.9	17.9	17.9		(L)
Zinc	mg	5.98	4.48	4.48		(L)
Vitamins						
Vitamin A*	IU	265.00	199.00	538.00	Adult & Growth: Reproduction:	23 901.00 (N) 19 917.00 (N)
Vitamin D*	IU	19.90	14.90	16.70		(L) 1 793.00 (N)
Vitamin E*	IU	3.03	2.30	2.30		
Thiamine	mg	0.35	0.26	0.33		
Riboflavin*	mg	0.25	0.19	0.24		
Pantothenic acid	mg	0.46	0.34	0.34		
Vitamin B6 (Pyridoxine)*	mg	0.20	0.15	0.15		
Vitamin B12	µg	1.40	1.05	1.08		
Niacin	mg	2.52	1.91	1.91		
Folic acid	µg	60.50	44.90	44.90		
Biotin*	µg	4.78	3.59	4.18		
Choline	mg	191.00	143.00	143.00		
Vitamin K*	µg	-	-	-		

a Scientific data show that sodium levels up to 0.90g/MJ ME are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.

3. COMPLETE PET FOOD (CONT'D.) – SUBSTANTIATION OF NUTRIENT RECOMMENDATIONS' TABLES

The following section provides substantiation and explanation for the recommended allowances (RA) (nutrient recommendations) for dogs and cats in the

previous tables. These recommendations are based on scientific publications, NRC 2006 and unpublished data from experts in the field

3.1 Substantiation of nutrient recommendations for dogs

GENERAL

Amino acids, trace elements, vitamins (Adult dogs) Unless indicated with an * and substantiated hereafter, the values recommended for adult dogs are the levels recommended by NRC 2006 increased by 20% to compensate for the lower energy requirement of household dogs (see ANNEX 1) compared to the energy intake assumed by NRC. ^a

^a NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 359-360, table 15-4.

PROTEIN

Total protein

Total protein (Adult dogs) The RA by NRC-2006 of 25g/1000kcal (6g/MJ) for adult dogs is based on Sanderson et al. ^a However, the diet in this study had a high protein digestibility and the energy intake was around 130kcal (550kJ)/kgBW^{0.75}.

^a Sanderson SL, Gross KL, Ogburn PN, et al. (2001) Effects of dietary fat and L-carnitine on plasma and whole blood taurine concentrations and cardiac function in healthy dogs fed protein-restricted diets. *Am. J. Vet. Res.* 62: 1616-1623.

^b Williams CC, Cummins KA, Hayek MG, Davenport GM. Effects of dietary protein on whole-body protein turnover and endocrine function in young-adult and aging dogs. *J. Anim. Sci.* 2001; 79: 3128-3136.

^c Finco DR, Brown SA, Crowell WA, et al. Effects of aging and dietary protein intake on uninephrectomized geriatric dogs. *Am. J. Vet. Res.* 1994; 55: 1282-1290.

FEDIAF protein levels are based on NRC (2006) recommendations, but have been adjusted to take into account i) an apparent crude protein digestibility of 80%, ii) lower energy intakes for dogs and iii) requirements of older dogs. ^{b,c}

If formulating below the recommended minimum for total protein it is particularly important to ensure that the amino acid profile meets FEDIAF guidelines for adult maintenance.

Total protein (Reproduction) The recommendation for protein assumes the diet contains some carbohydrate to decrease the risk of hypoglycaemia in the bitch and neonatal mortality. If carbohydrate is absent or at a very low level, the protein requirement is much higher, and may be double. ^{a,b,c}

^a Romsos DR, Palmer HJ, Muiruri KL, et al. Influence of a low carbohydrate diet on performance of pregnant and lactating dogs. *J. Nutr.* 1981; 111: 678-689.

^b Kienzle E, Meyer H, Lorie H. Einfluß kohlenhydratfreier Rationen mit unterschiedlichen Protein / Energie-Relationen auf foetale Entwicklung und Vitalität von Welpen sowie die Milchzusammensetzung von Hündinnen. *Fortschnitte in der Tierphysiologie und Tierernährung.* 1985; Suppl. 16: 73-99.

^c Kienzle E, Meyer H. The effects of carbohydrate-free diets containing different levels of protein on reproduction in the bitch. In: *Nutrition of the dog and cat.* Burger IH, Rivers JPW edits. Cambridge University Press Cambridge, UK. 1989: pp. 229-242.

Total protein (Growth) For practical foods made from cereals and various animal by-products, the crude protein level needed for maximum nitrogen retention appears to be about 25 per cent dry matter for newly weaned puppies, whereas for puppies over 14 weeks of age it is 20 per cent dry matter. ^a

^a NRC. Nitrogen (Crude Protein) minimum requirements, recommended allowances, and adequate intakes In: *Nutrient Requirements of Dogs and Cats.* The National Academic Press, Washington, DC. 2006: pp. 116-120.

Arginine

Arginine (All life stages) The arginine requirement increases with increased protein content owing to its role as an intermediate in the urea cycle. For every gram of crude protein above the stated values, an additional 0.01g of arginine is required. ^a See ANNEX 3.

^a NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats.* The National Academic Press, Washington, DC. 2006: pp. 357-363 tables 15-3, 15-5 and 15-8..

Lysine

Lysine (nutritional maximum for puppies) Czarnecki et al. (1985) ^a showed that excess dietary lysine (4.91% DM [basal diet 0.91% + 4% from a supplement]) decreases weight gain in puppies but not 2.91 % DM (basal diet + 2% from a supplement).

^a Czarnecki GL, Hirakawa DA, Baker DH. (1985) Antagonism of arginine by excess dietary lysine in the growing dog. *J. Nutr.* 1985; 111: 743-752.

It was concluded that the highest no-effect-level of lysine for puppies was 2.91% DM (energy density 4156kcal/kg or 17.39MJ/kg). This is equivalent to 7.0g/1000kcal (1.67g/MJ) or 2.8% DM (at 4kcal/g DM) and this is therefore the FEDIAF maximum for puppy growth.

Methionine-cystine

Methionine-cystine (Adult dogs) The recommended values are based on a dog food containing a very low taurine content, i.e. <100mg/kg dry matter. ^a For products containing higher levels of taurine the RA for sulphur amino acids can be lower than the values quoted in the table. For further information see taurine section ANNEX 2.

Methionine In the case of lamb and rice foods, the methionine level may have to be increased. ^a

Cystine Sulphur amino acid requirements of cats (Teeter et al., 1978) and dogs (Blaza et al., 1982) have been determined through studies using methionine and cystine. Cystine is a dimer of cysteine, during analysis, cystine and cysteine are both determined as cysteic acid in hydrolysates of oxidised sample, but calculated as cystine. ^{a, b}

^a Sanderson SL, Gross KL, Ogburn PN, et al. (2001) Effects of dietary fat and L-carnitine on plasma and whole blood taurine concentrations and cardiac function in healthy dogs fed protein-restricted diets. *Am. J. Vet. Res.* 62: 1616-1623.

^a For details and references see ANNEX 2 – taurine.

^a Blaza SE, Burger IH, Holme DW, Kendall PT. Sulfur-containing amino acid requirements of growing dogs. *J Nutr.* 1982 Nov; 112(11): 2033-42.

^b Teeter RG, Baker DH, Corbin JE. Methionine and cystine requirements of the cat. *J Nutr.* 1978 Feb; 108(2): 291-5.

Tyrosine

Tyrosine (All life stages) For maximisation of black hair colour, the tyrosine content may need to be 1.5 to 2 times higher than the amount stated. ^{a, b}

^a NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats.* The National Academic Press, Washington, DC. 2006: pp. 357-363 tables 15-3, 15-5 and 15-8.

^b Biourge V., R. Sergheraert (2002). Hair pigmentation can be affected diet in dogs. *Proc. Comp. Nutr. Soc. Number 4, Kirk-Baer, C.L., 103-104.*

FAT

Total fat

Total fat (All life stages) Dogs fed foods containing normal levels of protein tolerate very high levels of fat (e.g. sled dogs). However very high fat foods with very low protein content have been linked with adverse effects in dogs. ^a

^a Lindsay S, Entenman C, Chaikoff IL. Pancreatitis accompanying hepatic disease in dogs fed a high fat, low protein diet. *Arch. Path.* 1948; 45: 635-638.

Fat per se is not essential and as long as the minimum recommendation for all essential fatty acids is met or exceeded there is no risk of nutritional deficiency. Therefore the minimum recommendation for total fat in adult dogs with a MER of 95kcal/kg BW^{0.75} has not been adjusted for energy intake versus the recommendation for adult dogs with a MER of 110kcal/kgBW^{0.75}.

Omega 3 and 6 fatty acids

Omega-3 and Omega-6 poly-unsaturated long chain fatty acids (Growth & Reproduction) During gestation and early life after birth, DHA and arachidonic acid (AA) are selectively accumulated within the brain and retina. ^f Supplementation with α -linolenic acid (ALA) and linoleic acid during gestation and lactation is an ineffective means of increasing the milk content of DHA and AA respectively. ^a Although very young puppies have the capacity to convert some ALA into DHA, after weaning puppies lose this capacity. ^c

Moreover, electroretinograms have revealed improved vision in puppies from mothers fed n-3 long chain poly-unsaturated fatty acids and fed the same food after weaning. ^{b, d, e} Consequently it is preferable to have small amounts of DHA and/or EPA, as well as AA in foods for growth and reproduction to supply enough for neonatal nutritional modifications.

Omega 3 fatty acids (Adult dogs) Although there is increasing evidence of beneficial effects of omega-3 fatty acids, the current information is insufficient to recommend a specific level of omega-3 fatty acids for adult dogs.

Omega 3 vs. 6 FA (Adult dogs) The effects of omega-3 fatty acids depend on the level as well as on the ratio of omega-6 to omega-3 fatty acids. Very high levels of long chain omega-3 fatty acids can decrease cellular immunity, particularly in the presence of a low level of omega-6 fatty acids. ^{a, b}

^a Bauer JE, Heinemann KM, Bigley KE, et al. Maternal diet alpha-linolenic acid during gestation and lactation does not increase docosahexaenoic acid in canine milk. *J. Nutr.* 2004; 134 (8S): 2035S-2038S.

^b Bauer J, Heinemann KM, Lees GE, Waldron MK. Retinal functions of young dogs are improved and maternal plasma phospholipids are altered with diets containing long-chain n-3 PUFA during gestation, lactation and after weaning. *J. Nutr.* 2006; 136: 1991S-1994S.

^c Bauer JE, Heinemann KM, Lees GE, Waldron MK. Docosahexaenoic acid accumulates in plasma of canine puppies raised on α -linolenic acid-rich milk during suckling but not when fed α -linolenic acid-rich diets after weaning. *J. Nutr.* 2006; 136: 2087S-2089S.

^d Heinemann KM, Waldron MK, Bigley KE, et al. Long-Chain (n-3) Polyunsaturated fatty acids are more efficient than α -linolenic acid in improving electroretinogram responses of puppies exposed during gestation, lactation, and weaning. *J. Nutr.* 2005; 135: 1960-1966.

^e Heinemann KM, Waldron MK, Bigley KE, Bauer JE. Improvement of retinal function in canine puppies from mothers fed dietary long chain n-3 polyunsaturated fatty acids during gestation and lactation. *J Vet Int Med* 2005; 19 (3): 442-443, Abstr. 155.

^f Heinemann KM, Bauer JE. *Timely Topics in Nutrition - Docosahexaenoic acid and neurologic development in animals.* *J. Am Vet Med Assoc* 2006; 228 (5): 700-705.

NRC 2006

^a Effect of dietary n-6-to n-3 fatty acid ratio on complete blood and total white blood cell counts, and T-cell subpopulations in aged dogs. *Am. J. Vet. Res.* 1999; 60 (3): 319-327.

^b Wander RC, Hall JA, Gradin JL, et al. The ratio of dietary (n-6) to (n-3) fatty acids influences immune system function, eicosanoid metabolism, lipid peroxidation and vitamin E in aged dogs. *J Nutr* 1997; 127: 1198-1997.

MINERALS

Calcium

Calcium (Adult dogs) As the calcium level approaches the stated nutritional maximum, it may be necessary to increase the levels of certain trace elements such as zinc and copper.

Calcium (RA for puppies) A calcium level of 0.8g/100g DM has been shown to be adequate for growing dogs.^{a, b, c, f} However, this level has been reported to be marginal for some breeds^{d, e} particularly during the fast growing phase (particularly breeds with lower energy requirements).

After comparing all the data^g, FEDIAF recommends that the calcium level in a pet food for early growth should be at least 1g/100g DM. During late growth, it is recommended that large breed and giant breed puppies continue to be fed a pet food containing at least 1 % of calcium until about 6 months of age. During the whole late growth phase, pet foods for puppies of small and medium size breeds may contain less calcium (minimum 0.8% DM) and the calcium-phosphorus ratio can be increased to 1.8/1.

Calcium (Maximum for puppies) High intake of calcium has an adverse effect on skeletal development in large breed dogs, particularly during the early growth phase.^{a, b} Therefore a strict nutritional maximum is recommended for foods intended for large breed puppies.

Weber et al. showed that when feeding a balanced food, a calcium level of 1.6 % DM from 9 weeks of age does not cause side effects.^{c, d}

During later growth up to 1.8% DM can be fed to all breed dogs including giant breeds with the exception of great Danes. This breed may be more susceptible and it is preferable to continue with a food containing a maximum calcium content of 1.6%.^{c, d, e}

^a Jenkins KJ, Phillips PH. *The Mineral Requirements of the Dog I. Phosphorus Requirement and Availability.* J. Nutr. 1960; 70: 235-240.

^b Jenkins KJ, Phillips PH. *The Mineral Requirements of the Dog II. The Relation of Calcium, Phosphorus and Fat Levels to Minimal Calcium and Phosphorus Requirements.* J. Nutr. 1960; 70: 241-246.

^c Goodman SA, Montgomery RD, Fitch RB et al. *Serial orthopaedic examinations of growing great Dane puppies fed three diets varying in calcium and phosphorus.* In: *Recent advances in canine and feline nutrition. Vol 2. Iams Nutrition Symposium Proceedings.* G. Reinhardt & D. Carye edits. Wilmington, Ohio, Orange Frazer Press. 1998; pp. 3-12.

^d Alexander JE, Moore MP, Wood LLH. *Comparative growth studies in Labrador retrievers fed 5 commercial calorie-dense diets.* *Modern Veterinary practice* 1988; 31: 144-148.

^e Laflamme DP. *Effect of breed size on calcium requirements for puppies.* *Supplement to Compendium on Continuing Education for the Practicing Veterinarian* 2001; 23 (9A): 66-69.

^f Lauten SD, Cox NR, Brawner WR, et al. *Influence of dietary calcium and phosphorus content in a fixed ration on growth and development of Great Danes.* *Am J Vet Res.* 2002; 63 (7): 1036-1047.

^g Dobenecker B. et al. unpublished.

^a Hazewinkel HAW. *Influences of different calcium intakes on calcium metabolism and skeletal development in young Great Danes.* Thesis Utrecht University, 1985.

^b Schoenmakers I, Hazewinkel HAW, Voorhout G, et al. *Effect of diets with different calcium and phosphorus contents on the skeletal development and blood chemistry of growing Great Danes.* *Vet Rec.* 2000; 147: 652-660.

^c Weber M, Martin L, Dumon H, et al. *Growth and skeletal development in two large breeds fed 2 calcium levels.* *J. Vet Int. Med* 2000; 14 (May/June): 388 Abstr. 243.

^d Weber M, Martin L, Dumon H, et al. *Calcium in growing dogs of large breed: a safety range? ESVCN Congress Amsterdam, April 2000, Abstr.*

^e Laflamme DP. *Effect of breed size on calcium requirements for puppies.* *Supplement to Compendium on Continuing Education for the Practicing Veterinarian* 2001; 23 (9A): 66-69.

Sodium

Sodium (Adult dogs) Studies in dogs have demonstrated that 45.4mg / MJ (0.19g / 1000kcal) sodium is adequate for all life stages.^a

^a Czarnecki-Maulden GL, Deming JG, Izquierdo JV. Evaluation of practical dry dog foods suitable for all life stages. *J. Amer. Vet. Med. Assoc.* 1989; 195 (5): 583-590.

Sodium (Adult dogs) Studies in dogs have demonstrated that foods containing 2% of sodium (DM) may result in a negative potassium balance.^a

^a Boemke W, Palm U, Kaczmarczyk G, Reinhardt HW Effect of high sodium and high water intake on 24 h-potassium balance in dogs. *Z. Versuchstierkd.* 1990; 33 (4): 179-185.

Chloride

Chloride Value based on the assumption that chloride is provided as NaCl.

TRACE ELEMENTS

General

General Manufacturers are reminded that the bioavailability of trace-elements is reduced by a high content of certain minerals (e.g. calcium), the level of other trace elements (e.g. high zinc decreases copper absorption) and sources of phytic acid (e.g. some soy products).

Copper

Copper Owing to its low availability copper oxide should not be considered as a copper source.^a

^a Fascetti AJ, Morris JG, Rogers QR. Dietary copper influences reproductive efficiency of queens. *J. Nutr* 1998; 128: 2590S-2592S

Iodine

Iodine From studies by Castillo et al.^{a, b} a low nutritional maximum for iodine in dogs (0.4mg/100gDM) was recommended. However in these studies puppies were significantly overfed (approx. 75% above energy requirement) which resulted in a substantially increased intake of iodine. Furthermore the food was deficient in a number of key nutrients, e.g. Ca, P and K, and therefore inappropriate for puppies. Consequently, these results are irrelevant for normal commercial nutritionally balanced foods, and the existing legal maximum is safe for all dogs.

^a Castillo VA, Pisarev MA, Lalia JC, et al. Commercial diet induced hypothyroidism due to high iodine. A histological and radiological analysis. *Veterinary Quarterly* 2001; 23 (4): 218-223.

^b Castillo VA, Lalia JC, Junco M, et al. Changes in thyroid function in puppies fed a high iodine commercial diet. *Veterinary Journal* 2001; 161 (1): 80-84.

Iron

Iron Because of very poor availability, iron from oxide or carbonate salts that are added to the diet should not be considered sources contributing to the minimum nutrient level. ^a

^a NRC Absorption and bioavailability of dietary iron in dogs and cats. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 168-169.

Selenium

Selenium (Growth) The minimum requirement for selenium in growing puppies has been determined at 0.21mg per kg dry matter. ^{a, b} However, a safety margin has to be added because the availability of selenium in pet food may be low. ^{a, b, c}

^a Wedekind K., Combs Jr. G. Selenium in pet foods: Is bioavailability an issue? *Compend Cont Educ Pract Vet* 2000; 22 (Suppl.): 17-22.

^b Wedekind K, Yu S, Combs GF. The selenium requirement of the puppy. *J. Anim. Physiol. a. Anim. Nutr.* 2004; 88: 340-347.

^c Wedekind K, Beyer R, Combs Jr. G. Is selenium addition necessary in pet foods? *FASEB J.* 1998; 12: Abstr. 823.

Selenium (Adult dogs) There are no data available about the exact requirements for selenium of adult dogs. However, according to experts the availability of and requirement for selenium in dogs are similar to those in the cat. ^a Therefore, the recommended allowance for cats is used for dogs until more information becomes available.

^a Wedekind K. Personal communication.

Zinc

Zinc (Growth) Based on a study with a purified diet, 5mg zinc per 100g DM is sufficient to meet the requirements for growing puppies.^a Considering potential factors present in practical pet foods that could decrease zinc availability, doubling the minimum recommended level may be considered safe.

^a Booles D, Burger IH, Whyte AL, et al. Effects of two levels of zinc intake on growth and trace element status in Labrador puppies. *J Nutr* 1991; 121: S79-S80.

VITAMINS

Vitamin A

Vitamin A The FEDIAF maximum is based on the studies reported by Hathcock et al., Goldy et al. and Cline et al. in adult dogs. ^{a, b, c} The value is 80% of the dose that Goldy et al. identified “as may be approaching a level that challenges the dog’s ability to maintain normal vitamin A homeostasis” and about 45% of the no-adverse-effect intake established by Cline et al. over one year (no detrimental effects on bone health). Furthermore Hathcock et al. reported an intake at least three times the FEDIAF nutritional maximum as safe in adult dogs fed for ten months (body growth and haematological indices unaffected).

^a Hathcock JN. D. G. Hattan, M. Y. Jenkins, et al. Evaluation of vitamin A toxicity. *Am. J. Clin. Nutr.* 1990;52: 183-202.

^b Goldy GG, Burr JR, Longardner CN et al. Effects of measured doses of vitamin A fed to healthy dogs for 26 weeks. *Veterinary Clinical Nutrition* 1996; 3 (2): 42-49

^c Cline JL, Czarnecki-Maulden, Losonsky JM, et al. Effect of increasing dietary vitamin A on bone density in adult dogs. *J. Anim. Sci.* 1997; 75: 2980-2985.

In view of these data the FEDIAF maximum is considered appropriate for all life stages.

Vitamin A (Puppies) There is no evidence so far that the nutritional maximum for puppies should be different from the current nutritional maximum for adults. This value has been used in this guide for at least 10 years and has never given rise to any problems in growing dogs. ^{c, d, e} Moreover, in a study supported by the pet food industry no adverse effect has been seen in puppies of different breeds when fed a puppy food containing 40,000 IU of vitamin A per 100g DM (4kcal/g or 16.74kJ/g). ^{a, b}

- ^a Zentek J, Kohn B, Morris P, et al. Effect of dietary vitamin A on plasma levels and urinary excretion of retinol and retinyl esters and clinical parameters in puppy dogs. In: *Proceedings of the 13th Congress of the ESVCN, Oristano, Italy 15-17 October 2009*, p. 97.
- ^b Morris PJ, Salt C, Raila J, et al. Safety evaluation of vitamin A in growing dogs. *Br J Nutr* 2012; 108: 1800-1809.
- ^c Schweigert FJ, Ryder OA, Rambeck WA, Zucker H. The majority of vitamin A is transported as retinyl esters in the blood of most carnivores. *Comp. Biochem. Physiol. A* 1990; 95, 573-578.
- ^d Schweigert FJ, Thomann E, Zucker H. Vitamin A in the urine of carnivores. *Int. J. Vitam. Nutr. Res.* 1991; 61, 110-113.
- ^e Schweigert FJ, Bok V. Vitamin A in blood plasma and urine of dogs is affected by the dietary level of vitamin A. *Int J Vitam Nutr Res* 2000; 70, 84-91.

Vitamin D

Vitamin D Studies in great Dane puppies showed that a dietary vitamin D level of 435 IU/100g DM can affect Ca absorption and may stimulate endochondral ossification disturbances. ^{a, b}

Therefore, 320 IU per 100g DM should be the nutritional maximum for growing giant breed dogs. ^c Based on differences in cholecalciferol metabolism between giant breed and small breed puppies ^b, 425 IU/100g DM can be considered a safe nutritional maximum for small breed puppies.

- ^a Tryfonidou MA, Stevenhagen JJ, van den Bemd GJCM, et al. Moderate cholecalciferol supplementation depresses intestinal calcium absorption in growing dogs. *J. Nutr.* 2002; 132: 2644-2650.
- ^b Tryfonidou MA, Holl MS, Vastenburg M, et al. Chapter 7. Moderate vitamin D3 supplementation mildly disturbs the endochondral ossification in growing dogs. In: *PhD Thesis Utrecht University 19 December 2002: pp. 110-122.*
- ^c NRC. *Vitamin D In: Nutrient Requirements of Dogs and Cats. The National Academic Press, Washington, DC. 2006: pp. 200-205 and tables 15-10, 15-12 and 15-14 pp. 357-363.*

Since there is no information on maximum safe intakes for adult dogs and breeding bitches. FEDIAF recommends the same nutritional maximum for other life stages as those indicated for puppies.

Vitamin E

Vitamin E Vitamin E requirements depend on the intake of polyunsaturated fatty acids (PUFA) and the presence of other antioxidants. An increased level of vitamin E may be required if the intake of PUFA is high, particularly from fish oil. ^{a, b, c}

- ^a Hall JA. Potential adverse effects of long-term consumption of (n-3) fatty acids. *Comp Cont Educ Pract Vet.* 1996; 18 (8): 879-895.
- ^b Hall JA, Tooley KA, Gradin JL, et al. Influence of dietary n-6 and n-3 fatty acids and vitamin E on the immune response of healthy geriatric dogs. *Am J Vet Res* 2003; 64 (6): 762-772.
- ^c Hendriks WH, Wu YB, Shields RG, et al. Vitamin E requirement of adult cats increases slightly with high dietary intake of polyunsaturated fatty acids. *J Nutr* 2002; 132: 1613S-1615S.

B Vitamins

The recommended minimum of B Vitamins corresponds to NRC^a. Adequate Intake (AI) based on bioavailable forms coming from a vitamin premix at the point of consumption. When no AI level has been identified, the recommended minimum was based on the NRC Recommended Allowance.

^a NRC Nutrient requirements and dietary nutrient concentrations. In: *Nutrient Requirements of dogs and cats. National Research Council, Washington, DC. 2006: 354-370.*

Riboflavin

Riboflavin Based on erythrocyte glutathione reductase activity coefficient (EGRAC) Cline et al. determined that the riboflavin requirement for the adult dog at maintenance is 66.8µg/kg BW per day, when feeding a semi-purified diet. ^a This corresponds with about 0.6mg/100g DM for practical pet foods by including a safety margin of 25%.

^a Cline JL, Odle J, Easter RA. The riboflavin requirement of adult dogs at maintenance is greater than previous estimates *J Nutr.* 1996 Apr; 126 (4):984-988

Biotin

Biotin For healthy dogs biotin does not need to be added to the food unless the food contains antimicrobial or anti-vitamin compounds. ^{a, b}

^a Kronfeld DS, Biotin and Avidin. In *vitamin & Mineral Supplementation for dogs and cats – A monograph on micronutrients Veterinary Practice Publishing Company 1989: 71-72.*

^b Kronfeld DS, Biotin. In *vitamin & Mineral Supplementation for dogs and cats – A monograph on micronutrients Veterinary Practice Publishing Company 1989: 99.*

Vitamin K

Vitamin K Vitamin K does not need to be added unless diet contains antimicrobial or anti-vitamin compounds. ^{a, b}

^a NRC 2006

^b Kronfeld D.S. *Vitamin and mineral supplementation of dogs and cats. A monograph on micronutrients. Santa Barbara, Calif.: Veterinary Practice Publishing Co. 1989.*

3.2 Substantiation of nutrient recommendations for cats

PROTEIN

Total protein

Amino acids (Adult cats) FEDIAF protein levels are based on NRC (2006) recommendations^a, but have been adjusted to take into account i) an apparent crude protein digestibility of 80% and ii) energy intakes for cats.

^a NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 366-367, table 15-11.

Glutamate (Kittens) The level of glutamate should not exceed 6 per cent dry matter in foods for kittens. ^{a, b}

^a Deady JE, Anderson B, O'Donnell III JA, et al. Effects of level of dietary glutamic acid and thiamine on food intake, weight gain, plasma amino acids and thiamin status of growing kittens. *J. Nutr.* 1981; 111: 1568-1579.

^b Deady JE, Rogers QR, Morris JG. Effect of high dietary glutamic acid on the excretion of 35S-thiamin in kittens. *J. Nutr.* 1981; 111: 1580-1585.

Arginine

Arginine (All life stages) The arginine requirement increases with increased protein content owing to its role as an intermediate in the urea cycle. For every gram of crude protein above the stated values, an additional 0.02g of arginine is required. ^a

^a NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 357-363 tables 15-10, 15-12 and 15-14.

Arginine (Kittens) Taylor (1995) found that 45g/kg diet (470kcal/100g) was associated with a small decrease in growth rate. NRC therefore sets a prudent maximum of 3.5g/100g DM (400kcal/100g). ^a

^a Taylor TP. MS thesis Univ California, Davis, CA USA. 1995

Methionine-cystine

Methionine-cystine (Adult cats) The recommended values are based on a study by Burger and Smith ^a showing that adult cats need 0.16g methionine (without cystine) per MJ ME to maintain a positive N-balance. After adding a safety margin of 20% this corresponds to 0.34% DM or 0.85g per 1000kcal ME methionine + cystine.

^a Burger IH, Smith P. Aminosäurenbedarf erwachsener Katzen. In: *Ernährung, Fehlernährung, und Diätetik bei Hund und Katze – Proceedings of the International Symposium Hannover (DE), September 3-4, 1987: pp. 93-97.*

Cystine Sulphur amino acid requirements of cats (Teeter et al., 1978) and dogs (Blaza et al., 1982) have been determined through studies using methionine and cystine. Cystine is a dimer of cysteine, during analysis, cystine and cysteine are both determined as cysteic acid in hydrolysates of oxidised sample, but calculated as cystine. ^{a, b}

^a Blaza SE, Burger IH, Holme DW, Kendall PT. Sulfur-containing amino acid requirements of growing dogs. *J Nutr.* 1982 Nov; 112(11): 2033-42.

^b Teeter RG, Baker DH, Corbin JE. Methionine and cystine requirements of the cat. *J Nutr.* 1978 Feb; 108(2): 291-5.

Lysine

Lysine (Adult cats) The recommended values are based on a study by Burger and Smith ^a showing that adult cats need 0.16g lysine per MJ ME to maintain a positive N-balance. After adding a safety margin of 20% this corresponds to 0.34% DM or 0.85g per 1000kcal ME.

^a Burger IH, Smith P. Aminosäurenbedarf erwachsener Katzen. In: Ernährung, Fehlernährung, und Diätetik bei Hund und Katze – Proceedings of the International Symposium Hannover (DE), September 3-4, 1987: pp. 93-97.

Tryptophan

Tryptophan (kittens) Taylor et al. (1998) fed 15g/kg in a diet containing 450kcal/100g with no ill effects. ^a

^a Taylor TP, Morris JG, Kass PH. Maximal growth occurs at a broad range of essential amino acids to total nitrogen ratios in kittens. *Amino Acids* 1998; 15: 221-234

Herwill (1994) fed levels up to 60g/kg in a diet containing 470kcal/100g. Twenty was satisfactory but food intake decreased at 40g/kg; much more severe effects were observed at 60g/kg. Therefore the maximum can be set at 2g per 470kcal or 1.7g per 100g DM (400kcal/100g). ^b

^b Herwill A. MS thesis Univ California, Davis, CA USA. 1994

Phenylalanine-tyrosine

Phenylalanine-tyrosine (All life stages) Diets with a moderate level of phenylalanine + tyrosine but higher than the minimum requirement for growth may cause discolouring of black hair in kittens. ^{a, b} This is corrected by feeding a food containing $\geq 1.8\%$ DM of phenylalanine or a combination of tyrosine and phenylalanine. ^b To maximise black hair colour, the tyrosine level should be equal or higher than that of phenylalanine. ^c

^a Yu S, Rogers QR, Morris JG. Effect of low levels of dietary tyrosine on the hair colour of cats. *Journal of small Animal Practice* 2001; 42: 176-180.

^b Anderson PJB, Rogers QR, Morris JG. Cats require more dietary phenylalanine or tyrosine for melanin deposition in hair than for maximal growth. *J. Nutr.* 2002; 132: 2037-2042.

^c NRC Chapter 15. Nutrient Requirements and Dietary Nutrient Concentrations. In: *Nutrient Requirements of Dogs and Cats. The National Academic Press, Washington, DC. 2006: pp. 357-363 tables 15-10, 15-12 and 15-14.*

Taurine

Taurine Studies have shown that the bioavailability is lower when cats are fed a heat treated canned food. ^{a, b} To maintain adequate taurine status, a heat-processed wet cat food needs to contain approximately 2 to 2.5 times more taurine than a dry extruded food; the latter should contain 0.1% DM taurine. ^{c, d}

^a Hickman MA, Rogers QR, Morris JG. Effect of processing on fate of dietary [¹⁴C]taurine in cats. *J. Nutr.* 1990; 120: 995-1000.

^b Hickman MA, Rogers QR, Morris J.G. Taurine Balance is Different in Cats Fed Purified and Commercial Diets. *J. Nutr.* 1992; 122: 553-559.

^c Earle KE, Smith PM. The effect of taurine content on the plasma taurine concentration of the cat *Brit. J. Nutr.* 1991; 66: 227-235.

^d Douglass GM, Fern EB, Brown RC. Feline plasma and whole blood taurine levels as influenced by commercial dry and canned diets. *J. Nutr.* 1991; 121: 179S-180S.

FAT

Total fat

Fat per se is not essential and as long as the minimum recommendation for all essential fatty acids is met or exceeded there is no risk of nutritional deficiency. Therefore the minimum recommendation for total fat in adult cats with a MER of 75kcal/kg BW^{0.67} has not been adjusted for energy intake versus the recommendation for adult cats with a MER of 100kcal/kgBW^{0.67}.

Omega 3 and 6 fatty acids

Omega 3 fatty acids (Growth & Reproduction)

The study by Pawlosky et al. suggests that juvenile felines it is important that the status of DHA in the nervous system is maintained for optimal retinal function. However, young felines have a low synthetic capacity to produce DHA. ^a Therefore it is recommended to have a small amounts of DHA and/or EPA in foods for growth and reproduction.

^a Pawlosky RJ, Denkins Y, Ward G, et al. Retinal and brain accretion of long-chain polyunsaturated fatty acids in developing felines: the effects of corn oil-based maternal diets. *Am. J. Clin Nutr* 1997; 65 (2): 465-472.

Omega 3 fatty acids (Adult cats) Although there is increasing evidence of beneficial effects of omega-3 fatty acids, the current information is insufficient to recommend a specific level of omega-3 fatty acids for adult cats.

MINERALS

Calcium

Calcium The FEDIAF value is higher than NRC 2006 including a safety margin to take into account the bioavailability of raw materials used.

Sodium

Sodium (Adult cats) Based on plasma aldosterone concentration, Yu and Morris concluded that the minimum requirement of sodium for maintenance of adult cats is 0.08 % DM at 5.26kcal ME/g (22kJ). ^a This corresponds with 0.076% at 4kcal ME/g after adding a safety margin of about 25%.

^a Yu S, Morris JG. Sodium requirement of adult cats for maintenance based on plasma aldosterone concentration. *J. Nutr.* 1999; 129: 419-423.

Sodium (Adult cats) Scientific data show that sodium levels up to 3.75g/1000kcal ME are safe for healthy cats ^{a, b}. Higher levels may still be safe, but no scientific data are available.

^a Burger I. Water balance in the dog and the cat. *Pedigree Digest* 1979; 6: 10-11.

^b Nguyen P, Reynolds B, Zentek J, Passlack N, Leray V. Sodium in feline nutrition. *J Anim Physiol Anim Nutr* 2016.

Sodium (Growth) Based on plasma aldosterone concentration Yu and Morris recommended that a food for kittens should contain a minimum of 0.16% DM of sodium at 5.258kcal ME/g (22kJ). ^a This corresponds with 0.16% at 4kcal ME/g after adding a safety margin of about 30%.

^a Yu S, Morris JG. The minimum sodium requirement of growing kittens defined on the basis of plasma aldosterone concentration. *J. Nutr.* 1997; 127: 494-501.

Chloride

Chloride Value based on the assumption that chloride is provided as NaCl.

Magnesium

Magnesium Studies have demonstrated that 10mg/MJ will maintain adult cats. This value has been doubled to accommodate interactions with other dietary factors. ^a

^a Pastoor FJ, Van't Klooster AT, Opitz R, et al. Effect of dietary magnesium level on urinary and faecal excretion of calcium, magnesium and phosphorus in adult, ovariectomized cats. *Br J Nutr.* 1995; 74 (1): 77-84.

TRACE ELEMENTS

General

General Manufacturers are reminded that the bioavailability of trace-elements is reduced by a high content of certain minerals (e.g. calcium), the level of other trace elements (e.g. high zinc decreases copper absorption) and sources of phytic acid (e.g. cereals, legumes).

Copper

Copper Owing to its low availability copper oxide should not be considered as a copper source. ^a

^a Fascetti AJ, Morris JG, Rogers QR. Dietary copper influences reproductive efficiency of queens. *J. Nutr* 1998; 128: 2590S-2592S

Iodine

Iodine Based on the Tc99m thyroid to salivary ratio, Wedekind et al. (2010) have estimated that the minimum requirement of iodine for the cat is 0.46mg/kg DM; but closer analysis of the data indicated that iodine requirements may be closer to 1.1mg/kg DM. ^a

^a Wedekind KJ, Blumer ME, Huntington CE, et al. The Feline Iodine Requirement is Lower than the 2006 NRC Recommended Allowance. *J Anim Phys and Anim Nutr* 2010; 94 (4): 527-539.

The recommended allowance, therefore, has been set at 1.3mg/kg DM, taking into account a safety margin of 20%. This corresponds with the minimum requirement stated by NRC (Table 15-12).^b

^b NRC Iodine. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 181-184; Table 15-12 pp. 366-367.

Iron

Iron Because of very poor availability, iron from oxide or carbonate salts that are added to the diet should not be considered sources contributing to the minimum nutrient level.^a

^a NRC Absorption and bioavailability of dietary iron in dogs and cats. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: pp. 168-169.

VITAMINS

Vitamin A

Vitamin A (Adult cats) The FEDIAF maximum is based on the study reported by Seawright et al. in kittens.^a

^a Seawright AA, English PB, Gartner RJW. Hypervitaminosis A and deforming cervical spondylosis of the cat. *J. Comp. Path.*1967; 77:29-39.

The FEDIAF maximum of 40000 IU/100g DM is about 50% of the maximum NOAEL reported by Seawright et al.^a in kittens from 6 to 8 weeks of age fed for 41 weeks. Since kittens are at least equally vulnerable as adults to hypervitaminosis A, this level should also be safe for adult cats.

Vitamin A (Growth and reproduction) Seawright et al.^a reported no adverse effects in kittens from 6 to 8 weeks of age fed for 41 weeks on a vitamin A intake of 50,000 IU/kg BW corresponding to about 90,000 IU per 100g DM. Therefore, FEDIAF's maximum of 40,000 IU/100g DM can be considered safe for growing kittens.

^a Seawright AA, English PB, Gartner RJW. Hypervitaminosis A and deforming cervical spondylosis of the cat. *J. Comp. Path.*1967; 77: 29-39.

^b Freytag TL, Liu SM, Rogers AR, Morris JG. Teratogenic effects of chronic ingestion of high levels of vitamin A in cats. *J. Anim Phys and Anim Nutr.* 2003; 87: 42-51.

Freytag et al.^b reported that feeding a food with 100,000 IU/100g DM to pregnant queens caused fatal malformations in kittens. The next lowest value of 2000 IU/100g DM caused no adverse effects. From these data NRC 2006 recommended not to exceed 33,330 IU/100g DM in feeding stuffs intended for reproduction.^c

^c NRC Chapter 8. Vitamins - Hypervitaminosis A. In: *Nutrient Requirements of Dogs and Cats*. The National Academic Press, Washington, DC. 2006: p. 200.

In view of these data, FEDIAF recommends a maximum vitamin A level of 33,330 IU/100g DM for products designed for reproducing queens.

Vitamin D

Vitamin D Based on the study of Sih et al. (2001) a nutritional maximum of 3000 IU/100 DM (7500 IU/1000kcal) can be considered safe for cats of all life stages.^a

^a Sih TR, Morris JG, Hickman MA. Chronic ingestion of high concentrations of cholecalciferol in cats. *Am. J. Vet. Res.* 2001; 62 (9): 1500-1506.

Vitamin E

Vitamin E The vitamin E requirement depends on the intake of polyunsaturated fatty acids (PUFA) and the presence of other antioxidants. An increased level of vitamin E may be required under conditions of high PUFA intake. For cat food, it is recommended to add 5 to 10 IU Vitamin E above minimum level per gram of fish oil added per kilogram of diet. ^a

^a Hendriks WH, Wu YB, Shields RG, et al. Vitamin E requirement of adult cats increases slightly with high dietary intake of polyunsaturated fatty acids. *J Nutr* 2002; 132: 1613S-1615S.

B Vitamins

The recommended minimum of B Vitamins corresponds to NRC^a. Adequate Intake (AI) based on bioavailable forms coming from a vitamin premix at the point of consumption. When no AI level has been identified, the recommended minimum was based on the NRC Recommended Allowance.

^a NRC Nutrient requirements and dietary nutrient concentrations. In: *Nutrient Requirements of dogs and cats*. National Research Council, Washington, DC. 2006: 354-370

Vitamin B6 (Pyridoxine)

Vitamin B6 (All life stages) Requirements of vitamin B6 increase with increasing protein content of the food. ^{a, b}

^a Bai SC, Sampson DA, Morris JG, Rogers QR. Vitamin B-6 requirement of growing kittens. *J. Nutr.* 1989; 119: 1020-1027

^b Bai SC, Sampson DA, Morris JG, Rogers QR. The level of dietary protein affects vitamin B-6 requirement of cats. *J. Nutr.* 1991; 121: 1054-1061.

Biotin

Biotin For healthy cats biotin does not need to be added to the food unless the food contains antimicrobial or anti-vitamin compounds. ^{a, b}

^a Kronfeld DS, Biotin and Avidin. In *vitamin & Mineral Supplementation for dogs and cats – A monograph on micronutrients* Veterinary Practice Publishing Company 1989: 71-72;

^b Kronfeld DS, Biotin. In *vitamin & Mineral Supplementation for dogs and cats – A monograph on micronutrients* Veterinary Practice Publishing Company 1989: 99.

Vitamin K

Vitamin K Usually vitamin K does not need to be added. However there is some indication that canned pet food for cats being high in fish, may increase the risk of prolonged coagulation times; therefore it has been suggested to supplement high fish diets with vitamin K^{a-c}.

^a Strieker MJ, Morris JG, Feldman BF, Rogers QR. Vitamin K deficiency in cats fed commercial fish-based diets. *J Small Anim Pract.* 1996; 37 (7): 322-326.

^b NRC 2006

^c Kronfeld D.S. *Vitamin and mineral supplementation of dogs and cats. A monograph on micronutrients*. Santa Barbara, Calif.: Veterinary Practice Publishing Co. 1989.

IV Complementary Pet Food

Complementary pet food is legally defined as pet food which has a high content of certain substances but which, by reason of its composition, is sufficient for a daily ration only if used in combination with other pet foods [Regulation (EC) 767/2009].

Complementary pet food covers a wide range of products including:

- a. Products which significantly contribute to the energy content of the daily ration but are not complete:
 - Products intended to be mixed with other food components in the household to form a complete feed.
 - Treats and snacks are normally given to strengthen the human animal bond and as rewards during training.

Although they are not intended to contribute significantly to the daily ration, they may be given in quantities that impact total energy intake. The feeding instructions should give clear recommendations on how not to overfeed.

- b. Products, which contribute to the daily nutrition and may or may not add significantly to the energy content of the daily ration.
 - Products used to complement foods, e.g. snacks supplying higher levels of ω -3 & ω -6 fatty acids.
- c. Products that are not intended to contribute to the nutritional content of the daily ration, but are given to occupy the animal and can be eaten.
 - Dog chews

1. RECOMMENDED ALLOWANCES

In view of the many different types of complementary pet foods, manufacturers are advised to base their feeding instructions on the intended role of the product in the total ration. The total daily ration should

match the recommended allowances and nutritional and legal maximum values listed in the tables for complete pet food.

2. VALIDATION PROCEDURE

FEDIAF recommends that for the purpose of nutrition validation, complementary pet food should be divided into three parts:

For products belonging to category A, the validation procedure should comply with that laid down for complete pet food in order to assess the nutritional adequacy of the total daily ration.

For products belonging to category B, the validation procedure should cover those nutrients that are relevant for the intended use of the product.

For occupational products (designed for chewing) belonging to category C; no specific validation procedure for nutritional adequacy is needed.

3. REPEAT ANALYSES

When a validation procedure is recommended the same rules should apply for complementary and

complete pet food.

V Analytical Methods

In order to obtain representative results, samples have to be collected and treated according to the general principles laid down in Commission Regulation (EC) No 152/2009 of 27 January 2009 establishing Community methods of sampling and analysis for the official control of feeding stuffs.

The analysis of only one sample may not reflect the level declared in the average analysis of the product.

To obtain a representative analysis, multiple samples coming from different batches have to be analysed. A composite sample made from multiple samples is also valid. To evaluate the results of a single-sample analysis, maximum tolerances for deviation from the declared values, as foreseen in ANNEX 4 of Regulation 767/2009 on the marketing and use of feed should be permitted as well as tolerances for analytical latitudes.

TABLE V-1. NON-EXHAUSTIVE LIST OF ANALYTICAL METHODS

Nutrient	Method Reference(S)
Sampling	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6491
Moisture	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO /DIS 6496
Protein (crude)	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Arginine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Histidine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Isoleucine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Lysine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Methionine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Cystin/Cystein	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Phenylalanine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Tyrosine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Threonine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Valine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Tryptophane	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 2 nd ISO/CD 13904
Fat (crude)	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Linoleic Acid	VDLUFA method 5.6.2 B.S.I method BS684: section 2.34 : ISO 5509-1997 AOAC 15 th ed. (1990) 969.33 & 963.22
Arachidonic Acid	VDLUFA method 5.6.2 B.S.I method BS684: section 2.34 : ISO 5509-1997 AOAC 15 th ed. (1990) 969.33 & 963.22
Fiber (crude)	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Ash (crude)	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Calcium	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869

Nutrient	Method Reference(S)
Phosphorus	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6491
Potassium	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Sodium	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Chloride	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 §35 LMBG L06.00-5 AOAC 14 th ed. (1984) 3.069-3.070 AOAC 15 th ed. (1990) 920.155 & 928.04 AOAC 16 th ed. (1998) potentiometric method 50.1.10
Magnesium	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Iron	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Copper	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Manganese	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Zinc	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 ISO/DIS 6869
Iodine	Ministry of Agriculture, Fisheries and Food (1997). Dietary intake of iodine and fatty acids. Food Surveillance Information Sheet, 127. MAFF
Selenium	The Analyst 1979, 104, 784 VDLUFA, BD III method 11.6 (1993) AOAC 16 th ed. (1998) 9.1.01
Vitamin A	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 VDLUFA method 13.1.2 2 nd ISO/CD 14565
Vitamin D*	VDLUFA method 13.8.1 D3 AOAC 15 th ed. (1990) 982.29 BS EN 12821 : 2000
Vitamin E	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 2 nd ISO/CD 6867 VDLUFA method 13.5.4
Vitamin K	Analytical Proceedings, June 1993, Vol. 30, 266-267 (Vit. K3) J. of Chrom. 472 (1989) 371-379 (Vit. K1) BS EN 14148: 2003 (Vit. K1)
Thiamine	AOAC Int. 76 (1993) 1156-1160 and 1276-1280 AOAC Int. 77 (1994) 681-686 The Analyst, 2000, No. 125, pp 353-360 EN 14122 (2003)
Riboflavin	AOAC Int. 76 (1993) 1156-1160 and 1276-1280 AOAC Int. 77 (1994) 681-686 AOAC 16 th ed. (1998) M 940.33 The Analyst, 2000, No. 125, pp 353-360 EN 14152 (2003)

Nutrient	Method Reference(S)
Pantothenic Acid	AOAC 945.74 /42.2.05 (1990) USP XXIII, 1995, M 91
Niacin	AOAC 944.13 /45.2.04 (1990) USP XXIII, 1995, M 441
Vitamin B6 (Pyridoxine)	AOAC 16 th ed. (1998) M 985.32 EN 14663: 2005
Folic Acid	AOAC 16 th ed. (1998) M 944.12 Biacore AB: Folic Acid Handbook; BR 1005-19
Biotin	USP XXI, 1986, M 88 Biacore AB: Biotin Kit Handbook; BR 1005-18
Vitamin B12	USP XXIII, 1995, M171 AOAC 952.20 Biacore AB: Vitamin B12 Handbook; BR 1004-15
Choline	AOAC Int. Vol 82, No. 5, 1999 pp 1156-1162 EG-Draft 15.706/1/M/68-D/bn
Taurine	AOAC Int. Vol. 82 No. 4, 2000 pp 784-788
Total dietary fibre (TDF)	AOAC Official Method 985.29 or 45.4.07 for Total Dietary Fibre in Food and Food Products
Insoluble fibre (IF)	AOAC Method 991.42 or 32.1.16 for the Insoluble Dietary Fibre in Food and Food Products
Soluble fibre (SF)	AOAC Official Method 993.19 or 45.4.08 for Soluble Dietary Fibre in Food and Food Products

* Vitamin D analysis of pet foods containing levels which are approaching the minimum recommendation, say between 500 and 1000 IU/kg DM is difficult and unreliable. The detection limit for HPLC methods is approximately 3000 to 5000 IU/kg. Analysis is not required if supplementation is practised and it is unlikely that un-supplemented products with adequate levels of vitamins A and E will be deficient in vitamin D.

VI Feeding Test Protocols

Table VI-1. Recommended feeding trial protocol for the determination of metabolizable energy of cat and dog food

GE	Gross energy	CP	Crude protein
DE	Digestible energy	DP	Digestible protein
ME	Metabolizable energy	BW	Body weight
kJ	Kilojoule	Cr₂O₃	chromium III oxide
kcal	Kilocalorie		

1. INDICATOR METHOD

1.1 Introduction

This feeding protocol has been designed in order to determine ME of cat & dog foods in a way not harmful for cats and dogs and is adapted from the “AAFCO

dog and cat food metabolizable energy protocols - Indicator Method” (AAFCO 2007).

1.2 Protocol

1.2.1 Animals

A minimum of six fully grown animals at least one year of age shall complete the test. The animals shall be in good health and of known weight, sex and

breed. Animals shall be individually housed during the trial (collection period).

1.2.2 Feeding procedures

Feeding procedures shall be standardized. The feeding shall consist of two phases.

as necessary, to maintain body weight.

The first phase shall be the pre-collection period of at least three days for dogs and five days for cats (Nott et al. 1994) with the objective of acclimatising the test animals to the diet and adjusting food intake,

The second phase shall be the total collection period; faeces and possibly urine will be collected during at least four days (96 hours) for dogs and five days (120 hours) for cats.

1.2.3 Food

Food type, flavour, and production codes representing the composite feed shall be recorded. The food source shall remain constant throughout the test period.

The indicator shall be uniformly mixed in a quantity

of food sufficient to feed all animals for the duration of the pre-collection and collection periods. If chromic oxide is used, approximately 0.25% of a high quality chromium III oxide (Cr₂O₃) free of soluble chromium shall be mixed with the food.

1.2.4. Food allowances

The amount of food presented to each animal may be based upon existing data on the quantity of food required to maintain body weight, or the estimated

daily maintenance energy requirements [110kcal (460kJ) ME per kg BW^{0.75} for dogs and about 60kcal (250kJ) ME per kg BW for cats] (See ANNEX 2 - Energy).

1.2.5 Times of feeding

Animals shall be fed at least once daily and at the same time each day. Water shall be available at all times. Food shall be fed as is, or per normal feeding

instructions for the product. The excess food shall be weighed back after feeding.

1.2.6 Pre-trial termination

If, during the pre-collection phase, the food is continually rejected or results in minimal

consumption by a majority of the animals, the trial shall not proceed into the collection phase.

1.2.7 Collection

Faeces collection It is imperative that all collection containers be clearly marked using double labels or any alternative adequate coding. The labels shall include the animal number, diet number, and dates of

collection. Aliquots of faeces from five separate days shall be collected. Every effort should be made to avoid collecting contaminants such as hair. The aliquots shall be dried and pooled per individual animal.

Urine collection During the collection period, all daily urine shall be collected for each animal and weighed, unless a correction factor is used to estimate

metabolizable energy. Every effort should be made to avoid collecting contaminants such as hair.

1.2.8 Sample preparation

Food The food shall be blended to ensure a uniform consistency and an adequate quantity used for appropriate assays. Ample quantities of the remaining

sample should be frozen and retained until assay results have been reviewed and found acceptable.

Faeces Faeces shall be analyzed using composite samples. The samples shall be blended to ensure a uniform consistency and an adequate quantity used for

appropriate assays. Ample quantities of the remaining sample should be frozen and retained until assay results have been reviewed and found acceptable.

Urine Urine shall be collected in sulphuric acid containing receptacles to stabilize the urine and prevent loss of nitrogen. Aliquots of urine from the

collection period shall be freeze dried and pooled per animal in sufficient amount for GE assay.

1.2.9 Analytical determination

Prepared samples shall be used for analysis. AOAC approved analytical methodology shall be used when available or one of the recommended analytical methods listed on p. 33. Food and faeces shall be assayed for gross energy (bomb calorimetry), crude protein, and the indicator. If urine is collected, gross energy and crude protein in the urine should also be determined.

Food and faeces are analysed for the indicator by the same method (Atomic absorption spectrophotometry is the preferred method if chromic oxide is used as the indicator (Arthur 1970). Since controlled sample digestion and oxidation of the chromic oxide to chromates is critical for reproducible results, colorimetric analysis of chromium is less reproducible than atomic absorption spectrophotometry.

If digestibility values of dry matter, fat or other nutrients are wanted, food and faeces should also be assayed for those substances.

Food, faeces and urine (if collected) are stored in the freezer in case of need for further analysis

1.2.10 Calculation of digestible energy and digestible nutrients

Digestible energy & protein The determination is based on assays of the gross energy or crude protein

consumed minus the energy or crude protein in the faeces.

DE (kcal or kJ/g) =	$\frac{\{1 - (\text{GE of faeces} \times \% \text{Cr}_2\text{O}_3 \text{ in food})\} \times \text{GE of food}}{(\text{GE of food} \times \% \text{Cr}_2\text{O}_3 \text{ in faeces})}$
---------------------	--

DP (% food) =	$\frac{\{1 - (\% \text{CP in faeces} \times \% \text{Cr}_2\text{O}_3 \text{ in food})\} \times \text{CP in food}}{(\% \text{CP in food} \times \% \text{Cr}_2\text{O}_3 \text{ in faeces})}$
---------------	--

Digestible fat, ash and dry matter can be calculated in the same way as digestible protein.

1.2.11 Calculation of metabolizable energy

Metabolizable energy The determination is based on assays of the gross energy consumed minus the

energy lost in faeces and in the urine.

If urine is collected	$\text{ME (kcal or kJ/g)} = \text{DE} - \text{GE of urine}$
-----------------------	---

If urine is not collected

ME (kcal or kJ/g) = DE - (DP x correction factor for energy lost in urine)

Correction factor for energy lost in urine (Kienzle et al. 1998):

1.25kcal or 5.23kJ/g for dogs

0.86kcal or 3.60kJ/g for cats

2. QUANTITATIVE COLLECTION METHOD

2.1 Introduction

This feeding protocol has been designed in order to determine ME of cat & dog foods in a way not harmful for cats and dogs and is adapted from the “AAFCO

dog and cat food metabolizable energy protocols – Quantitative Collection Method” (AAFCO 2007).

2.2 Protocol

2.2.1 Animals

A minimum of six fully grown animals at least one year of age shall complete the test. The animals shall be in good health and of known weight, sex and

breed. Animals shall be individually housed during the trial (collection period).

2.2.2 Feeding procedures

Feeding procedures shall be standardized. The feeding shall consist of two phases.

The first phase shall be the pre-collection period of at least three days for dogs and five days for cats (Nott et al. 1994) with the objective of acclimatising the test animals to the diet and adjusting food intake, as necessary, to maintain body weight.

The second phase shall be the total collection period of at least four days (96 hours) for dogs and five days (120 hours) for cats.

The amount of food offered during the second phase shall remain constant. Food intake shall be recorded throughout both phases.

2.2.3 Food

Food type, flavour, and production codes representing the composite feed shall be recorded.

The food source shall remain constant throughout the test period.

2.2.4 Food allowances

The amount of food presented to each animal may be based upon existing data on the quantity of food required to maintain body weight or the estimated daily

maintenance energy requirements [110kcal (460-480kJ) ME per kg BW^{0.75} for dogs and about 60kcal (250-293kJ) ME per kg BW for cats] (See ANNEX 2 - Energy).

2.2.5 Times of feeding

Animals shall be fed at least once daily and at the same time each day. Water shall be available at all times. Food shall be fed as is, or per normal feeding

instructions for the product. The excess food shall be weighed back after feeding.

2.2.6 Pre-trial termination

If, during the pre-collection phase, the food is continually rejected or results in minimal consumption

by a majority of the animals, the trial shall not proceed into the collection phase.

2.2.7 Faeces collection

It is imperative that all collection containers be clearly marked using double labels or any alternative adequate coding. The labels shall include the animal number, diet number, and dates of collection. Faeces shall be collected daily for a minimum of four days for dogs and five days for cats. Every effort should be made to collect all of the faeces and avoid collecting contaminants such as hair. The methodology is as follows:

- a. Weigh collection container and record weight.
- b. Place faeces in the respective animal's container for that day of collection. Collect faeces as quantitatively as possible.

- c. Place collections in freezer for storage.
- d. Faeces may be dried each day.

- Weigh and record the weight of the faeces and container each day, and determine net weight of faeces. If the volume of faeces is large, an aliquot may be retained for drying.
- Dry daily faeces collection (or aliquot). Faeces should be thin enough to dry quickly. Otherwise, nitrogen and carbon losses may occur due to fermentation products.
- Pool the entire collection or proportional aliquots.

2.2.8 Sample preparation

Food The food shall be blended to ensure a uniform consistency and an adequate quantity used for appropriate assays. Ample quantities of the

remaining sample should be frozen and retained until assay results have been reviewed and found acceptable.

Faeces Faeces shall be analyzed using composite samples. The samples shall be blended to ensure a uniform consistency and an adequate quantity used for

appropriate assays. Ample quantities of the remaining sample should be frozen and retained until assay results have been reviewed and found acceptable.

Urine If urine collections are made, they shall be for the same period as the faeces collections. Urine shall be collected with a minimum of contamination, in a urine receptacle containing sulphuric acid to stabilize

the urine and prevent nitrogen loss. After the total urine volume is determined, aliquot samples shall be freeze-dried in an appropriate container.

2.2.9 Analytical determination

Prepared samples shall be used for analysis. AOAC approved analytical methodology shall be used when available or one of the methods p.

is not collected, food and faeces also shall be assayed for crude protein.

Food, faeces and urine (if collected) shall be assayed for gross energy (bomb calorimetry). If urine

If digestibility values of dry matter, fat or other nutrients are wanted, food and faeces should also be assayed for those substances.

2.2.10 Calculation of digestible energy and digestible nutrients

The determination is based on assays of the gross energy consumed minus the energy in the faeces.

DE (per g food) =	$\frac{(\text{GE of food consumed} - \text{GE of faeces collected})}{\text{amount of food consumed}}$
-------------------	---

DP (% of food) =	$\frac{(\text{CP of food consumed} - \text{CP of faeces collected}) \times 100}{\text{amount of food consumed}}$
------------------	--

Digestible fat, ash and dry matter can be calculated in the same way as digestible protein.

2.2.11 Calculation of metabolizable energy

The determination is based on assays of the gross energy consumed minus the energy in the faeces and

correction for energy lost in the urine (or energy lost in urine as determined by calorimetry).

Without urine collection

ME =	$\frac{[(\text{GE of food consumed} - \text{GE of faeces collected}) - (\text{grams protein consumed} - \text{grams protein in faeces}) \times \text{correction factor for energy loss in urine}]}{\text{amount of food consumed}}$
------	---

Correction factor for energy lost in urine (Kienzle et al. 1998):

1.25kcal or 5.23kJ/g for dogs
0.86kcal or 3.60kJ/g for cats

Example:

- a. gross energy of food.....= 4.35kcal/g or 18.2kJ/g
- b. amount of food consumed= 1250g
- c. gross energy of faeces= 1.65kcal/g or 6.90kJ/g
- d. amount of faeces collected= 600g
- e. protein in food= 24%
- f. protein in faeces.....= 9%
- g. correction factor (dog).....= 1.25kcal/g or 5.23kJ/g

ME =	$\frac{(a \times b) - (c \times d) - [(b \times e) - (d \times f)]}{100 \times g} \times 1000$
	b

ME (kcal/kg) =	$\frac{[(4.35 \times 1250) - (1.65 \times 600)] - [(1250 \times 24) - (600 \times 9)]}{100 \times 1.25} \times 1000$
	1,250

ME (MJ/kg) =	$\frac{[(18.2 \times 1250) - (6.9 \times 600)] - [(1250 \times 24) - (600 \times 9)]}{100 \times 5.23}$
	1,250

ME =	3,312kcal/kg or 13.9 MJ/kg
------	----------------------------

With urine collection

ME =	$\frac{[(\text{GE of food consumed} - \text{GE of faeces collected}) - \text{GE of urine collected}]}{\text{amount of food consumed}}$
------	--

Example:

- a. gross energy of food = 4.35kcal/g or 18.2kJ/g
- b. amount of food consumed = 1250g
- c. gross energy of faeces = 1.65kcal/g or 6.9kJ/g
- d. amount of faeces collected = 600g
- e. gross energy of urine = 0.25kcal/ml or 1.05kJ/ml
- f. volume of urine = 1230ml

ME (kcal/kg) =	$\frac{[(a \times b - c \times d) - e \times f] \times 1000}{b}$
----------------	--

ME (kcal/kg) =	$\frac{[(4.35 \times 1,250 - 1.65 \times 600) - (0.25 \times 1,230)] \times 1000}{1,250}$
----------------	---

ME (MJ/kg) =	$\frac{18.2 \times 1,250 - 6.9 \times 600 - 1.05 \times 1,230}{1,250}$
--------------	--

ME =	3,312kcal/kg or 13.86 MJ/kg
------	-----------------------------

3. REFERENCES

1. AAFCO. AAFCO dog and cat food metabolizable energy protocols. In: Official Publication - Association of American Feed Control Officials Inc. 2011:175-180.
2. Arthur D. The determination of chromium in animal feed and excreta by atomic absorption spectrophotometry. *Can. Spect.* 1970; 15: 134.
3. Kienzle E, Opitz B, Earl KE, et al. The development of an improved method of predicting the energy content in prepared dog and cat food. *J. Anim Physiol. A. Anim. Nutr.* 1998; 79: 69-79.
4. Nott HMR, Rigby SI, Johnson JV, et al. Design of digestibility trials for dogs and cats. *J. Nutr.* 1994; 124 (12S): 2582S-2583S.

VII Annexes

1. BODY CONDITION SCORE

1.1 Introduction

About one third of cats and dogs over one year of age presented to veterinary practices in the USA are either overweight or obese (BCS 7 & 8, see Table VII 1&2), and the prevalence increases to almost 50% between the age of 6 and 11 years. (Lund et al. 2005 & 2006). The prevalence in Europe is very similar (Sloth 1992, Colliard et al. 2006 & 2009). Energy requirements should be

based on optimal body weight (BW). Although BW is an objective and precise measure, it does not give sufficient information as to whether the BW is optimal or not. Assessing body condition in combination with BW provides a more accurate evaluation of the animal's condition and a better basis for determining energy requirements.

1.2 Validated Body Condition Score

A body condition score (BCS) is a subjective, semi-quantitative method for assessing the animal's body composition, particularly the percentage of body fat (%BF), and for estimating the degree of over- and underweight. Different body condition score (BCS) systems have been developed over the years. A scale of 1-to-9 has been validated for dogs and cats and showed very good repeatability and predictability (Laflamme 1997a & b). The body condition of animals is a continuum, which body condition scoring attempts

to partition into a number of categories (Burkholder 2000), therefore, values of % BF of successive BCS may overlap. Tables 1 and 2 show the BCS with description and corresponding percentages of body fat and increase or decrease of body weight under or above optimal body weight.

For comparison the 5-point scoring is added in column 2 of both tables.

1.3 Practical use and interpretation

On a scale of 1 to 9 a score of 5 should reflect optimal % BF; which is estimated to be between 20 and 30% for cats (Laflamme 1997a; Harper et al. 2001; Bjornvad et al. 2011) and 15 to 25% for dogs (Laflamme 1997b; Kealy et al. 2002)

Cats Studies have shown that neutered cats are at risk of accumulating more fat than intact cats (Fettman et al. 1997; Harper et al. 2001; Kanchuk et al. 2002) and normal weight inactive neutered cats could have relatively less lean body mass (Bjornvad et al. 2011). These data suggest that for neutered inactive cats a BCS of 4/9 may be optimal rather than the 5/9 score which is optimal for intact more active cats.

Dogs Based on a 14 year study with Labrador dogs, Kealy et al. found that restricted feeding was associated

with a longer median life span and delayed onset of chronic diseases (Kealy et al. 2002). These dogs had a BCS of 4/9 to 5/9 with a %BF ranging from 12 to 20% (Kealy et al. 2002), which corresponds better to the optimal BCS found by Mawby et al. 2004. The ideal BCS should therefore be between 4/9 and 5/9.

The main objective of most studies validating the BCS was to provide a practical tool for accurately assessing obesity (Laflamme '1997a & b; Mawby et al. 2004; Bjornvad et al. 2011). This resulted in a bias towards higher body weights and %BF; scores at the lower end of the scale being either absent or underrepresented (Laflamme 1997a & b; Mawby et al. 2004; Bjornvad et al. 2011). In addition, scores at the lower end of the BCS are confounded by muscle atrophy (Baez et al. 2007; Michel et al. 2011). Recently a 4-scale muscle mass

scoring system has been developed for evaluating muscle mass in critically ill patients (Baez et al. 2007;

Michel et al. 2011) (Table 3).

1.4 Conclusion

The combination of BW and the 9-point BCS is a good basis for determining energy requirements and is a useful tool in helping owners, who often fail to recognize that their animal is overweight or obese (Mason 1970). NRC 2006 refers to the 9-point BCS as a reference on which the MER for adult cats is based (NRC 2006) and the World Small Animal Veterinary Association (WSAVA) included the system in their global nutritional guidelines (www.WSAVA.org).

As for other physical examination techniques, there is a need to gain experience with the technique in order to optimize the accuracy of the body condition scoring (Burkholder 2000; German et al. 2006). One study showed that also owners can gain experience with a BCS system with sufficient accuracy (German et al. 2006)

Table VII-1.
Guide to 9-point and 5-point Body Condition Scores in cats

Score		Location Feature	Estimated body fat (%)	% BW below or above BCS 5
9-point	5-point			
1. Emaciated	1	Ribs and bony prominences are visible and easily palpable with no fat cover. Severe abdominal tuck when viewed from the side and an exaggerated hourglass shape when viewed from above.	≤10%	- ≥40%
2. Very Thin		Ribs and bony prominences are visible on shorthaired cats and easily palpable with no fat cover. Severe abdominal tuck, when viewed from the side and a marked hourglass shape when viewed from above.	5-15%	-30-40%
3. Thin	2	Ribs and bony prominences are easily palpable with minimal fat cover. Marked abdominal tuck when viewed from the side and an obvious waist when viewed from above.	10-20%	-20-30%
4* Slightly underweight		Ribs and bony prominences are easily palpable with minimal fat cover. Abdominal tuck when viewed from the side, and a well proportioned waist when viewed from above.	15-25%	-10-15%
5* Ideal	3	Ribs and bony prominences are palpable with a slight fat cover. Abdominal tuck is present when viewed from the side, and a well proportioned waist when viewed from above.	20-30%	0%
6. Slightly overweight		Ribs and bony prominences can be felt under a moderate fat cover. Abdominal tuck and waist are less pronounced. A mild abdominal fat pad may be palpable.	25-35%	+10-15%
7. Overweight	4	Ribs and bony prominences can be felt under a moderate fat cover. No abdominal tuck but a moderate abdominal fat pad is visible when viewed from the side and no waist when viewed from above.	30-40%	+20-30%
8. Obese		Ribs and bony prominences are difficult to palpate, under a thick fat cover. Pendulous ventral bulge with some abdominal fat deposits, when viewed from the side. Broadened back when viewed from above.	35-45%	+30-40%
9. Grossly Obese	5	Ribs and bony prominences are very difficult to feel under a thick fat cover. Large pendulous ventral bulge with extensive abdominal fat deposits, when viewed from the side. Markedly broadened back when viewed from above. Fat deposits around face, neck and limbs.	>45%	+>40%

Adapted from Laflamme 1997a & 2006, Laflamme et al. 1995, and Bjornvad et al. 2011.

*Data suggest that for neutered inactive cats a BCS of 4/9 may be optimal rather than the 5/9 score which is optimal for intact more active cats (Bjornvad et al. 2011).

Table VII-2.
Guide to 9-point and 5-point Body Condition Scores in dogs

Score		Location Feature	Estimated body fat (%)	% BW below or above BCS 5
9-point	5-point			
1. Emaciated	1	<p>Ribs & other bony prominences Visible from a distance & easily palpable with no overlaying fat.</p> <p>Abdomen Severe abdominal tuck when viewed from the side, exaggerated hourglass shape when viewed from above.</p> <p>Tail base Prominent, raised bone structures with no tissue between the skin and bone. Obvious loss of muscle mass and no discernible body fat.</p>	<4%	- ≥40%
2. Very Thin		<p>Ribs & other bony prominences Visible & easily palpable with no fat layer under the skin.</p> <p>Abdomen Strong abdominal tuck when viewed from the side, accentuated hourglass shape when viewed from above.</p> <p>Tail base Prominent, raised bone structures with no tissue between the skin and bone. Minimal loss of muscle mass.</p>	4-10%	-30-40%
3. Thin	2	<p>Ribs & other bony prominences discernible & easily palpable with minimal fat cover.</p> <p>Abdomen pronounced abdominal tuck when viewed from the side, marked hourglass shape when viewed from above.</p> <p>Tail base Raised bony structures with little tissue between skin and bone.</p>	5-15%	-20-30%
4. Slightly underweight		<p>Ribs & other bony prominences Easily palpable with minimal fat cover.</p> <p>Abdomen Abdominal tuck when viewed from the side, slightly marked hourglass shape when viewed from above.</p> <p>Tail base Raised bony structures with little subcutaneous tissue.</p>	10-20%	-10-15%
5. Ideal	3	<p>Ribs & other bony prominences ribs not visible, but easily palpable, with thin layer of fat. Other bony prominences are palpable with slight amount of overlaying fat.</p> <p>Abdomen abdominal tuck when viewed from the side and well proportioned lumbar waist (hourglass shape) when viewed from above.</p> <p>Tail base smooth contour or some thickening, bony structures palpable under a thin layer of subcutaneous fat.</p>	15-25%	0%
6. Slightly overweight		<p>Ribs & other bony prominences palpable with moderate fat cover.</p> <p>Abdomen less obvious abdominal tuck when viewed from the side, hourglass shape less pronounced when viewed from above.</p> <p>Tail base smooth contour or some thickening, bony structures remain palpable under moderate layer of subcutaneous fat.</p>	20-30%	+10-15%
7. Overweight	4	<p>Ribs & other bony prominences difficult to palpate, thick fat cover.</p> <p>Abdomen little abdominal tuck when viewed from the side or waist, and back slightly broadened when viewed from above.</p> <p>Tail base Smooth contour or some thickening, bony structures remain palpable under subcutaneous fat.</p>	25-35%	+20-30%

Score		Location Feature	Estimated body fat (%)	% BW below or above BCS 5
9-point	5-point			
8. Obese		<p>Ribs & other bony prominences Ribs are very difficult to palpate, with thick layer of fat. Other bony prominences are distended with extensive fat deposit.</p> <p>Tail base Appears thickened, difficult to palpate bony structures.</p> <p>General ventral bulge under abdomen, no waist, and back markedly broadened when viewed from above. Fat deposits over lumbar area and neck.</p>	30-40%	+30-45%
9. Grossly Obese	5	<p>Ribs & other bony prominences ribs are very difficult to palpate, with massive layer of fat; other bony prominences are distended with extensive fat deposit between bone and skin.</p> <p>Tail base Appears thickened, bony structures almost impossible to palpate.</p> <p>General Pendulous ventral bulge under abdomen, no waist, back markedly broadened when viewed from above. Fat deposits over lumbar area, neck, face, limbs and in the groin. A dip may form on the back when lumbar and thoracic fat bulges dorsally</p>	>40%	>45%

Adapted from Laflamme 1993, 1997b, & 2006, Laflamme et al. 1994, and Mawby et al. 2004.

Table VII-3. 4-point muscle mass scoring system

0	On palpation over the spine, scapulae, skull, or wings of the ilia, muscle mass is severely wasted.
1	On palpation over the spine, scapulae, skull, or wings of the ilia, muscle mass is moderately wasted.
2	On palpation over the spine, scapulae, skull, or wings of the ilia, muscle mass is mildly wasted as evidenced by slight but discernible decreased muscle mass.
3	On palpation over the spine, scapulae, skull, or wings of the ilia, muscle mass is normal.

After Baez et al. 2007 and Michel et al. 2011

1.5 References

1. Baez JL, Michel KE, Sorenmo K, Shofer FS. A prospective investigation of the prevalence and prognostic significance of weight loss and changes in body condition in feline cancer patients. *J Feline Med Surg* 2007; 9: 411-417.
2. Bjornvad CR, Nielsen DH, Armstrong PJ, et al. Evaluation of a nine-point body condition scoring system in physically inactive pet cats. *Am J Vet Res* 2011; 72 (4): 433-437.
3. Burkholder WJ. Use of body condition scores in clinical assessment of the provision of optimal nutrition. *Timely Topics in Nutrition. J Amer Vet Med Assoc* 2000; 217 (5): 650-654.
4. Colliard L, Ancel J, Benet J-J, et al. Risk factors of obesity in dogs in France. *J Nutr.* 2006; 136: 1951S-1954S.
5. Colliard L, Paragon B-M, Lemuet B, et al. Prevalence and risk factors of obesity in an urban population of healthy cats. *J Fel Med Surg.* 2009; 11: 135-140.
6. Fettman MJ, Stanton CA, Banks LL, et al. Effects of neutering on bodyweight, metabolic rate and glucose tolerance of domestic cats. *Res Vet Sci.* 1997; 62: 131-136.
7. German AJ, Holden SL, Moxham GL, et al. A simple, reliable tool for owners to assess the body condition. *J Nutr* 2006; 136: 2031S-2033S.
8. Harper EJ, Stack DM, Watson TD, et al. Effects of feeding regimens on body weight, body composition and condition score in cats following ovariectomy *J Small Anim Pract* 2001; 42: 433-438.
9. Kanchuk ML, Backus RC, Calvert CC, et al. Neutering induces changes in food intake, body weight, plasma insulin and leptin concentrations in normal and lipoprotein lipase-deficient male cats. *J Nutr.* 2002; 132: 1730S-1732S.
10. Kealy RD, Lawler DF, Ballam JM, et al. Effects of diet restriction on life span and age-related changes in dogs. *J Am Vet Med Assoc.* 2002; 220 (9): 1315-1320.
11. Laflamme DP. Body condition scoring and weight maintenance. In: *Proceed. of the North Amer Vet Conf* 1993; 290-291.
12. Laflamme D. Development and validation of a body condition score system for cats: A clinical tool. *Feline Practice* 1997a; 25 (5-6): 13-18.
13. Laflamme D. Development and validation of a body condition score system for dogs. *Canine Practice* 1997b; 22 (4): 10-15.
14. Laflamme DP, Kealy RD, Schmidt DA, et al. Estimation of body fat by body condition score. *J Vet Int Med* 1994; 8: 154 Abstr. 48.

15. Laflamme DP. *Understanding and managing obesity in dogs and cats.* *Vet Clin Small Anim* 2006; 36 (6): 1283-1295.
16. Lund EM, Armstrong PJ, Kirk CA, Klausner JS. *Prevalence and risk factors for obesity in adult cats from private US veterinary practices.* *Intern J Appl Res vet Med* 2005; 3 (2): 88-96.
17. Lund EM, Armstrong PJ, Kirk CA, Klausner JS. *Prevalence and risk factors for obesity in adult dogs from private US veterinary practices.* *Intern J Appl Res vet Med* 2006; 4 (2): 177-186.
18. Mason E. *Obesity in pet dogs.* *Vet Rec.* 1970; 86: 612-616.
19. Mawby DJ, Bartges JW, d'Avignon A, et al. *Comparison of various methods for estimating body fat in dogs.* *JAAHA* 2004; 40: 109-114.
20. Michel KE, Anderson W, Cupp C, Laflamme DP. *Correlation of a feline muscle mass score with body composition determined by dual-energy X-ray absorptiometry.* *Br J Nutr.* 2011 Oct;106 Suppl 1: S57-S59.
21. *NRC Energy requirements of cats – adult maintenance.* In: *Nutrient requirements of dogs and cats.* National Research Council of the National Academics, Washington, DC. 2006: 42.
22. Sloth C. *Practical management of obesity in dogs and cats.* *J Small Anim Pract.* 1992; 33: 178-182.

2. ENERGY

2.1 Introduction

The feeding guide, more than anything else on a pet food label, draws the attention of the consumer, to whom the amount to feed is certainly key.

Energy requirements vary considerably between individual dogs and cats, even between animals kept under the same conditions. This wide variation between individual animals can be the consequence of differences in age, breed, body size, body condition, insulation characteristics of skin and hair coat, temperament, health status or activity. It can also be caused by environmental factors such as ambient temperature and housing conditions (Meyer & Zentek 2005, NRC 2006).

No single formula will allow to calculate the energy requirements for all dogs or cats (Heusner 1991), and every equation only predicts a theoretical average for a specific group of animals.

Providing satisfactory feeding recommendations remains thus an ongoing challenge for pet food companies. The next section provides general recommendations for household dogs and cats and should be considered a starting point. The following discussion is intended to clarify some of the substantial differences seen between individual dogs or cats.

Table VII-4. Abbreviations

BCS	Body condition score (lean, ideal, overweight, obese)	kJ	Kilojoule
BMR	Basal metabolic rate	ME	Metabolizable energy
BW	Body weight	MJ	Megajoule
DE	Digestible energy	MER	Maintenance energy requirements
DER	Daily energy requirements	NFE	Nitrogen free extract
DM	Dry matter	REE	Resting energy expenditure
ECF	Extra cellular fluid	RER	Resting energy requirements
GE	Gross energy	TNZ	Thermo-neutral zone
kcal	Kilocalorie	UCT	Upper critical temperature

2.2 Energy density of the food

Energy is expressed either in kilocalories (kcal) or in kilojoules (kJ)

Conversions

1kcal = 1000 cal = 4.184kJ, 1 MJ = 1000kJ = 239kcal

2.2.1 Gross energy

The gross energy (GE) of a food is defined as the total chemical combustible energy arising from complete combustion of a food in a bomb calorimeter (NRC

2006a). The predicted GE values of protein, fat and carbohydrate are listed in table VII-5.

Table VII-5.

Predicted gross energy values of protein, fat and carbohydrate

Nutrient	Gross Energy	
Crude protein	5.7kcal/g	23.8kJ/g
Fat	9.4kcal/g	39.3kJ/g
NFE + Crude fibre	4.1kcal/g	17.1kJ/g

(Kienzle et al. 2002; NRC 2006a) NFE = nitrogen free extract

2.2.2 Metabolizable energy

Digestible energy and metabolizable energy are a more accurate way of expressing the energy density of a food. Metabolizable energy reflects better the energy that is utilised by the animal, but is more difficult to determine. The metabolizable energy (ME) of a pet food is measured most accurately by performing digestibility trials using one of the two methods described in Chapter VI. Since animal studies are labour intensive, predictive equations are used extensively for calculating metabolizable energy (ME) concentrations of dog and cat foods. Several of these predictive equations have been developed during the

years, and their accuracy and precision have been compared to those of equations developed from animal feeding studies. Within the Petfood industry the most commonly used predictive equations for prepared pet foods are the “modified Atwater” equation and two equations (one for dog foods and one for cat foods) cited by the National Research Council (NRC, 2006). However, there is currently no uniformity as to their use. Considering the labelling declarations required for certain pet food products listed in Annex I to Directive 2008/38/EC it is clear that there is a need for harmonisation at EU level.

a) Predictive Equations for ME in prepared foods for dogs and cats

a.) Modified Atwater factors For processed pet food “modified” Atwater factors can be used; they are

based on an average digestibility of 90% for fat, 85% for carbohydrate (NFE) and 80% for protein (NRC 1985b).

kcal ME /100g =	% crude protein x 3.5 + % crude fat x 8.5 + % NFE x 3.5 (AAFCO 2008)
kJ ME /100g =	% crude protein x 14.65 + % crude fat x 35.56 + % NFE x 14.65

a₂) Predictive Equations (NRC 2006a) for ME in prepared foods for dogs and cats

ME in prepared pet foods for cats and dogs (dry and wet) the following 4-step-calculation can be used:

1.	Calculate GE	
	GE (kcal) =	$(5.7 \times \% \text{ protein}) + (9.4 \times \% \text{ fat}) + [4.1 \times (\% \text{ NFE} + \% \text{ crude fibre})]$
	GE (kJ) =	$(23.85 \times \% \text{ protein}) + (39.33 \times \% \text{ fat}) + [17.15 \times (\% \text{ NFE} + \% \text{ crude fibre})]$
2.	Calculate energy digestibility (%):	
Dogs:	% energy digestibility =	$91.2 - (1.43 \times \% \text{ crude fibre in DM})$
Cats:	% energy digestibility =	$87.9 - (0.88 \times \% \text{ crude fibre in DM})$
3.	Calculate digestible energy:	
	kcal DE =	$(\text{kcal GE} \times \text{energy digestibility}) / 100$
	kJ DE =	$(\text{kJ GE} \times \text{energy digestibility}) / 100$
4.	Convert into metabolizable energy:	
Dogs:	kcal ME =	$\text{kcal DE} - (1.04 \times \% \text{ protein})$
	kJ ME =	$\text{kJ DE} - (4.35 \times \% \text{ protein})$
Cats:	kcal ME =	$\text{kcal DE} - (0.77 \times \% \text{ protein})$
	kJ ME =	$\text{kJ DE} - (3.22 \times \% \text{ protein})$

Note: In dog foods with crude fibre content above 8 % in DM and a high percentage of fermentable NSP in the crude fibre fraction the predictive equation can underestimate the energy density.

Recent reviews (Calvez et al. 2012a; Calvez et al. 2012b; Dobenecker 2015) comparing the accuracy between the modified Atwater method and the equations cited by the National Research Council (NRC) versus measured ME have shown the following:

- The equations cited by NRC provide a more

accurate estimate of ME compared to the modified Atwater method in dry pet foods;

- The modified Atwater method and the NRC equations provide an equally moderate accuracy of ME estimation for wet foods for both dogs and cats.

The above-mentioned findings will be used for the development of a European Standard referencing the predictive equations described in a₂ for the calculation and declaration of the energy density in prepared pet foods.

b) The ME in products of vegetable or animal origin, in their natural state, fresh or preserved, such as meat, offal, milk products, cooked starch

sources; highly digestible special products such as milk substitutes or diets for enteral nutrition has to be predicted with the following equations.

Dogs:	
kcal ME =	$(4 \times \% \text{ protein}) + (9 \times \% \text{ fat}) + (4 \times \% \text{ NFE})$
kJ ME =	$(16.7 \times \% \text{ protein}) + (37.6 \times \% \text{ fat}) + (16.7 \times \% \text{ NFE})$
Cats:	
kcal ME =	$(4 \times \% \text{ protein}) + (8.5 \times \% \text{ fat}) + (4 \times \% \text{ NFE})$
kJ ME =	$(16.7 \times \% \text{ protein}) + (35.6 \times \% \text{ fat}) + (16.7 \times \% \text{ NFE})$

c) Determination of ME content of foods by feeding trials

Manufacturers should be aware that feeding trials are regarded as the gold standard for determination of the energy content of any pet food. Using the trials described in Chapter VI the digestible energy (DE) can be accurately measured. An approximate factor to convert digestible into metabolizable energy is 0.9. Alternatively, NRC 2006 recommends subtracting

1.25kcal/g digestible crude protein (5.23kJ/g) for dogs and 0.9kcal/g (3.77kJ/g) for cats (NRC 2006a).

FEDIAF recommends that members who wish to use feeding trials should employ the quantitative collection protocol described in Chapter VI, Section 2.

2.3 Literature review on energy requirements of dogs

While the formulae give average metabolizable energy needs, actual needs of cats and dogs may vary greatly depending on various factors (Meyer & Zentek 2005, NRC 1985 & 2006).

Energy allowances, recommended for maintenance of adult dogs, differ widely, with figures ranging from less than 90kcal ME/kg^{0.75} (377kJ) to approximately 200kcal ME/kg^{0.75} (810kJ). This diversity is not surprising when we consider the variation in adult

size between the different breeds, which, with mature body weights ranging from one kg (Chihuahua) to 90kg or more (St. Bernard), is the greatest diversity across mammalian species (Lauten 2006). The amount of energy a particular dog will finally need is significantly influenced by factors such as age, breed, size, activity, environment, temperament, insulation characteristics of skin and hair coat, body condition or disease.

2.3.1 Maintenance Energy Requirements (MER) of adult dogs

Energy requirements of animals with widely differing body weights are not correlated with kg body weight (BW) in a linear way (Meyer & Heckötter 1986, NRC 1985). Energy requirements are more closely related to BW raised to some power: The

daily energy requirements of dogs most often are calculated in function of a metabolic weight, which equals kg^{0.75}. Its accuracy for dogs has been questioned, and a valid alternative (kg^{0.67}) is more related to body surface, and may thus better reflect

heat production (Finke 1994, Kienzle & Rainbird 1991, Männer 1991). What such an equation tells you is the expected mean value for a “typical dog of the given size”. We will continue to use the $\text{kg}^{0.75}$, which is also recommended by NRC 2006. It is widely accepted and easy to calculate by cubing BW and then taking its square root twice (Lewis et al. 1987a).

Maintenance energy requirement (MER) is the amount of energy expended by a moderately active adult animal. It consists of the basal metabolic rate (BMR) plus the energy cost for obtaining, digesting and absorbing food in amounts that are necessary to maintain BW. It includes calories for spontaneous (inevitable) activity, and, in case of passing the critical temperature, energy needed to maintain normal body temperature (Meyer & Zentek 2005, Rainbird & Kienzle 1989). Independent from BW, MER is influenced by differences in age, type and breed, activity, temperament, environmental temperature,

insulation characteristics of skin (i.e. hair length and subcutaneous fat), and social environment, among which “**age and activity**” appeared to be the most important contributors to individual energy needs (Burger 1994, Finke 1994, Kienzle & Rainbird 1991, Meyer & Heckötter 1986, NRC 1985).

Recommendations for MER may overestimate energy needs by 10 to 60 % (Männer 1991, NRC 2006a). They often include a reasonable amount for activity, whereas approximately 19 per cent of the owners never play with their dogs, and 22 per cent let their dogs out for exercise for less than three hours a week (Slater et al. 1995).

2.3.2 Activity

It is clear that spontaneous activity significantly influences MER; for example, standing up requires 40 per cent more energy than lying down (Meyer and Zentek 2005). However, recommendations for MER do not always mention the degree of activity included, whilst it is important that activity is taken into account when calculating the energy needs of an individual

animal. Indeed, average recommendations could be too high for about one out of four dogs, since almost a quarter of the owners exercise their dogs less than **three hours a week** (Slater et al. 1995). To avoid overfeeding and the risk of obesity, it may be better to start from a lower calculated MER and add as needed to maintain optimal body weight.

2.3.3 Age

Apart from lactation and imposed activity during work or sport, age may be the single most-important factor influencing MER of most household dogs (Finke 1994). Three groups of adult dogs can be distinguished: dogs of one to two years old, the average adult dog (three to seven years old) and dogs of more than seven years of age (Finke 1994 & 1991, Kienzle & Rainbird 1991). Young adult dogs, under two years of age, require more energy because they are more active and despite a body weight similar to that of older individuals of the same breed, may still be developing (Meyer & Zentek 2005, Rainbird & Kienzle 1989). Older animals need fewer calories because of decreased activity (Finke 1991, Meyer

& Zentek 2005). In some dogs, however, calorie needs may further decrease as a consequence of an increase in subcutaneous fat and a decrease in body temperature (Meyer & Zentek 2005). Dogs over seven years of age may need 10- 15 per cent less energy than at three to seven years (Finke 1994, Kienzle & Rainbird 1991). Therefore, practical recommendations should always be related to age (Finke 1994, Gesellschaft für Ernährungsphysiologie 1989a). The age at which a dog’s activity decreases can differ according to breed and between individuals. Most of the assessed scientific work uses the age of seven years as a cut-off point, but this should not be regarded as a general rule.

2.3.4 Breed & type

It has been shown that some breeds such as Newfoundland dogs and huskies have relatively lower energy requirements, while Great Danes have a MER above the average (Kienzle & Rainbird 1991, Rainbird & Kienzle 1989, Zentek & Meyer 1992). Breed-specific needs probably reflect differences in temperament, resulting in higher or lower activity, as well as

variation in stature or insulation capacity of skin and hair coat, which influences the degree of heat loss. However, when data are corrected for age, inter-breed differences become less important (Finke 1994). Yet NRC 2006 reports Newfoundland dogs, Great Danes and terriers as breeds with energy requirements outlying the predictive range (NRC 2006a).

2.3.5 Thermoregulation and housing

Cool environment increases animals' energy expenditure (Blaza 1982, Finke 1991, Meyer & Zentek 2005, NRC 1985, Walters et al. 1993). When kept outside in winter, dogs may need 10 to 90 per cent more calories than during summer.

Energy needed for maintaining body temperature is minimal at a temperature called the thermo-neutral zone (TNZ). The TNZ is species and breed specific and is lower when the thermal insulation is better. The TNZ has been estimated to be 15-20°C for long-haired dog breeds and 20-25°C for short haired dog breeds; it may be as low as 10-15°C for Alaskan Huskies (Kleiber 1961b, Männer 1991, Meyer & Zentek 2005, Zentek & Meyer 1992).

Besides insulation capacity, the energy expenditure also depends on differences in stature, behaviour and activity during cold weather, and degree of acclimatisation (Finke 1991, Meyer & Zentek 2005, NRC 1985, Zentek & Meyer 1992), as well as on air movement and air humidity (McNamara 1989, Meyer & Zentek 2005). Animals kept together may decrease the rate of heat loss by huddling together; this phenomenon is very important for neonates (Kleiber 1961b).

During exposure to heat, the basal metabolic rate cannot be lowered (Ruckebusch et al. 1984). If the environmental temperature increases above the upper critical temperature (UCT), the animal has to get rid of the heat by either increasing blood flow to the surface (vasodilatation) or enhanced evaporation of water (panting), which also costs energy (Kleiber 1961b). Vasodilatation becomes ineffective when the environmental is equal to the rectal temperature (Kleiber 1961b). The UCT for adult dogs seems to be 30 to 35 °C (NRC 2006b).

Individually housed dogs, with little opportunity to move, may have daily energy requirements (DER) as low as 70kcal ME/kg^{0.75}. When housed in kennels together with other dogs and a lot of mutual interaction, which stimulates activity, DER may rise to over 144kcal ME/kg^{0.75} (602.5kJ/kg^{0.75}) (NRC 2006a).

Diet-induced thermogenesis plays a small role; it represents about 10 per cent of the daily energy expenditure in dogs. It increases with diets rich in protein and is greater in dogs fed four meals per day than in dogs fed once daily (NRC 2006a).

2.4 Practical recommendations for daily energy intake by dogs and cats in different physiological states

As mentioned before, it is impossible to have one equation which expresses the energy requirements for every individual animal. Since the energy requirement of an individual animal may differ from the average

shown in the tables, these recommendations should only be used as starting points, and the owner has to adapt the amount when the animal tend to lose or gain weight.

2.4.1 Dogs

Tables 2-4 provide practical recommendations for maintenance energy requirements (MER) of adult dogs at different ages (Table 2), energy needed

in relation to activity (Table 3) or for growth and reproduction (Table 4).

a) Maintenance energy requirements

Based on the study by Kealy et al. it is recommended that dogs should be fed to maintain a body condition score (BCS) between 4 and 5 on the 9-point BCS (see

ANNEX 2) for optimal health and longevity (Kealy et al.2002).

Table VII-6.
Practical recommendations for MER in dogs at different ages

Age (years)	kcal ME/kg ^{0.75}	kJ ME/kg ^{0.75}
1 – 2	130 (125-140)	550 (523-585)
3 – 7	110 (95-130)	460 (398-545)
> 7 (senior dogs)	95 (80-120)	398 (335-500)

Burger 1994, Connor 2000, Finke 1991 &1994, Harper 1998, Kealy 2002, Männer 1991, NRC 2006a, Patil and Bisby 2001, Thes 2012, Walters 1993 and Wichert 1999.

The values shown in Table VII-6 are only starting points, the amount of energy a particular dog will finally need is significantly influenced by other factors

such as activity, environment, breed, temperament, insulation characteristics of skin and hair coat, body condition or disease.

Table VII-6 provides MER at different ages without taking into account the degree of activity. However, some young adult dogs may have a sedentary lifestyle and need fewer calories than the average

shown in table VII-6, whereas older dogs (> 7 years of age) which are still playing and running will need more energy than indicated.

Table VII-7 provides examples of daily energy requirements of dogs at different activity levels, for specific breeds and for obese prone adults. It is a

good alternative to table VII-6 to estimate the energy requirements of adult dogs.

Table VII-7. Recommendations for DER in relation to activity

Activity level	kcal ME/kg ^{0.75}	kJ ME/kg ^{0.75}
Low activity (< 1 h/day) (e.g. walking on the lead)	95	398
Moderate activity (1 – 3 h/day) (low impact activity)	110	460
Moderate activity (1 – 3 h/day) (high impact activity)	125	523
High activity (3 – 6 h/day) (working dogs, e.g. sheep dogs)	150 -175	628 – 732
High activity under extreme conditions (racing sled dogs 168 km/d in extreme cold)	860-1240	3600-5190
Obese prone adults	≤ 90	≤ 377
Breed specific differences:		
Great Danes	200 (200-250)	837 (837-1046)
Newfoundlands	105 (80-132)	439 (335-550)

Burger 1994, Connor 2000, Kealy 2002, Männer 1990, NRC 2006a & b, Patil & Bisby 2001, Thes 2012, Wichert 1999.

In addition, when dogs are housed at an ambient temperature, which is below or over their specific

thermo-neutral zone, MER increases by 2-5kcal (8-21kJ) per kg^{0.75} for every degree centigrade (NRC 2006b).

b) Growth and reproduction

Energy requirements for lactation depend on the litter size. Except for bitches with only one or two puppies, lactating bitches should be fed ad libitum.

Table VII-8 provides equations to calculate the average energy needs of lactating bitches at different stages of lactation.

Table VII-8.

Average energy requirements during growth and reproduction in dogs

Puppies	Age	Energy requirement	
	Newborn puppies	25kcal/100g BW	105kJ/100g BW
	Up to 50 % of adult weight	210kcal/kg ^{0.75}	880kJ/kg ^{0.75}
	50 to 80 % of adult weight	175kcal/kg ^{0.75}	730kJ/kg ^{0.75}
	80 to 100 % of adult weight	140kcal/kg ^{0.75}	585kJ/kg ^{0.75}
Bitches	Reproduction phase	Energy requirement	
Gestation*	first 4weeks of gestation	132kcal/kg BW ^{0.75}	550kJ/kg BW ^{0.75}
	last 5 weeks of gestation	132kcal/kg BW ^{0.75} + 26/kg BW	550kJ/kg BW ^{0.75} + 110/kg BW
Lactation**	Lactating bitch:	kcal	kJoule
	1 to 4 puppies	145/kg BW ^{0.75} + 24n x kg BW x L	607/kg BW ^{0.75} + 100n x kg BW x L
	5 to 8 puppies	145/kg BW ^{0.75} + (96 + 12n) x kg BW x L	607/kg BW ^{0.75} + (400 + 50n) x kg BW x L

* Gesellschaft für Ernährungsphysiologie 1989a; ** NRC 2006a & 2006c, n = number of puppies; L = 0.75 in week 1 of lactation; 0.95 in week 2; 1.1 in week 3 and 1.2 in week 4

Overfeeding puppies can result in skeletal deformities especially in large and giant breeds (Dämmrich 1991, Kealy et al. 1992 & 2002; Meyer & Zentek 1992; Richardson

& Toll 1993). Therefore, puppies should never be fed ad libitum and weight gain closely monitored.

2.4.2 Cats

Owing to the small variation in adult body weights, the energy needs of cats are often expressed per kg BW instead of per kg metabolic weight. In addition, if metabolic weight is used to calculate MER, the intra-specific allometric coefficient of 0.67 proposed by Heusner in 1991 should be used (NRC 2006a), which has recently been confirmed to be a more accurate than the 0.75 (Nguyen et al. 2001; Edtstadler-Pietsch 2003).

Although NRC specifies that 100kcal/kg^{0.67} is only valid for cats with a lean body condition, many lean cats may need less energy (Riond et al. 2003, Wichert

et al. 2007). FEDIAF recommendations for normal active adult cats are in accordance with NRC (2006) assuming a maintenance energy requirement of 100kcal/kgBW^{0.67}. For indoor and/or neutered adult cats the average maintenance energy requirement is estimated to be 75kcal/kgBW^{0.67} (Fettman et al., 1997, Harper et al., 2001).

Bjornvad et al. recommend that neutered cats should be fed to maintain a body condition score (BCS) of 4 on the 9-point BCS (see ANNEX 1) (Bjornvad et al. 2011).

Table VII-9.
Average daily energy requirements of adult cats

Gender - Activity	kcal ME/kg ^{0.67}	kcal ME/kg BW (4 kg cat)	kJ ME/kg ^{0.67}	kJ ME/kg BW (4 kg cat)
Neutered and/or indoor cats	52-75	35-45	215-314	145-190
Active cats	100	60-65	418	250-270

NRC 2006 a & c, Riond et al. 2003, Wichert et al. 2007.

Table VII-10.
Average energy requirements during growth and reproduction in cats

Kittens	Age	Times MER	
	Up to 4 months	2.0-2.5	
	4 to 9 months	1.75-2.0	
	9 to 12 months	1.5	
Queens	Reproduction phase		
Gestation		140kcal/kg ^{0.67} BW	585kJ/kg ^{0.67} BW
Lactation	< 3 kittens	100kcal/kg ^{0.67} + 18 x kg BW x L	418kJ/kg ^{0.67} + 75 x kg BW x L
	3-4 kittens	100kcal/kg ^{0.67} + 60 x kg BW x L	418kJ/kg ^{0.67} + 250 x kg BW x L
	> 4 kittens	100kcal/kg ^{0.67} + 70 x kg BW x L	418kJ/kg ^{0.67} + 293 x kg BW x L

Loveridge 1986 and 1987, Rainbird 1988, Kienzle 1998, Dobenecker et al. 1998, Debraekeleer 2000; Nguyen et al. 2001, NRC 2006a & c.
L = 0.9 in weeks 1-2 of lactation; 1.2 in weeks 3-4; 1.1 in week 5; 1 in week 6; and 0.8 in week 7.

Table VII-11.

Recommended nutrient levels for dogs & cats

– Units per kg metabolic bodyweight (dogs kgBW^{0.75}, cats kgBW^{0.67})

Nutrient	UNIT	Minimum Recommended Nutrient Levels per kg metabolic BW (dogs kgBW ^{0.75} ; cats kgBW ^{0.67})	
		Adult Dog Maintenance	Adult Cat Maintenance
Protein*	g	4.95	6.25
Arginine*	g	0.14	0.25
Histidine	g	0.06	0.08
Isoleucine	g	0.13	0.12
Leucine	g	0.23	0.29
Lysine*	g	0.12	0.09
Methionine*	g	0.11	0.04
Methionine + cystine*	g	0.21	0.09
Phenylalanine	g	0.15	0.12
Phenylalanine + tyrosine*	g	0.24	0.44
Threonine	g	0.14	0.15
Tryptophan	g	0.05	0.04
Valine	g	0.16	0.15
Taurine (canned pet food)*			0.05
Taurine (dry pet food)*			0.03
Fat*	g	1.51	2.25
Linoleic acid (ω-6) *	g	0.36	0.13
Arachidonic acid (ω-6)	mg	-	1.50
Alpha-linolenic acid (ω-3) *	g	-	-
EPA + DHA (ω-3) *	g	-	-
Minerals			
Calcium	g	0.14	0.15
Phosphorus	g	0.11	0.13
Potassium	g	0.14	0.15
Sodium*	g	0.03	0.02
Chloride	g	0.04	0.03
Magnesium	g	0.02	0.01
Trace elements*			
Copper*	mg	0.20	0.13
Iodine*	mg	0.03	0.03
Iron*	mg	1.00	2.00
Manganese	mg	0.16	0.13
Selenium*	µg	8.25	7.50
Zinc*	mg	2.00	1.88
Vitamins			
Vitamin A*	IU	167	83.25
Vitamin D*	IU	15.2	6.25
Vitamin E*	IU	1.00	0.95
Thiamine	mg	0.06	0.11
Riboflavin*	mg	0.17	0.08
Pantothenic acid	mg	0.39	0.14
Vitamin B6 (Pyridoxine)	mg	0.04	0.06
Vitamin B12	µg	0.92	0.44
Niacin	mg	0.45	0.79
Folic acid	µg	7.10	19.0
Biotin*	µg	-	1.50
Choline	mg	45	60
Vitamin K*	µg	-	-

Table VII-12

Impact of energy requirement on nutrient intake and minimum recommendations

Example: Impact of energy requirement on dry matter and nutrient intake				
	4 kg cat		15 kg dog	
MER	100kcal/kgBW ^{0.67}	75kcal/kgBW ^{0.67}	110kcal/kgBW ^{0.75}	95kcal/kgBW ^{0.75}
Daily energy intake	253kcal	189kcal	838kcal	724kcal
DM intake (400kcal/100g DM)	63g	47g	210g	181g
Total daily Zn requirement	4.75mg		15mg	
Adequate Zn level	7.5 mg/100g DM	10.0 mg/100g DM	7.2 mg/100g DM	8.34 mg/100g DM

2.5 Impact of energy requirement on product formulation

Balanced nutrition ensuring adequate intakes of energy, protein, minerals and vitamins is essential for cats and dogs to ensure health and longevity. In order to achieve the recommended intake of energy and nutrients, products must be formulated to match these needs. The Fediaf recommendations are principally based on NRC (2006) as well as on other peer reviewed science as referenced in the substantiation tables. Major differences between Fediaf and NRC recommendations for adult cats and dogs are driven by a systematic adjustment applied to all essential nutrients due to different assumptions on daily maintenance energy requirements.

The NRC (2006) adult maintenance recommendations for dogs are based on an average maintenance energy requirement of 130kcal/kgBW^{0.75}/d (1000 kcal ME/d), which is the average energy intake observed in laboratory kennel dogs or active pet dogs. Fediaf however takes a different approach and uses an average energy requirement of 110kcal/kgBW^{0.75}/d (838kcal/d) as basis for the adult maintenance recommendations, which is typical for dogs with 1-3 hours of low impact activity or less than 1 hour high impact activity (Burger et al., 1994; Connor et al., 2000; Kealy et al., 2002). Studies investigating the maintenance energy requirement of adult pet dogs in single pet households with less than 1

hour per day of low impact activity e.g. walking on the lead, showed an average energy intake ranging from 94 to 105kcal (Connor et al., 2000; Patil and Bisby, 2001; Thes et al., 2012; Wichert et al., 1999). These findings have been acknowledged by Fediaf through the introduction of separate nutrient recommendations for adult dogs with a maintenance energy requirement of 95kcal/kgBW^{0.75} (724kcal/d).

Fediaf recommendations for normal active adult cats are in accordance with NRC (2006) assuming a daily energy requirement of 100kcal/kgBW^{0.67}/d (253kcal/d). For indoor and/or neutered adult cats the average maintenance energy requirement is estimated to be 75kcal/kgBW^{0.67}/d (189kcal/d) (Fettman et al., 1997, Harper et al., 2001). Strict indoor living in combination with neutering becomes increasingly applicable for adult pet cats in Europe. This is acknowledged in common with findings in dogs by introduction of separate nutrient recommendations for adult cats consuming 75kcal/kgBW^{0.67}/d.

Are differences in energy intake affecting nutritional recommendations?

The approach to provide nutrient recommendations expressed as units/1000kcal or MJ recognises the close relationship between energy and nutrient intake.

However the energy needs may be satisfied before the

requirements of protein, minerals or vitamins are met. This leads to an increased risk of nutritional deficiencies with a consequent negative impact on health and well-being. Hence a systematic adjustment applied to all

essential nutrients is needed when fed below the NRC standard assumption of 100kcal/kgBW^{0.67}/d for a 4kg cat and 130 kcal/ kgBW^{0.75}/d for a 15kg dog respectively.

The target nutrient density (units/1000kcal) can be calculated using the following equation in order to

meet the minimum nutrient requirements.

Units/1000kcal =	Nutrient requirement per day (Units/kg metabolic BW) x 1000
	DER (kcal/kg metabolic BW)

The metabolic BW in dogs is defined as kgBW^{0.75}, in cats it is set at kgBW^{0.67}

2.6 References

1. AAFCO. Regulation PF9. Statements of Calorie Content. In: Official Publication, 2008: pp. 125-126.
2. Alexander JE, Wood LLH. Growth studies in Labrador retrievers fed a caloric-dense diet: time-restricted versus free-choice feeding. *Canine practice* 1987; 14 (2): 41-47.
3. Bermingham, E.N., Thomas, D. G., Morris, P.J and Hawthorne, A.J. Energy requirements of adult cats. *Brit. J. Nutr* 2010; 103, 1083–1093.
4. Bjornvad CR, Nielsen DH, Armstrong PJ, et al. Evaluation of a nine-point body condition scoring system in physically inactive pet cats. *Am J Vet Res* 2011; 72 (4): 433-437.
5. Blanchard G, Grandjean D, Paragon BM. Calculation of a dietary plan for puppies. *J. Anim. Physiol. Anim. Nutr.* 1998; 80: 54-59.
6. Blaza SE. Energy requirements of dogs in cool conditions. *Canine Practice* 1982; 9 (1): 10-15.
7. Burger IH, Johnson JV. Dogs large and small: The allometry of energy requirements within a single species. *J. Nutr.* 1991; 121: S18-S21.
8. Burger IH. Energy needs of companion animals: Matching food intakes to requirements throughout the life cycle. *J. Nutr.* 1994; 2584S-2593S.
9. Butterwick RF, Hawthorne AJ. Advances in dietary management of obesity in dogs and cats. *J. Nutr.* 1998; 128: 2771S-2775S.
10. Calvez, J., Weber, M. and Ecochard, C. Metabolizable Energy In Dry Dog Food Is Best Predicted By NRC 2006 Equation. In: AAVN, New Orleans, Louisiana 2012.
11. Calvez, J., Weber, M. and Ecochard, C. Metabolizable Energy In Dry Cat Food Is Best Predicted By NRC 2006 Equation. In: ESVCN, Bydgoszcz, Poland 2012.
12. Connor, M.M., Labato, A., Laflamme, D.P.(2000). Variation in maintenance energy requirements of pet dogs. *Purina Nutrition Forum Proceedings Supplement to Compendium of continuing education for the practising veterinarian* 23 (9a):84.
13. Dämmrich K. Relationship between Nutrition and Bone Growth in Large and Giant Dogs *Journal of Nutrition* 1991; 121 (11S): S114-S121.
14. Debraekeleer J, Gross KL, Zicker SC. Chapter 9. Normal Dogs. In: *Small Animal Clinical Nutrition* 4th edit. Hand, Thatcher, Remillard & Roudebush MMI Topeka, KS 2000; 213-260.
15. Debraekeleer J. Body Weights and Feeding Guides for Growing Dogs and Cats - Appendix F In: *Small Animal Clinical Nutrition* 4th edit. Hand, Thatcher, Remillard & Roudebush MMI Topeka, KS 2000; 1020-1026.
16. Dobenecker B, Zottmann B, Kienzle E, Wolf P, Zentek J. Milk yield and milk composition of lactating queens. *J. Anim. Physiol. Anim. Nutr.* 1998, 80:173-178.

17. Dobenecker, B. (2015) *Metabolisable energy in pet food - a comparison between the accuracy of predictive equations versus experimental determination. FEDIAF internal report.*
18. Edney ATB, Smith PM. *Study of obesity in dogs visiting veterinary practices in the United Kingdom. Vet Rec* 1986; 118: 391-396.
19. Edstadtler-Pietsch, G. *Untersuchungen zum Energiebedarf von Katzen Doctoral thesis. Veterinary faculty, Ludwig-Maximilians-University, München, 2003.*
20. Fettman M.J., Stanton C.A., Banks L.L., Hamar D.W., Johnson D.E., Hegstad R.L., Johnston S. (1997) *Effects of neutering on bodyweight, metabolic rate and glucose tolerance of domestic cats. Res Vet Sci.* 62(2):131-6.
21. Finke M D. *Energy Requirements of adult female Beagles. J Nutr.* 1991; 121: S22-S28.
22. Finke MD. *Evaluation of the energy requirements of adult kennel dogs. J Nutr* 1994; 121: 2604S-2608S.
23. Gesellschaft für Ernährungsphysiologie. *Empfehlungen für die Versorgung mit Energie. In: Ausschluß für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie, Energie- und Nährstoff bedarf, Nr.5 (Hunde/dogs), DLG Verlag Frankfurt (Main) 1989b; pp. 32-44.*
24. Gesellschaft für Ernährungsphysiologie. *Grunddaten für die Berechnung des Energie- und Nährstoff bedarfs. In: Ausschluß für Bedarfsnormen der Gesellschaft für Ernährungsphysiologie, Energie- und Nährstoff bedarf, Nr.5 (Hunde/dogs), DLG Verlag Frankfurt (Main) 1989a; pp. 9-31.*
25. Harper E.J. *Changing perspectives on aging and energy requirements: aging and energy intakes in humans, dogs and cats. J Nutr.* 1998; 128(12):2623S-2626S.
26. Harper EJ, Stack DM, Watson TDG, et al. (2001) *Effect of feeding regimens on bodyweight, composition and condition score in cats following ovariohysterectomy. J Small Anim Pract* 42, 433-438.
27. Hedhammar Å., Wu F-M, Krook L, et al. *Over nutrition and Skeletal Disease - An experimental Study in Growing Great Dane Dogs. Cornell Veterinarian* 1974; 64 (supplement 55): 9-160.
28. Heusner AA. *Body Mass, Maintenance and basal Metabolism in Dogs. J. Nutr.* 1991; 121: S8-S17.
29. Hill RC. *A Rapid method of estimating maintenance energy requirement from body surface area in inactive adult dogs and cats. JAVMA* 1993; 202 (11): 1814-1816.
30. Kealy RD, Olsson SE, Monti KL, et al. *Effects of limited food consumption on the incidence of hip dysplasia in growing dogs. JAVMA* 1992; 201 (6): 857-863.
31. Kealy RD, Lawler DF, Ballam JM, et al. *Effects of diet restriction on life span and age-related changes in dogs. J Am Vet Med Assoc.* 2002; 220 (9): 1315-1320.
32. Kendall PT, Burger IH. *The effect of Controlled and Appetite Feeding on Growth and Development in Dogs. In: Proceedings of the Kalkan Symposium September 29-30, 1979; 60-63.*
33. Kienzle E, Rainbird A. *Maintenance Energy Requirement of Dogs: What is the Correct Value for the Calculation of Metabolic Body Weight in Dogs? J. Nutr.* 1991; 121: S39-S40.
34. Kienzle E, Schrag I, Butterwick R, Opitz B. *Calculation of gross energy in pet foods: Do we have the right values for heat of combustion? J. Nutr.* 2002; 132: 1799S-1800S.
35. Kienzle. *Factorial calculation of nutrient requirements in lactating queens. J. Nutr.* 1998; 128: 2609S-2614S.
36. Kleiber M. *The Heat loss of Animals. In: The Fire of Life. John Wiley & Sons, Inc. Publishers 1961a; pp.129-145.*
37. Kleiber M. *Animal temperature regulation. In: The Fire of Life. John Wiley & Sons, Inc. Publishers 1961b; pp.146-174.*
38. Kleiber M. *Metabolic body size and prediction of metabolic rate. In: The Fire of Life - an introduction to animal energetics. Huntington, NY: R.E. Krieger Publishing Company 1975; 211-214.*
39. Lauten SD. *Nutritional risks to large-breed dogs: from weaning to the geriatric years. Vet. Clinics of North Amer. Small. Anim. Pract.* 2006; 36: 1345-1359.
40. Lewis LD, Morris ML Jr., Hand MS. *Dogs - Feeding and care. In: Small Animal Clinical Nutrition III, MMA, Topeka, Kansas, 1987b; pp. 3.1-3.32.*

41. Lewis LD, Morris ML Jr., Hand MS. Nutrients. In: *Small Animal Clinical Nutrition III*, MMA, Topeka, Kansas, 1987a; pp. 1.1-1.25.
42. Loveridge GG. Body weight changes and energy intakes of cats during gestation and lactation. *Animal Technology* 1986; 37: 7-15.
43. Loveridge GG. Some factors affecting kitten growth. *Animal Technology* 1987; 38: 9-18.
44. Lust G, Geary JC, Sheffy BE. Development of Hip Dysplasia in Dogs. *Am J Vet Res.* 1973; 34 (1): 87-91.
45. Männer K, Bronsch K, Wagner W. Energiewechselmessungen bei Beaglehunden im Erhaltungsstoffwechsel und während der Laktation. In: *Ernährung, Fehlernährung und Diätetik bei Hund und Katze. Proceed. International Symposium Hannover 1987*; Sept. 3-4: pp. 77-83.
46. Männer K. Energy Requirement for Maintenance of Adult Dogs. *J. Nutr.* 1991; 121: S37-S38.
47. Männer K. Energy Requirement for Maintenance of Adult Dogs of Different Breeds. Poster presented at the Waltham Int'l symposium U.C. Davis, Ca. 1990; Sept. 4-8.
48. Mason E. Obesity in Pet Dogs. *Veterinary Record* 1970; 86: 612-616.
49. McNamara JH. "The Duo Combo" management by Humiture. *Hill's Pet Products* 1989.
50. Meyer H, Kienzle E, Dammers C. Milchmenge und Milchezusammensetzung bei der Hündin sowie Futteraufnahme und Gewichtsentwicklung ante und post partum. *Fortschritte in der Tierphysiologie und Tierernährung*, 1985; suppl. 16: 51-72.
51. Meyer H, Kienzle E, Zentek J. Body size and relative weights of gastrointestinal tract. *J. Vet. Nutr.* 1993; 2: 31-35.
52. Meyer H, Zentek J. Energie und Nährstoffe - Stoffwechsel und Bedarf. In: *Ernährung des Hundes*, 5th edition P. Parey Verlag, 2005; pp. 49-96.
53. Meyer H, Zentek J. Energy requirements of growing Great Danes. *J. Nutr.* 1991; 121: S35-S36.
54. Meyer H, Zentek J. Über den Einfluß einer unterschiedlichen Energieversorgung wachsender Doggen auf Körpermasse und Skelettentwicklung 1. Mitteilung: Körpermasseentwicklung und Energiebedarf. *J. Vet. Med. A*, 1992; 39: 130-141.
55. Nguyen P, Dumon H, Frenais R, et al. Energy expenditure and requirement assessed using three different methods in adult cats. *Supplement to Compendium on Continuing Education for the Practicing Veterinarian* 2001; 22 (9a): 86.
56. Nguyen P, Mariot S, Martin L, et al. Assessment of energy expenditure with doubly labelled water in adult cats. *Supplement to compendium on Continuing Education for the Practicing Veterinarian* 2000; 22 (9a): 96.
57. NRC. Chapter 3: Energy. In: *Nutrient requirements of dogs and cats*. National Academies Press, Washington, DC, USA, 2006a: 28-48.
58. NRC. Chapter 11: Physical Activity and Environment. *Nutrient requirements of dogs and cats*. National Academies Press, Washington, DC, USA, 2006b: 258-312.
59. NRC. Chapter 15: Nutrient requirements and dietary nutrient concentrations. In: *Nutrient requirements of dogs and cats*. National Academies Press, Washington, DC, USA, 2006c: 354-370.
60. NRC. Nutrient Requirements and signs of deficiency. In: *Nutrient Requirements of Dogs*. National Academy Press, Washington, DC 1985a 2-5.
61. NRC. Composition of ingredients of dog foods. In: *Nutrient Requirements of Dogs*. National Academy Press, Washington, DC 1985b 40-41
62. NRC (2006) *Nutrient Requirements of Dogs and Cats*, 1st ed. Washington DC: National Academic Press.
63. Patil, A.R. and Bisby, T.M. (2002). Comparison of maintenance energy requirement of client-owned dogs and kennel dogs. *Purina Nutrition Forum Proceedings Supplement to Compendium of Continuing Education for the Practising Veterinarian* 24 (9a):81
64. Pellet PL. Food energy requirements in humans. *Am. J. Clin. Nutr.* 1990; 51: 711-722.

65. Radicke B. Effect of nutrient composition of complete diets on maintenance energy requirements, energy accretion and energy utilization for accretion and crude protein requirements of adult cats. Doctoral thesis, Freie Universität Berlin, 1995.
66. Rainbird AL, Kienzle E. Untersuchungen zum Energiebedarf des Hundes in Abhängigkeit von Rassezugehörigkeit und Alter. *Kleintierpraxis*, 1989; 35: 149-158.
67. Rainbird AL. Feeding throughout life. In: *Dog & Cat Nutrition* 2nd edition Edney ATB, Oxford, UK: Pergamon Press 1988; 75-96.
68. Richardson DC, Toll PW. Relationship of Nutrition to Developmental Skeletal Disease in Young Dogs. *Veterinary Clinical Nutrition of Companion Animals*, Adelaide, Australia 1993: 33. Riond JL, Stiefel M, Wenk C, Wanner M. Nutrition studies on protein and energy in domestic cats. *J. Anim. Physiol. Anim. Nutr.* 2003; 87: 221-228.
69. Ruckebusch Y, Phaneuf L-Ph, Dunlop R. Body temperature and energy exchange. In: *Physiology of small and large animals*. Philadelphia, PA: B.C. Decker, 1991: 387-398.
70. Slater M R, Robinson L E, Zoran D L et al. Diet and exercise patterns in pet dogs. *JAVMA* 1995; 207 (2): 186-190.
71. Stiefel M. Effect of three different diets on energy and protein metabolism of adult cats with special consideration of physical activity. Doctoral thesis, University of Zürich, 1999.
72. Thes M, Becker N, Fritz J, Wendel E, Kienzle E. Metabolizable energy (ME) requirements of client owned adult dogs. In: *Proceedings of the 16th Congress of the European Society of Veterinary and Comparative Nutrition*, Bydgoszcz, Poland 2013:34.
73. Toll PW, Richardson DC, Jewell DE, Berryhill SA. The Effect of Feeding Method on Growth and Body Composition in Young Puppies. In: *Abstract book of Waltham Symposium on the Nutrition of Companion Animals*, Adelaide, Australia 1993: 33.
74. Walters LM, Ogilvie GK, Salman MD, et al. Repeatability of energy expenditure measurements in clinically normal dogs by use of indirect calorimetry. *Am. J. Vet. Res.* 1993; 54 (11): 1881-1885.
75. Wichert B, Müller L, Gebert S, et al. Additional data on energy requirements of young adult cats measured by indirect calorimetry. *J. Anim. Physiol. Anim. Nutr.* 2007; 91: 278-281.
76. Wichert, B., Opitz, B., Wehr, U. and Kienzle, E. (1999). Energy requirements of pet dogs. P80 in *Proceedings 26th World Veterinary Association (WVA), 24th World Small Animal Veterinary Association (WSAVA), 3rd Conference of the European Society of Veterinary and Comparative Nutrition (ESVCN)*, Lyon.
77. Zentek J, Meyer H. Energieaufnahme adulter Deutscher Doggen. *Berl Munch Tierarztl Wochenschr* 1992, 105, 325-327.
78. Zentek J. et al. Über den Einfluss einer unterschiedlichen Energieversorgung wachsender Doggen auf Körpermasse und Skelettentwicklung 3. Mitteilung: Klinisches Bild und chemische Skelettuntersuchungen. *Zbl Vet. Med. A* 1995; 42 (1): 69-80.

3. TAURINE

3.1 Introduction

Taurine (2-Aminoethanesulfonic acid = $\text{NH}_2\text{CH}_2\text{-CH}_2\text{-SO}_3\text{H}$) is a β -aminosulfonic acid rather than an α -carboxylic amino acid (Huxtable 1992). It was first isolated from the bile of the ox "Bos Taurus" and was named after it (Huxtable 1992).

Dogs and cats exclusively use taurine to conjugate bile acids. In dogs the rate of taurine synthesis appears

to be adequate to meet the needs, if their food contains adequate amounts of sulphur-containing amino acids. In cats, the ability to synthesize taurine is limited and insufficient to compensate for the natural losses via the conjugated bile acid (taurocholic acid) in the gastrointestinal tract. Hence taurine is an essential nutrient for the cat.

3.2 Cat

Taurine deficiency can lead to feline central retinal degeneration, dilated cardiomyopathy and reproductive failure. Taurine intake is considered to be adequate when plasma levels are greater than 50-60 $\mu\text{mol/L}$ (Pion et al. 1987, Douglas et al. 1991) or the whole blood concentration 200 $\mu\text{mol/L}$ or higher (Fox 2000).

In the late 1980s, the feeding of commercial cat foods containing levels of taurine that were considered to be adequate [based on studies with purified diets (Burger et al. '82, NRC 1986)] resulted in low plasma taurine levels in cats, and were associated with retinal degeneration and dilated cardiomyopathy (Pion et al. 1987).

Taurine is not degraded by mammalian enzymes,

but is excreted as such in the urine or in the form of taurocholate or related bile acids via the gastrointestinal tract (Huxtable 1992, Odle et al. '93). However, balance studies have indicated that taurine can be degraded by the intestinal microflora (Morris et al. 1994). The composition of the cat food, as well as the type of production process influence this intestinal degradation (Morris et al. 1994). Hickman et al. showed that heat-processed cat foods resulted in lower taurine plasma levels and greater losses compared to the same food but frozen-preserved (Hickman et al. 1990 & 1992). This was the consequence of increased sensitivity of taurine to intestinal bacterial degradation owing to the heat processing (Morris et al. 1994). For this reason the recommendation for taurine in canned cat food is higher than that for dry food or purified diets.

3.3 Dog

Healthy dogs synthesize sufficient taurine from dietary sulphur-containing amino acids such as methionine and cysteine. Nevertheless, low plasma or low whole-blood taurine levels may be seen in dogs fed non-supplemented very low protein diets, or foods that are low in sulphur-containing amino acids or with poor availability of the sulphur-containing amino acids (Sanderson et al. 2001, Backus et al. 2003).

Feeding certain lamb and rice foods may increase the risk of a low-taurine status, because of lower

bioavailability of sulphur-containing amino acids and increased faecal losses of taurine possibly caused by rice bran (Backus et al. 2003, Delaney et al. 2003, Fascetti et al. 2003, Torres et al. 2003).

In dogs, low plasma levels of taurine ($<40\mu\text{mol/L}$) may also predispose to dilated cardiomyopathy (Pion et al. 1998). However, some breeds seem to be more sensitive to develop such side effects (Pion et al. 1998), particularly Newfoundland dogs, in which the rate of taurine synthesis is decreased (Backus et al. 2006). The

addition of taurine to such foods or increasing the intake of the precursors of taurine (methionine and cysteine) can prevent such a decrease (Backus et al. 2003, Torres

et al. 2003). In dogs, adequate levels of taurine are values greater than 40µmol/L in plasma and greater than 200µmol/L in whole blood (Elliott et al. 2000).

3.4 Conclusion

The taurine values for cats, stated in the tables on pages 18-20, are starting points. Individual companies can have different levels of taurine in their products as long as they ensure that the products maintain adequate blood value in the cat's body (plasma levels should be greater than 50/60 µmol/L, > 200 µmol/L in whole blood). For dogs dietary taurine is not essential,

since dogs can synthesize taurine from sulphur amino acids, therefore dog foods should be formulated to maintain adequate body reserves of taurine (> 40µmol/L in plasma and >200µmol/L in whole blood).

Analytical methods for taurine are given on page 40.

3.5 References

1. Backus RC, Cohen G, Pion PD, et al. Taurine deficiency in Newfoundlands fed commercially balanced diets. *Journal of the American Medical Association* 2003; 223 (8): 1130-1136.
2. Backus RC. Low plasma taurine concentration in Newfoundland dogs is associated with plasma methionine and cyst(e)ine concentrations and low taurine synthesis. *J. Nutr.* 2006; 136: 2525-2533.
3. Burger, I.H. and Barnett, K. C. The taurine requirement of the adult cat *J. Small. Anim. Pract.* 1982; 23: 533-537.
4. Delaney, S.J., Kass, P.H., Rogers, Q.R. and A.J. Fascetti. (2003) Plasma and whole blood taurine in normal dogs of varying size fed commercially prepared food. *Journal of Animal Physiology and Animal Nutrition* 87: 236-344.
5. Douglass, G.M., Fern E. B., Brown R. C. Feline plasma and whole blood taurine levels as influenced by commercial dry and canned diets *J. Nutr.* 1991; 121: S179-S180.
6. Earle, K.E. and Smith, P.M. The effect of taurine content on the plasma taurine concentration of the cat *Br. J. Nutr.* 1991; 66: 227-235.
7. Elliott DA, Marks SL, Cowgill L, et al. *Am. J.* 2000; 61: 869-.
8. Fascetti AJ, Reed JR, Rogers QR, and Backus RC, Taurine deficiency in dogs with dilated cardiomyopathy: 12 cases (1997-2001). *JAVMA* 2003; 223 (8): 1137-1141.
9. Fox PR. Taurine deficiency dilated cardiomyopathy and idiopathic myocardial failure. In: *Textbook of Veterinary Internal Medicine.* SJ Ettinger, EC Feldman Edits. 5th edition, WB Saunders Company Philadelphia, PA. 2000: pp. 908-912.
10. Hickman M.A., Rogers Q.R., Morris J.G. Effect of Processing on Fate of Dietary [14C] Taurine in Cats. *J. Nutrition* 1990; 120: 995-1000.
11. Hickman M.A., Rogers Q.R., Morris J.G. Taurine Balance is Different in Cats Fed Purified and Commercial Diets. *J. Nutr.* 1992; 122: 553-559.
12. Huxtable RJ. Physiological actions of taurine. *Physiological reviews*; 1992; 72 (1): 101-163.
13. Morris JG, Rogers QR, Kim SW, Backus RC. Dietary taurine requirement of cats is determined by microbial degradation of taurine in the gut. *Vet. Clin. Nutr.* 1994; 1 (3): 118-127.
14. Oddle J, Roach M, Baker DH. Taurine utilization by cats. *J. Nutr.* 1993; 123: 1932-1933.
15. Pion PD, Sanderson SL, and Kittleson MD. The effectiveness of taurine and levocarnitine in dogs with heart disease. *Vet Clin of North Am Small Anim Pract* 1998; 1495-1514.
16. Pion, Kittleson & Rogers Myocardial failure in cats associated with low plasma taurine: a reversible cardiomyopathy *Science* 1987; 237: 764-768.

17. Sanderson SL, Gross KL, Ogburn PN, et al. Effects of dietary fat and L-carnitine on plasma and whole-blood taurine concentrations and cardiac function in healthy dogs fed protein-restricted diets. *Am J Vet Res.* 2001; 62: 1616-1623.
18. Spitze A.R, Wong D.L, Rogers Q.R, Fascetti A.J. (2003) Taurine concentrations in animal feed ingredients; cooking influences taurine content. *Journal of Animal Physiology and Animal Nutrition* 87: 251-262.
19. Stratton-Phelps M, Backus RC, Rogers QR, and Fascetti AJ. Dietary rice bran decreases plasma and whole-blood taurine in cats. *J. Nutr.* 2002; 132: 1745S-1747S.
20. Tôrres CL, Backus RC, Fascetti AJ, Rogers QR. Taurine status in normal dogs fed a commercial diet associated with taurine deficiency and dilated cardiomyopathy. *Journal of Animal Physiology and Animal Nutrition* 2003; 87: 359-372.

4. ARGININE

The arginine requirement increases with increased protein content owing to its role as an intermediate in the urea cycle. The NRC 2006 advises an extra 0.01g arginine for every 1% increase in protein (% DM) above the recommended allowance for all life stages in dogs, and an extra 0.02g arginine for every 1% increase in protein for cats.

The following tables outline the arginine recommendations for various protein contents. All values are stated as g/100g DM.

Table VII-13. Increases in arginine requirement with increasing protein content

DOGS					CATS	
Protein content	Arginine level				All life stages	
	Adult	Growth	Early growth	Reproduction	Protein	Arginine
% DM	g/100g DM	g/100g DM	g/100g DM	g/100g DM	% DM	g/100g DM
18	0.52	-	-	-	25	1.00
20	0.54	0.69	-	-	28	1.06
22.5	0.57	0.72	0.79	0.79	30	1.10
25	0.59	0.74	0.82	0.82	35	1.20
30	0.64	0.79	0.87	0.87	40	1.30
35	0.69	0.84	0.92	0.92	45	1.40
40	0.74	0.89	0.97	0.97	50	1.50
45	0.79	0.94	1.02	1.02	55	1.60
50	0.84	0.99	1.07	1.07	60	1.70
55	0.89	1.04	1.12	1.12	-	-

5. VITAMINS

5.1 Chemical compounds

Table VII-14. Conversion factors - Vitamin source to activity

Vitamin	Unit declared	Vitamin source used		Vitamin activity	
Vitamin A	IU			Retinol activity	
		vitamin A alcohol (retinol) ^{2, 3}	0.3 µg	=	1 IU
			1.0mg	=	3,333 IU
		vitamin A acetate	0.344 µg	=	1 IU
		vitamin A propionate	0.359 µg	=	1 IU
		vitamin A palmitate	0.55 µg	=	1 IU
		vitamin A alcohol (retinol)	1.0 µg	=	1 RE
			(RE = Retinol Equivalent)		
		Provitamin A (β-carotene) (dogs) ⁴	1.0mg	=	833 IU
Vitamin D Cholecalciferol	IU			Vitamin D activity	
		vitamins D ₃ & D ₂ ^{1, 3}	0.025 µg	=	1 IU
			1 µg	=	40 IU
Vitamin E Tocopherol	IU			Vitamin E activity	
		dl-α-tocopheryl acetate (all-rac-α-tocopheryl acetate)	1mg	=	1 IU
		Bio-equivalence of various tocopherols:			
		d-α-tocopherol	1mg	=	1.49 IU
		d-α-tocopherol acetate ¹	1mg	=	1.36 IU
		dl-α-tocopherol	1mg	=	1.10 IU
		dl-α-tocopheryl acetate	1mg	=	1.00 IU
		dl-β-tocopherol	1mg	=	0.33 IU
		dl-δ-tocopherol	1mg	=	0.25 IU
		dl-γ-tocopherol	1mg	=	0.01 IU
Vitamin B1 - Thiamine = Thiamine Cl	mg			Thiamine	
		thiamine mononitrate	1mg	=	0.92mg
		thiamine hydrochloride	1mg	=	0.89mg
D-Pantothenic acid	IU			Pantothenic acid	
		calcium D-pantothenate	1mg	=	0.92mg
		calcium DL-pantothenate	1mg	=	0.41 - 0.52mg
Vitamin B6 - Pyridoxine	mg			Pyridoxine	
		pyridoxine hydrochloride	1mg	=	0.89mg
Niacin	mg			Niamin	
		nicotinic acid	1mg	=	1mg
		nicotinamide	1mg	=	1mg
Choline	mg			Choline	
		choline chloride (basis choline ion)	1mg	=	0.75mg
		choline chloride (basis choline hydroxyl-analogue)	1mg	=	0.87mg
Vitamin K3 - Menadione	mg			Menadione	
		menadione sodium bisulphite (MSB)	1mg	=	0.51mg
		menadione pyrimidinol bisulphite (MPB)	1mg	=	0.45mg
		menadione nicotinamid bisulphite (MNB)	1mg	=	0.46mg

5.2 References

1. Arbeitsgemeinschaft für Wirkstoffe in der Tierernährung e. V. (AWT). *Vitamins in animal nutrition*. 2002.
2. McDowell. *Vitamins in animal and human nutrition*. 2nd edition Iowa State University Press 2000.
3. NRC. Table 2. In: *Nutrient Requirements of Cats*. National Academy Press, Washington, DC 1986: 42.
4. NRC. Composition of ingredients of dog foods. In: *Nutrient Requirements of Dogs*. National Academy Press, Washington, DC 1985: 40-41.

6. ADVERSE REACTIONS TO FOOD

6.1 Introduction

Adverse food reactions in cats and dogs are mainly expressed by pruritus and gastrointestinal signs. Acute anaphylactic reactions such as those seen in a minority

of people who are allergic to nuts and some other foods have not been reported in relation to pet food.

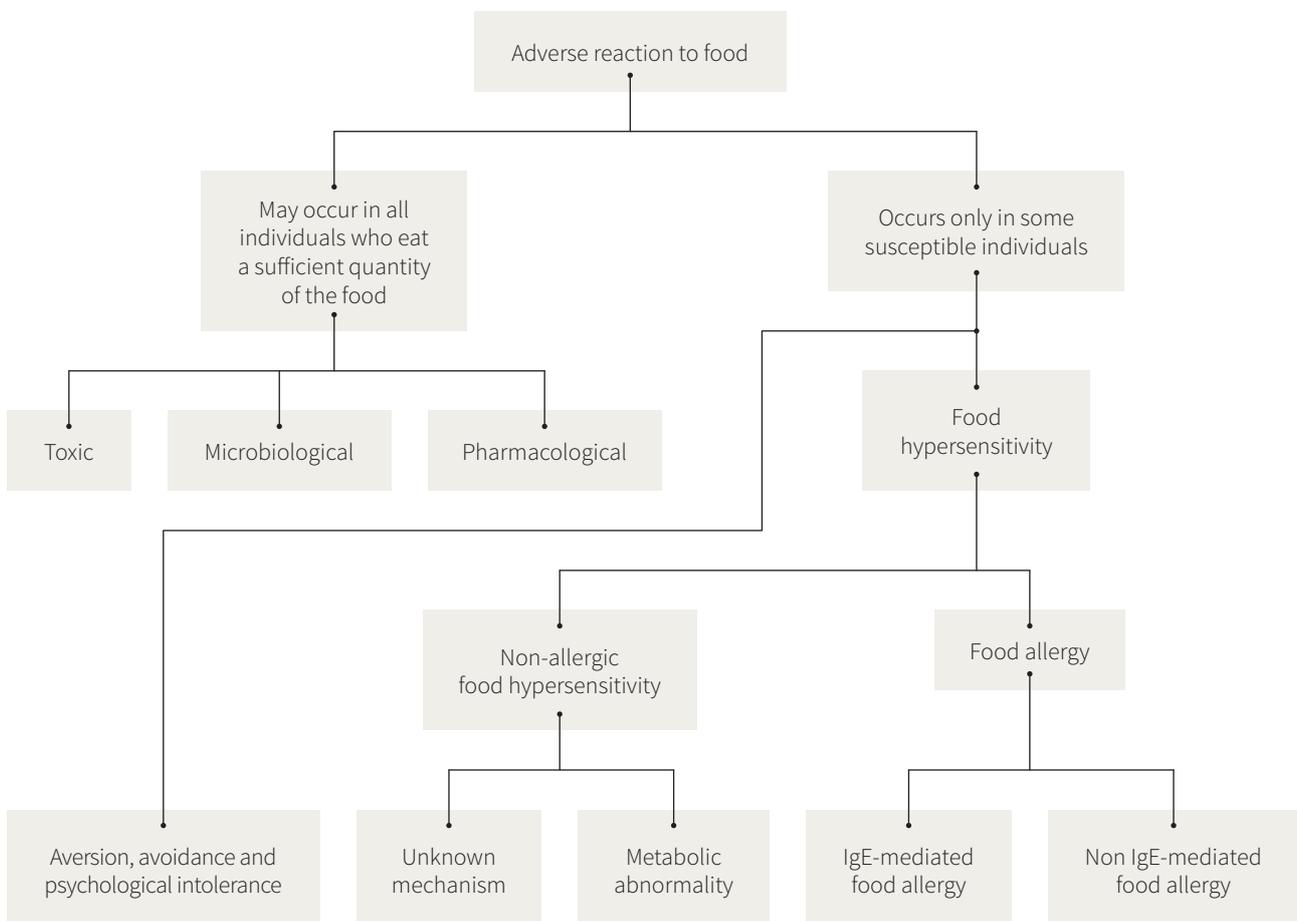
6.2 Definitions

6.2.1 Adverse reactions to food

An **adverse reaction** to a food is an abnormal or exaggerated clinical response to the ingestion of a food or food additive. It may be immune mediated

(called food allergy or hypersensitivity) or not immune mediated (called food intolerance) (Reedy et al. 1997).

Figure VII-1. Classification of adverse reactions to food



Source: ILSI Monograph Food Allergy 2003

6.2.2 Food allergy

Allergy Immune-mediated reaction resulting in one or more of the clinical signs described under 6.4. Adverse reactions to food in cats and dogs.

Anaphylaxis Anaphylaxis is an acute life-threatening multi-system allergic reaction resulting from exposure to an offending agent. In people,

foods, insect stings, and medication are the most common causes (Tang 2003, Oswalt et al. 2007, Wang et al. 2007). The term has been variably employed to denote a defined IgE-mediated antigen-induced reaction or as a descriptive term delineating a severe, abrupt, untoward event of unstated immunologic significance (Wasserman 1983).

6.2.3 Non-allergic food hypersensitivity

Food idiosyncrasy A non-immune mediated reaction to a food component that causes clinical signs resembling an immune-mediated reaction to food (food allergy).

Metabolic reaction Food intolerance. An adverse reaction caused by a metabolic defect (e.g. lactose intolerance).

6.2.4 All individuals susceptible if sufficient quantity eaten

Toxic reaction Reaction to a toxic food component (e.g. onions).

Microbiological reaction Reaction to a toxin released by contaminating organisms (e.g. mycotoxins).

Pharmacologic reaction Adverse reaction to a food as result of a naturally derived or added chemical

producing a drug-like or pharmacological effect in the host such as methylxanthines in chocolate or pseudo-allergic reactions caused by high histamine levels in not well-preserved scombroid fish (tuna or salmon).

Dietary indiscretion Adverse reaction resulting from such behaviour as gluttony, pica or ingestion of various indigestible materials or garbage.

6.3 Food allergy in humans

Food allergies are the single most common cause of generalised anaphylaxis seen in hospital emergency departments, accounting for about one third of cases seen (twice the number of cases seen for bee stings) (Sampson 1999). It is estimated that about 100 fatal cases of food-induced anaphylaxis occur in the US each year (Sampson 1999). The most

common allergens causing anaphylaxis in people are nuts, shellfish, milk, egg white, legumes, certain fruits, grains, chocolate, and fish (Wasserman 1983).

As far as we are aware of, cases of allergies in humans related to ingestion or contact with pet foods are not reported in the literature.

6.4 Adverse reactions to food in cats and dogs

The predominant clinical sign in dogs and cats (almost 100% of the cases) is pruritus (itching) (Rosser 1990, White 1986, White 1989, Scott et al. 2001). The pruritus can be generalised or localised,

sometimes being restricted to recurrent otitis. Other dermatological changes such as seborrhoea, recurrent pyoderma or *Malassezia* can be seen in allergic dogs (White 1986, Scott et al. 2001). In allergic

cats eosinophilic plaque, miliary dermatitis or alopecia caused by excessive grooming can be the only clinical sign present (White 1986, Scott et al. 2001).

An estimated 10 to 15 % of the cases of food allergy in dogs and cats are believed to result into gastrointestinal (GI) signs such as: diarrhoea and vomiting (Scott et al. 2001). However, the GI signs can be very discrete (e.g. more frequent bowel movements) (Scott et al. 2001) and their prevalence may be underestimated (Loeffler et al. 2004 & 2006).

In cats and dogs immune mediated reactions are seldom confirmed in practice. Therefore, the term adverse reactions to food is generally accepted and used for cats and dogs.

In dogs and cats, adverse reactions to food are only diagnosed through the elimination of the food component (eviction diet) following either dermatological or digestive symptoms (or both). Ideally this should be confirmed by a challenge (reintroduction of the suspected component) after clinical signs have disappeared when feeding the eviction diet (Wills J. 1994, Helm 2002).

Adverse reactions to food are deemed to account for about 1-5 % of all skin conditions in dogs and

1-6% of all feline dermatoses (animal presented to veterinary practices) (Reedy et al. '97). Most food ingredients have the potential to induce adverse reactions because they contain intact proteins.

Now, intact proteins are part of all products made by our industry including all pet foods (except special diets with hydrolysed proteins as the sole source of protein). All products containing intact protein can potentially cause allergic/adverse reactions in predisposed animals (McDonald 1997). There are proteins against which dogs and cats seem to react more often (Wills 1994). Milk, beef, eggs, cereals and dairy products are mentioned most often whereas more controlled studies mentioned wheat, soy, chicken and maize as the most important allergens. However, it is not always clear whether these data are taken over from human literature or not. In addition, the data do not always enable to see whether the high incidence is not simply the consequence of the fact that those proteins have been eaten more frequently by dogs and cats.

Through veterinarians, special diets made with selected protein sources or hydrolysed proteins are available for dogs and cats suffering of adverse reactions to food; the formulation and the label declarations for those foods are regulated by the specific EU legislation on dietetic foods for animals.

6.5 Conclusions

1. Most protein containing ingredients have the potential to induce allergic reactions if they are regularly fed to dogs and cats.
2. Anaphylactic reactions to food as seen in humans

are not, as far as we know, reported in literature relating to cats and dogs. The hallmark of adverse reaction in dogs and cats to food is pruritus.

6.6 References

1. Hall E J. *Gastro-intestinal aspects of food allergy: A review. Journal of Small Animal Practice* 1994; 35: 145 – 152.
2. Halliwell R E W. *Comparative aspects of food intolerance. Veterinary Medicine* 1992; 87: 893 – 899.
3. Halliwell R E W. *Management of dietary hypersensitivity in the dog. Journal of Small Animal Practice* 1992; 33: 156 – 160.
4. Helm RM. *Food allergy animal models: an overview. Ann N Y Acad Sci* 2002 May; 964:139-150.
5. Loeffler A, Lloyd DH, Bond R, et al. *Dietary trials with a commercial chicken hydrolysate diet in 63 pruritic dogs. Vet. Rec.* 2004; 154: 519-522.
6. Loeffler A, Soares-Magalhaes R, Bond R, Lloyd DH. *A retrospective*

analysis of case series using home-prepared and chicken hydrolysate diets in the diagnosis of adverse food reactions in 181 pruritic dogs. *Vet Dermatol.* 2006;17 (4): 273-279.

7. McDonald JM. Food trial: to do or not to do? TNAVC 1997 Proceedings.
8. Oswalt ML, Kemp SF. Anaphylaxis: office management and prevention *Immunol Allergy Clin North Am* 2007; 27 (2): 177-191.
9. Reedy LLM, Miller Jr. WH, Willemse T. Chapter 7. Food Hypersensitivity. In: *Allergic Diseases of Dogs and Cats 2nd edition* WB Saunders Company Ltd. London; 1997: 173 – 188.
10. Rosser EJ. Proceedings of the ACVD 1990.
11. Sampson HA. Food allergy. Part 1: Immunopathogenesis and clinical disorders. *The Journal of Allergy and Clinical Immunology* 1999; 103 (5): 717 - 728.
12. Scott DW, Miller WH, Griffin CE. Chapter 8. Skin immune system and allergic skin diseases In: *Muller & Kirk's Small Animal Dermatology.* 6th edition WB Saunders Company Philadelphia, PA. 2001: pp. 543-666.
13. Tang AW. A practical guide to anaphylaxis. *Am Fam Physician* 2003; 68 (7): 1325-1332.
14. Wang J, Sampson HA. Food Anaphylaxis. *Clin Exp Allergy.* 2007; 37 (5): 651-660.
15. Wasserman S I. Anaphylaxis Chapter 34. In: *Allergy Principles and Practice* E. Middleton, Jr., CE Reed, & EF Ellis Edits. The C.V. Mosby Company St. Louis, second edition, 1983: 689 – 699.
16. White SD, Sequoia D. Food hypersensitivity in cats: 14 cases (1982-1987). *J. Am. Vet. Assoc.* 1989; 194 (12): 692 - 695.
17. White SD. Food hypersensitivity in 30 dogs *J. Am. Vet. Med. Assoc.* 1986; 188 (7): 695-698.
18. Wills J, Harvey R. Diagnosis and management of food allergy and intolerance in dogs and cats *Aust Vet J* 1994 Oct; 71(10):322 – 326.

7. RISK OF SOME HUMAN FOODS REGULARLY GIVEN TO PETS

ANNEX 6 provides some practical information about some common human foods (such as raisins, grapes, onions, garlic and chocolate) with documented adverse effects when given to dogs or cats either as a treat or when left over from the table are shared with pets.

This annex lists signs that should alert pet owners and combines information that is not easily found in one place or has only been available recently. There may be other foods that are potentially hazardous when fed to dogs or cats, but they are not yet documented.

7.1 Grape and raisin toxicity in dogs

7.1.1 Background

Since 1989 the Animal Poison Control Centre (APCC) of the American Society for the Prevention of Cruelty to Animals has recorded cases of poisoning in dogs that had eaten grapes (*Vitis* spp) or raisins. From April

2003 to April 2004 the APCC managed 140 cases, of which 50 dogs developed clinical signs and seven died (ASPCA, 2004). Cases have been reported in the USA and the UK (Eubig et al. 2005, Penny et al. 2003).

7.1.2 Clinical signs and pathology

Affected dogs typically suffer gastrointestinal upset followed by acute renal failure (ARF). The initial signs of grape or raisin toxicity are vomiting (100% of reported cases) followed by lethargy, anorexia, diarrhoea, abdominal pain, ataxia, and weakness (Eubig et al. 2005). In the majority of dogs, vomiting, anorexia, lethargy and diarrhoea occur within the first 24 hours of exposure, in some cases vomiting starts as early as 5 to 6 hours after ingestion (Eubig et al. 2005). The vomit and or faeces may contain partially digested grapes or raisins or swollen raisins. Classic signs of ARF can develop within 24 hours or up to several days later. These include substantial increases in blood urea and serum creatinine, as well as in the calcium x phosphorus product, serum phosphorus and later in total calcium

level (Eubig et al. 2005). If the condition progresses, the dog eventually is unable to pass urine. At this stage the prognosis is generally poor and usually a decision is taken to euthanize the animal.

The most consistent histopathological lesions reported were diffuse renal tubular degeneration, especially in the proximal tubules (Eubig et al. 2005). Mineralization of necrotic renal structures has been reported, but also tubular cell regeneration in some cases. Mineralization and/or congestion of extra-renal tissues and organs have also been observed (Eubig et al. 2005). It has to be pointed out, however, that many dogs never develop AFR after ingestion of raisins or grapes.

7.1.3 Toxic agent

The toxic agent (or agents) has so far defied detection. Analysis for a variety of substances has proved negative, including mycotoxins, heavy metals, pesticides and vitamin D3 (AFIP 2003, Eubig et al. 2005). It is postulated that the cause may be a nephrotoxin or anaphylactic shock leading to renal problems (AFIP 2003). Excess sugar intake has also

been suggested, resulting in a disturbance of sugar metabolism, but this seems unlikely as dogs are not known for susceptibilities to high sugar intake.

The poisoning seems to occur with grapes and raisins of all types: those purchased from a store or grown at home, grape pressings from wineries and

seedless and seeded varieties (Eubig et al. 2005). Grape extract is not considered a threat; the grape or raisin itself has to be eaten for poisoning to occur (McKnight, 2005).

The lowest intake that has so far been reported to cause poisoning is around 2.8g of raisins per kg bodyweight (BW) and 19.6g of grapes per kg BW; one

dog became ill after only eating 10 to 12 grapes (Eubig et al. 2005). The severity of the illness does not seem to be dose-related (Eubig et al. 2005). Even a large dog of 40kg may need to eat only 120g to be at risk and as cartons of raisins typically contain 500g this amount could be ingested in one session. At present it appears that only dogs are affected – the susceptibility of other species is unknown.

7.1.4 Treatment

Immediate treatment consists of inducing emesis and lavage of the stomach to remove the poison, followed by decontamination using activated charcoal to inactivate the remaining poison. Aggressive fluid therapy is essential to increase the chances of

survival, and should be maintained long enough (at least 48 hours). Haemodialysis and diuretics such as furosemide have been recommended to treat the ARF and oliguria (McKnight, 2005), but do not seem to increase survival substantially (Eubig et al. 2005).

7.1.5 References

1. AFIP. (2003) Armed Forces Institute of Pathology, Department of Veterinary Pathology, Conference 7, 29 October.
2. ASPCA. (2004) Raisins and grapes can be toxic to dogs. ASPCA Animal Poison Control Centre Issues Nationwide Update, 6 July.
3. Eubig, P.A., Brady, M.S., Gwaltney-Brant S.M., et al. (2005) Acute renal failure in dogs after the ingestion of grapes or raisins: A retrospective evaluation of 43 dogs (1992-2002). *Journal of Veterinary Internal Medicine* 19, 663-674.
4. Gwaltney-Brant, S.M., Holding, J.K., Donaldson, C.W., et al. (2001) Renal failure associated with ingestion of grapes or raisins in dogs. *Journal of the American Veterinary Medical Association* 218 (10), 1555-1556.
5. McKnight, K. (2005). Grape and raisin toxicity in dogs. *Veterinary Technician*, February issue, 135-136.
6. Penny, D., Henderson, S.M., Brown, P.J. (2003) Raisin poisoning in a dog. *Veterinary Record* 152 (10), 308.

7.2 Chocolate toxicity

7.2.1 Background

Cocoa poisoning was highlighted during the Second World War, when pigs, calves, dogs and horses were poisoned because by-products of cacao beans were used to supplement feeds as a result of a surplus.

Chocolate is palatable to most dogs, but it is not an innocent snack being relatively toxic. In dogs signs of toxicity may develop within hours after consumption.

In addition, chocolate cakes and other cocoa

containing human foods are best avoided. It is not surprising that most accidents are reported during holiday periods such as Christmas and Easter (Campbell 2001). Chocolate treats specially developed for dogs are not toxic as they are made from ingredients that contain low or no theobromine.

No reports of chocolate poisoning in cats have been published to our knowledge, probably as a consequence of their different eating habits.

7.2.2 Toxic agent

The principle toxic components of chocolate and cocoa products are the methylxanthine alkaloids, of which theobromine is the major toxin (Campbell 2001). As long ago as 1917, cacao bean shell intoxication in horses was attributed to theobromine by French researchers. Theobromine is particularly toxic to dogs, because its elimination is very slow compared with the rate in other species such as man (Hooser 1984, Glauberg 1983). The half life of theobromine in dogs is about 17.5 hours (Farbman 2001, Hooser & Beasley 1986). Theobromine undergoes enterohepatic recirculation resulting in an accumulative effect (Campbell 2001, Farbman 2001). As a consequence, repeated intakes of smaller (non-toxic) quantities may still cause intoxication. The slow elimination of theobromine is also responsible for decreased survival rate in affected dogs and death may still occur at a stage when clinical signs are already attenuating (Strachan & Bennett 1994).

Caffeine is another methylxanthine present in cocoa products, and may contribute to the toxicity. However, the levels of caffeine in cocoa products are much lower than those of theobromine and the half

life is much shorter (4.5 hours) (Farbman 2001, Hooser & Beasley 1986).

The LD₅₀ of theobromine has been reported to be between 250mg and 500mg per kg body weight (BW); lethal cases have been seen when dogs ingested amounts of chocolate that reflect an estimated theobromine intake of 90-115mg/kg BW (Glauberg 1983, Hooser & Beasley 1986, Carson TL 2001).

The level of theobromine content of chocolate varies, with dark chocolate containing the highest level (Table 1). Unsweetened baking chocolate should definitely be kept out of reach of dogs, since it contains up to 20mg of theobromine per gram. Dogs also voluntarily eat cocoa powder, in which the average theobromine level varies from 10 to 30mg/g (Sutton '81). About four grams of cocoa powder per kg BW may be sufficient to kill a dog (Faliu 1991). Increasingly cocoa shell mulches are used to prevent weeds and for landscaping in gardens. They are often attractive to dogs because of the chocolate smell and therefore may be a potential cause of theobromine poisoning (Hansen et al. 2003).

Table VII-15. Theobromine content of different types of chocolate and cocoa products (mg/g)

White chocolate	0.009 - 0.035	Cocoa powder	4.5 - 30
Milk chocolate	1.5 - 2.0	Cocoa beans	10 - 53
Sweet to semisweet dark chocolate	3.6 - 8.4	Cocoa shell mulches	2 - 30
Bitter chocolate, chocolate liquor, baking chocolate	12 - 19.6	Coffee beans	-

Farbman DB 2001, Gwaltney-Brant S. 2001, Hansen et al. 2003, Shively et al. 1984, Carson 2001.

7.2.3 Clinical signs

In dogs methylxanthines cause stimulation of the central nervous system with tachycardia (fast heart

beating), respiratory stress and hyperactivity (Campbell 2001, Farbman 2001). The clinical signs include

vomiting, diarrhoea, agitation, muscular tremors and weakness, cardiac arrhythmias, convulsions, and, in severe cases, renal damage, coma and death (Glauberg 1983, Decker 1972, Nicholson 1995, Farbman 2001, Hooser & Beasley 1986). Death may occur within six to 15 hours after intake of excessive amounts of chocolate or cocoa products (Glauberg 1983, Decker

1972, Drolet et al. 1984).

At necropsy, congestion in liver, kidneys, pancreas and the gastro-intestinal tract are seen, as well as unclotted haemorrhagic fluid in peritoneal and thoracic cavities (Sutton '81, Strachan & Bennett 1994).

7.2.4 Treatment

No specific antidote is available for theobromine, only symptomatic treatment. In order to minimise the absorption of theobromine vomiting can be induced immediately after ingestion. Subsequently lavage can be applied with warm water to keep the chocolate

liquid. Repeated doses of activated charcoal can then be used to bind the remaining material and prevent further absorption and increase excretion (Glauberg 1983, Hooser & Beasley 1986, Farbman 2001, Carson 2001).

7.2.5 References

1. Benzel HA (1996) Chocolate poisoning in dogs. *Veterinary Technician* 135 & 184.
2. Campbell A. (2001) Chocolate intoxication in dogs. *UK Vet*, 6 (6): 40-42.
3. Carson TL, (2001) Methylxanthines. In: *Small Animal Toxicology*. Peterson ME, Talcott PA, edits. WB Saunders Company, Philadelphia, PA. pp. 563-570.
4. Decker RA, Myers GH. (1972) Theobromine Poisoning in a Dog. *JAVMA*, 161 (2), 198-199.
5. Drolet R, Arendt TD, Stowe CM. (1984) Cacao bean shell poisoning in a dog. *JAVMA*, 185 (8): 902.
6. Faliu L. (1991) Les intoxications du chien par les plantes et produits d'origine végétale. *Pratique médicale et chirurgicale de l'animal de compagnie*, 26 (6), 549-562.
7. Farbman DB. (2001) Death by chocolate? Methylxanthine toxicosis. *Veterinary Technician* 145-147.
8. Glauberg A, Blumenthal HP. (1983) Chocolate Poisoning in the Dog. *JAAHA*, 19 (3/4), 246-248.
9. Gwaltney-Brant S. (2001) Chocolate intoxication. *Toxicology Brief - Veterinary Medicine Publishing Group*.
10. Hansen S, Trammel H, Dunayer E, et al. (2003) Cocoa bean mulch as a cause of methylxanthine toxicosis in dogs. *NACCT - Poster*.
11. Hooser SB, Beasley VR. (1986) Methylxanthine poisoning (chocolate and caffeine toxicosis). In: *Current Veterinary Therapy IX Small Animal Practice* ed. RW Kirk, WB Saunders Company pp.191-192.
12. Hoskam EG, Haagsma J. (1974) Chocoladevergiftiging bij twee dashonden (Teckels) met dodelijke afloop. *Tijdschrift voor Diergeneeskunde* 99 (10), 523- 525.
13. Humphreys DJ, Clarck ML. (1991) In: *Canine Medicine and Therapeutics 3rd edit* Chandler; Thompson, Sutton Oxford Blackwell Scientific Publications. pp: 723-738.
14. Nicholson SS. (1995) Toxicology. In: *Textbook of Veterinary Internal Medicine 3rd edit*. S.J. Ettinger, E.C. Feldman, W.B. Saunders Company, pp. 312 – 326.
15. Shively CA, Tarka SM (1984) Methylxanthine composition and consumption patterns of cocoa and chocolate products. *Prog Clin Biol Res*. 158: 149-178.
16. Strachan ER, Bennett A. (1994) Theobromine poisoning in dogs *Vet Rec*. 284 (letter).
17. Sutton RH. (1981) Cocoa poisoning in a dog. *Vet. Rec*. 109, 563-564.

7.3 Toxicity of onions and garlic in cats & dogs

7.3.1 Background

It has been known since 1930 that dogs are very sensitive to onions (*Allium* spp) whether raw, cooked

or dehydrated.

7.3.2 Clinical signs and pathology

Regenerative anaemia with marked Heinz body formation has been reported in cats and dogs after eating onions or onion containing foods (Harvey et al. 1985, Kaplan 1995, Robertson et al. 1998, Spice 1976, Tvedten et al. 1996). Consumption of a sufficient amount of onions leads to oxidative injury of the lipid membrane of the erythrocytes and irreversible oxidative denaturation of haemoglobin. This results in formation of Heinz bodies, eccentrocytes (red blood cells with haemoglobin clustering at one side of the cell, which makes these cells more susceptible to lysis than normal red blood cells), haemolytic anaemia, haemoglobinuria, increased serum bilirubin and possibly methaemoglobinemia (Faliu 1991, Cope 2005, Harvey et al. 1985, Kaplan 1995, Lee et al. 2000, Robertson et al. 1998, Means 2002). Relatively small amounts of fresh onions (5 to 10g/kg BW) can already be toxic (Faliu 1991, Cope 2005). Robertson et al. 1998 showed that effect was dose dependent.

The clinical signs are secondary to the anaemia and include pale mucous membranes, tachycardia, tachypnoea, lethargy and weakness (Gfeller & Messonier 1998, Cope 2005). Vomiting, diarrhoea and abdominal pain may also be present. If only a moderate amount of onions has been eaten, the Heinz body anaemia resolves spontaneously after discontinuing the onions (Kaplan 1995, Robertson et al. 1998). In more severe cases, icterus and renal failure can be seen as a consequence of the haemolysis and haemoglobinuria respectively, and possibly death (Ogawa et al. 1986, Cope 2005).

Although onion ingestion has been reported as being the most common cause of Heinz body haemolysis in dogs (Weiser 1995), it may be difficult to correlate clinical

signs with the onion ingestion because of the lag of several days before the onset of clinical signs (Weiser 1995, Cope 2005).

Although onion poisoning is more common in dogs, cats are more sensitive to onion and garlic poisoning owing to their specific haemoglobin structure, making them more susceptible to oxidative stress (Giger 2000).

Garlic and Chinese chives have also been reported to cause the development of Heinz bodies, eccentrocytes, haemolytic anaemia and increases in methaemoglobin levels in dogs (Lee et al. 2000, Yamato et al. 2005). Lee et al. reported toxic effects after administration 1.25ml of garlic extract per kg BW (equivalent to 5g/kg BW of whole garlic) for 7 days, this is similar to the amounts reported in onion poisoning.

The increase in reduced glutathione (G-SH), which has been reported after ingestion of onions and garlic, may seem inconsistent with oxidative damage, but the increase can be a compensatory rebound reaction after an initial decrease in G-SH and other body anti-oxidants, and an increase in oxidised glutathione (GSSG) within the first few days (Yamoto 1992, Ogawa et al. 1986).

Dogs with hereditary high erythrocyte concentrations of reduced glutathione and potassium appear to be more sensitive to onion and garlic poisoning (Yamoto et al. 1992).

Wild onions (*A. validum* & *A. Canadense*) and wild garlic (*A. ursinum*) have caused haemolytic anaemia in horses and ruminants (Lee et al. 2000) and are potentially toxic for dogs and cats as well.

7.3.3 Toxic agent

Several organo-sulfoxides have been implicated in toxicity induced by onions and garlic (Table 2). Miyata reported the extraction from onions of an unnamed phenolic compound causing similar effects on red blood cells “in vitro” (Miyata 1990). Allicin,

a compound found in garlic, is similar to n-propyl disulfide found in onions (Gfeller & Messonier 1998). These organosulfur compounds are readily absorbed in the gastrointestinal tract and metabolised to highly reactive oxidants (Cope 2005).

Table VII-16.

Compounds isolated from onions and garlic and reported to oxidise canine erythrocytes

Onions	Garlic
n-propyl disulfide	sodium 2-propenyl thiosulfate
n-propyl	bis-2-propenyl trisulfide
3 different sodium alk(en)yl thiosulfates	bis-2-propenyl tetrasulfide
e.g. sodium n-propyl thiosulfate	bis-2-propenyl pentasulfide
trans-1-propenyl thiosulfate	bis-2-propenyl thiosulfonate
cis-1-propenyl thiosulfate	several sulphur containing esters

Chang et al. '04, Fenwick 1984, Hu et al. 2002, Yamato et al. 1998, Yamato et al. 2003.

7.3.4 Treatment

No specific antidote exists, and the treatment is supportive and is intended to reduce the oxidative effects and to prevent renal damage caused by haemoglobinuria. Oxygen therapy, fluid therapy (particularly crystalloids) and blood transfusion have been recommended (Gfeller & Messonier 1998). Induction of vomiting can be useful within the first

hour after ingestion of onions if the patient does not yet show clinical signs (Gfeller & Messonier 1998). Antioxidant vitamins such as vitamins E and C may have subclinical beneficial effects that help in milder cases, but a study in cats did not show a significant effect on the formation of Heinz bodies (Hill et al. 2001).

7.3.5 References

1. Chang HS, Yamato O, Sakai Y, et al. (2004) Acceleration of superoxide generation in polymorphonuclear leukocytes and inhibition of platelet aggregation by alk(en)yl thiosulfates derived from onion and garlic in dogs and humans. *Prostaglandins Leukot Essnt Fatty Acids*, 70 (1): 77-83.
2. Cope, R.B. (2005) *Allium species poisoning in dogs and cats. Toxicology brief Veterinary Medicine* pp. 562-566.

3. Faliu L. Les intoxications du chien par les plantes et produits d'origine végétale. *Prat Méd Chirurg Anim Comp*, 1991; 26 (6): 549-562.
4. Fenwick GR. (1984) Onion Toxicity. *Modern Veterinary Practice* 65 (4): 4.
5. Gfeller RW, Messonier SP. (1998) Onion and garlic toxicity. In: *Handbook of small animal toxicology and poisonings*. Mosby, Inc. St. Louis, MO, pp. 197-198.
6. Giger U. (2000) Regenerative anemias caused by blood loss or hemolysis. Chapter 177. In: *Textbook of veterinary Internal Medicine*. SJ Ettinger & EC Feldman edits. WB Saunders Company Philadelphia, PA, pp. 1784-1804.
7. Harvey JW, Rackear D. (1985) Experimental Onion-Induced Hemolytic Anemia in Dogs. *Vet Pathol*. 22: 387-392.
8. Hill AS, O'Neill S, Rogers QR, Christopher MM. (2001) Antioxidant prevention of Heinz body formation and oxidative injury in cats. *Am J Vet Res*. 62 (3): 370-374.
9. Hu Q, Yang Q, Yamato O, et al. (2002): Isolation and identification of organosulfur compounds oxidizing canine erythrocytes from garlic (*Allium sativum*). *J Agric Food Chem*, 50 (5): 1059-1062.
10. Kaplan AJ. (1995) Onion powder in baby food may induce anemia in cats. *Journal of the American Veterinary Medical Association* 207 (11): 1405 (letter).
11. Lee K-W, Yamato O, Tajima, et al. (2000) Hematologic changes associated with the appearance of eccentrocytes after intragastric administration of garlic extract to dogs. *Am. J. Vet. Res*. 61 (11): 1446-1450.
12. Means C. (2002) Selected herbal hazards. *Veterinary Clinics of North America – SAP*, 32 (2): 367-382.
13. Miyata D. (1990) Isolation of a new phenolic compound from the onion (*Allium Cepa* L. Onion) and its effect on erythrocytes. *Japanese Journal of Veterinary Research*, 38: 65.
14. Ogawa E, Shinoki T, Akahori F, Masaoka T. (1986) Effect of Onion Ingestion on Anti-oxidizing Aspects in Dog Erythrocytes. *Japanese Journal of Veterinary Science*. 48 (4): 685-691.
15. Roberston JE, Christopher MM, Rogers QR. (1998) Heinz body formation in cats fed baby food containing onion powder. *Journal of the American Veterinary Medical Association* 212 (8), 1260-1266.
16. Spice RN. (1976) Case Report Hemolytic anemia associated with ingestion of onions in a dog. *Can Vet J*. 17 (7): 181-183.
17. Tvedten HW, Holan K. (1984) What is your diagnosis? A 13-year-old Abyssinian-mixed breed cat. *Veterinary Clinical Pathology* 25 (4): 148-154.
18. Weiser MG. Erythrocyte responses and disorders. In: *Textbook of Veterinary Internal Medicine*, 3rd edit. SJ Ettinger, EC Feldman, WB Saunders Company, 1995; 1864-1891.
19. Yamato O, Hayashi M, Yamasaki M, Maede Y. (1998) Induction of onion-induced haemolytic anaemia in dogs with sodium n-propylthiosulphate. *Vet Rec*. 142 (9): 216-219.
20. Yamato O, Kasai E, Katsura T, et al. (2005) Heinz body hemolytic anemia with eccentrocytosis from ingestion of Chinese chive (*Allium tuberosum*) and garlic (*Allium sativum*) in a dog. *J Am Anim Hosp Assoc*, 41 (1): 68-73.
21. Yamato O, Maede Y. (1992) Susceptibility to onion-induced hemolysis in dogs with hereditary high erythrocyte reduced glutathione and potassium concentrations. *Am. J. Vet. Res*. 53 (1): 134-138.

8. PRODUCT FAMILIES

1. Product families are considered within a company.
2. Product families are defined by animal species (dogs/cats).
3. All products within a family must be of the same processing type (extruded, baked, pelleted, canned, fermented, etc.) and within the same moisture content category (dry, semi-moist and wet).
4. A product family refers to complete or complementary foods.
5. A product family has to refer to a specific life stage, a specific life style or a specific animal size.
6. The product family members must meet the metabolizable energy (ME) density (as it is described in the specific chapter of these Guidelines) of the lead product members and be formulated on an ME basis to :
 - meet the nutrient levels of the lead family product for key nutrients, and
 - not exceed the maximum levels of any nutrient or nutrient ratio established in the fediaf Nutritional Guideline or by law.

N.B. When analyses are performed, the same analytical methods must be used for all products belonging to the product family.

9. RECOMMENDED NUTRIENT LEVELS BY LIFESTAGE AND MAINTENANCE ENERGY REQUIREMENT

Tables VII-18_{a-d}. Recommended nutrient levels for dogs by lifestage and Maintenance Energy Requirement

18_a	Recommended nutrient levels for early growth and reproduction
18_b	Recommended nutrient levels for late growth
18_c	Recommended nutrient levels for adult dogs based on a MER of 110kcal/kgBW ^{0.75}
18_d	Recommended nutrient levels for adult dogs based on a MER of 95kcal/kgBW ^{0.75}

Tables VII-19_{a-c}. Recommended nutrient levels for cats by lifestage and Maintenance Energy Requirement

19_a	Recommended nutrient levels for feline growth and reproduction
19_b	Recommended nutrient levels for adult cats based on a MER of 100kcal/kgBW ^{0.67}
19_c	Recommended nutrient levels for adult cats based on a MER of 75kcal/kgBW ^{0.67}

When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter III 3.1 and III 3.2.

Table VII-18_a Recommended nutrient levels for dogs - early growth (< 14 weeks) & reproduction

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	62.50	-	14.94	-	25.00	-
Arginine*	g	2.04	-	0.49	-	0.82	-
Histidine	g	0.98	-	0.23	-	0.39	-
Isoleucine	g	1.63	-	0.39	-	0.65	-
Leucine	g	3.23	-	0.77	-	1.29	-
Lysine*	g	2.20	7.00 (N)	0.53	1.67 (N)	0.88	2.8 (N)
Methionine*	g	0.88	-	0.21	-	0.35	-
Methionine + cystine*	g	1.75	-	0.42	-	0.70	-
Phenylalanine	g	1.63	-	0.39	-	0.65	-
Phenylalanine + tyrosine*	g	3.25	-	0.78	-	1.30	-
Threonine	g	2.03	-	0.48	-	0.81	-
Tryptophan	g	0.58	-	0.14	-	0.23	-
Valine	g	1.70	-	0.41	-	0.68	-
Fat*	g	21.25	-	5.08	-	8.50	-
Linoleic acid (ω-6) *	g	3.25	16.25 (N)	0.78	3.88 (N)	1.30	6.50 (N)
Arachidonic acid (ω-6)	mg	75.00	-	17.90	-	30.00	-
Alpha-linolenic acid (ω-3) *	g	0.20	-	0.05	-	0.08	-
EPA + DHA (ω-3) *	g	0.13	-	0.03	-	0.05	-
Minerals							
Calcium*	g	2.50	4.00 (N)	0.60	0.96 (N)	1.00	1.6 (N)
Phosphorus	g	2.25	-	0.54	-	0.90	-
Ca / P ratio		1/1	1.6/1(N)	1/1	1.6/1(N)	1/1	1.6/1 (N)
Potassium	g	1.10	-	0.26	-	0.44	-
Sodium*	g	0.55	-	0.13	-	0.22	-
Chloride	g	0.83	-	0.20	-	0.33	-
Magnesium	g	0.10	-	0.02	-	0.04	-
Trace elements*							
Copper*	mg	2.75	(L)	0.66	(L)	1.10	2.8 (L)
Iodine*	mg	0.38	(L)	0.09	(L)	0.15	1.1 (L)
Iron*	mg	22.00	(L)	5.26	(L)	8.80	142 (L)
Manganese	mg	1.40	(L)	0.33	(L)	0.56	17.0 (L)
Selenium*	µg	100.00	(L)	23.90	(L)	40.00	56.8 (L) ^a
Zinc*	mg	25.00	(L)	5.98	(L)	10.00	22.7 (L)
Vitamins							
Vitamin A*	IU	1 250.00	100 000(N)	299.00	23 900 (N)	500.00	40 000 (N)
Vitamin D*	IU	138.00	(L) 800.00 (N)	33.00	(L) 191.00 (N)	55.20	227 (L) 320 (N)
Vitamin E*	IU	12.50	-	3.00	-	5.00	-
Thiamine	mg	0.45	-	0.11	-	0.18	-
Riboflavin*	mg	1.05	-	0.25	-	0.42	-
Pantothenic acid	mg	3.00	-	0.71	-	1.20	-
Vitamin B6 (Pyridoxine)	mg	0.30	-	0.07	-	0.12	-
Vitamin B12	µg	7.00	-	1.67	-	2.80	-
Niacin	mg	3.40	-	0.81	-	1.36	-
Folic acid	µg	54.00	-	12.90	-	21.60	-
Biotin*	µg	-	-	-	-	-	-
Choline	mg	425.00	-	102.00	-	209.00	-
Vitamin K*	µg	-	-	-	-	-	-

a. Reg organic selenium

Table VII-18_b
Recommended nutrient levels for dogs - late growth (≥ 14 weeks);

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	50.00	-	11.95	-	20.00	-
Arginine*	g	1.84	-	0.44	-	0.74	-
Histidine	g	0.63	-	0.15	-	0.25	-
Isoleucine	g	1.25	-	0.30	-	0.50	-
Leucine	g	2.00	-	0.48	-	0.80	-
Lysine*	g	1.75	7.00 (N)	0.42	1.67 (N)	0.70	2.8 (N)
Methionine*	g	0.65	-	0.16	-	0.26	-
Methionine + cystine*	g	1.33	-	0.32	-	0.53	-
Phenylalanine	g	1.25	-	0.30	-	0.50	-
Phenylalanine + tyrosine*	g	2.50	-	0.60	-	1.00	-
Threonine	g	1.60	-	0.38	-	0.64	-
Tryptophan	g	0.53	-	0.13	-	0.21	-
Valine	g	1.40	-	0.33	-	0.56	-
Fat*	g	21.25	-	5.08	-	8.50	-
Linoleic acid (ω -6) *	g	3.25	-	0.78	-	1.30	-
Arachidonic acid (ω -6)	mg	75.00	-	17.90	-	30.00	-
Alpha-linolenic acid (ω -3) *	g	0.20	-	0.05	-	0.08	-
EPA + DHA (ω -3) *	g	0.13	-	0.03	-	0.05	-
Minerals							
Calcium*	g	2.00 ^a - 2.50 ^b	4.50 (N)	0.48 ^a - 0.60 ^b	0.96 (N)	0.80 ^a - 1.00 ^b	1.6 (N)
Phosphorus	g	1.75	-	0.42	-	0.70	-
Ca / P ratio		1/1	1.6/1 ^b or 1.8/1 ^a (N)	1/1	1.6/1 ^b or 1.8/1 ^a (N)	1/1	1.6/1 ^b or 1.8/1 ^a (N)
Potassium	g	1.10	-	0.26	-	0.44	-
Sodium*	g	0.55	-	0.13	-	0.22	-
Chloride	g	0.83	-	0.20	-	0.33	-
Magnesium	g	0.10	-	0.02	-	0.04	-
Trace elements*							
Copper*	mg	2.75	(L)	0.66	(L)	1.10	2.8 (L)
Iodine*	mg	0.38	(L)	0.09	(L)	0.15	1.1 (L)
Iron*	mg	22.00	(L)	5.26	(L)	8.80	142 (L)
Manganese	mg	1.40	(L)	0.33	(L)	0.56	17.0 (L)
Selenium*	μ g	100.00	(L)	23.90	(L)	40.00	56.8 (L) ^c
Zinc*	mg	25.00	(L)	5.98	(L)	10.00	22.7 (L)
Vitamins							
Vitamin A*	IU	1 250.00	100 000(N)	299.00	23 900 (N)	500.00	40 000 (N)
Vitamin D*	IU	125.00	(L) 800.00 (N)	29.90	(L) 191.00 (N)	50.00	227 (L) 320 (N)
Vitamin E*	IU	12.50	-	3.00	-	5.00	-
Thiamine	mg	0.45	-	0.11	-	0.18	-
Riboflavin*	mg	1.05	-	0.25	-	0.42	-
Pantothenic acid	mg	3.00	-	0.72	-	1.20	-
Vitamin B6 (Pyridoxine)	mg	0.30	-	0.07	-	0.12	-
Vitamin B12	μ g	7.00	-	1.67	-	2.80	-
Niacin	mg	3.40	-	0.81	-	1.36	-
Folic acid	μ g	54.00	-	12.90	-	21.60	-
Biotin*	μ g	-	-	-	-	-	-
Choline	mg	425.00	-	102.00	-	170.00	-
Vitamin K*	μ g	-	-	-	-	-	-

a. For puppies of dog breeds with adult body weight up to 15kg, during the whole late growth phase (≥ 14 weeks)

b. For puppies of breeds with adult body weight over 15kg, until the age of about 6 months. Only after that time, calcium can be reduced to 0.8% DM (2g/1000 kcal or 0.48g/MJ) and the calcium-phosphorus ratio can be increased to 1.8/1.

c. Reg organic selenium

Table VII-18_c
 Recommended nutrient levels for adult dogs based on a MER of
 110 kcal ME/kg^{0.75}

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	45.00	-	10.80	-	18.00	-
Arginine*	g	1.30	-	0.31	-	0.52	-
Histidine	g	0.58	-	0.14	-	0.23	-
Isoleucine	g	1.15	-	0.27	-	0.46	-
Leucine	g	2.05	-	0.49	-	0.82	-
Lysine*	g	1.05	-	0.25	-	0.42	-
Methionine*	g	1.00	-	0.24	-	0.40	-
Methionine + cystine*	g	1.91	-	0.46	-	0.76	-
Phenylalanine	g	1.35	-	0.32	-	0.54	-
Phenylalanine + tyrosine*	g	2.23	-	0.53	-	0.89	-
Threonine	g	1.30	-	0.31	-	0.52	-
Tryptophan	g	0.43	-	0.10	-	0.17	-
Valine	g	1.48	-	0.35	-	0.59	-
Fat*	g	13.75	-	3.29	-	5.50	-
Linoleic acid (ω-6) *	g	3.27	-	0.79	-	1.32	-
Arachidonic acid (ω-6)	mg	-	-	-	-	-	-
Alpha-linolenic acid (ω-3) *	g	-	-	-	-	-	-
EPA + DHA (ω-3) *	g	-	-	-	-	-	-
Minerals							
Calcium*	g	1.25	6.25 (N)	0.30	1.49 (N)	0.50	2.5 (N)
Phosphorus	g	1.00	4.00 (N)	0.24	0.96 (N)	0.40	1.6 (N)
Ca / P ratio		1/1	2/1	1/1	2/1	1/1	2/1
Potassium	g	1.25	-	0.30	-	0.50	-
Sodium*	g	0.25	^a	0.06	^a	0.10	^a
Chloride	g	0.38	^a	0.09	^a	0.15	^a
Magnesium	g	0.18	-	0.04	-	0.07	-
Trace elements*							
Copper*	mg	1.80	(L)	0.43	(L)	0.72	2.8 (L)
Iodine*	mg	0.26	(L)	0.06	(L)	0.11	1.1 (L)
Iron*	mg	9.00	(L)	2.15	(L)	3.60	142 (L)
Manganese	mg	1.44	(L)	0.34	(L)	0.58	17.0 (L)
Selenium*	µg	75.00	(L)	17.90	(L)	30.00	56.8 (L)
Zinc*	mg	18.00	(L)	4.30	(L)	7.20	22.7 (L)
Vitamins							
Vitamin A*	IU	1 515.00	100 000(N)	362.00	23 900 (N)	606.00	40 000 (N)
Vitamin D*	IU	138.00	(L) 800.00 (N)	33.00	(L) 191.00 (N)	55.20	227 (L) 320 (N)
Vitamin E*	IU	9.00	-	2.20	-	3.60	-
Thiamine	mg	0.54	-	0.13	-	0.21	-
Riboflavin*	mg	1.50	-	0.36	-	0.60	-
Pantothenic acid	mg	3.55	-	0.85	-	1.42	-
Vitamin B6 (Pyridoxine)	mg	0.36	-	0.09	-	0.15	-
Vitamin B12	µg	8.36	-	2.00	-	3.35	-
Niacin	mg	4.09	-	0.98	-	1.64	-
Folic acid	µg	64.50	-	15.40	-	25.80	-
Biotin*	µg	-	-	-	-	-	-
Choline	mg	409.00	-	97.80	-	164.00	-
Vitamin K*	µg	-	-	-	-	-	-
			-		-		-

a. cf. footnote c to Tables III-3_{a-c}

Table VII-18_d
 Recommended nutrient levels for adult dogs based on a MER of
 95 kcal ME/kg^{0.75}

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	52.10	-	12.50	-	21.00	-
Arginine*	g	1.51	-	0.36	-	0.60	-
Histidine	g	0.67	-	0.16	-	0.27	-
Isoleucine	g	1.33	-	0.32	-	0.53	-
Leucine	g	2.37	-	0.57	-	0.95	-
Lysine*	g	1.22	-	0.29	-	0.46	-
Methionine*	g	1.16	-	0.28	-	0.46	-
Methionine + cystine*	g	2.21	-	0.53	-	0.88	-
Phenylalanine	g	1.56	-	0.37	-	0.63	-
Phenylalanine + tyrosine*	g	2.58	-	0.62	-	1.03	-
Threonine	g	1.51	-	0.36	-	0.60	-
Tryptophan	g	0.49	-	0.12	-	0.20	-
Valine	g	1.71	-	0.41	-	0.68	-
Fat*	g	13.75	-	3.29	-	5.50	-
Linoleic acid (ω-6) *	g	3.82	-	0.91	-	1.53	-
Arachidonic acid (ω-6)	mg	-	-	-	-	-	-
Alpha-linolenic acid (ω-3) *	g	-	-	-	-	-	-
EPA + DHA (ω-3) *	g	-	-	-	-	-	-
Minerals							
Calcium*	g	1.45	6.25 (N)	0.35	1.49 (N)	0.58	2.5 (N)
Phosphorus	g	1.16	4.00 (N)	0.28	0.96 (N)	0.46	1.6 (N)
Ca / P ratio		1/1	2/1	1/1	2/1	1/1	2/1
Potassium	g	1.45		0.35		0.58	-
Sodium*	g	0.29	^a	0.07	^a	0.12	^a
Chloride	g	0.43	^a	0.10	^a	0.17	^a
Magnesium	g	0.20		0.05		0.08	-
Trace elements*							
Copper*	mg	2.08	(L)	0.50	(L)	0.83	2.8 (L)
Iodine*	mg	0.30	(L)	0.07	(L)	0.12	1.1 (L)
Iron*	mg	10.40	(L)	2.49	(L)	4.17	142 (L)
Manganese	mg	1.67	(L)	0.40	(L)	0.67	17.0 (L)
Selenium*	µg	87.00	(L)	21.00	(L)	35.00	56.8 (L)
Zinc*	mg	20.80	(L)	4.98	(L)	8.34	22.7 (L)
Vitamins							
Vitamin A*	IU	1 754.00	100 000(N)	419.00	23 900 (N)	702.00	40 000 (N)
Vitamin D*	IU	159.00	(L) 800.00 (N)	38.20	(L) 191.00 (N)	63.90	227 (L) 320 (N)
Vitamin E*	IU	10.40	-	2.49	-	4.17	-
Thiamine	mg	0.62	-	0.15	-	0.25	-
Riboflavin*	mg	1.74	-	0.42	-	0.69	-
Pantothenic acid	mg	4.11	-	0.98	-	1.64	-
Vitamin B6 (Pyridoxine)	mg	0.42	-	0.10	-	0.17	-
Vitamin B12	µg	9.68	-	2.31	-	3.87	-
Niacin	mg	4.74	-	1.13	-	1.89	-
Folic acid	µg	74.70	-	17.90	-	29.90	-
Biotin*	µg	-	-	-	-	-	-
Choline	mg	474.00	-	113.00	-	189.00	-
Vitamin K*	µg	-	-	-	-	-	-

a. cf. footnote c to Tables III-3_{a-c}

Table VII-19_a
Recommended nutrient levels for cats – growth & reproduction

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	70.00 / 75.00		16.73 / 17.93		28.00 / 30.00	
Arginine*	g	2.68 / 2.78	8.75 (N)	0.64 / 1.00	2.09 (N)	1.07 / 1.11	3.50 (N)
Histidine	g	0.83	-	0.20	-	0.33	-
Isoleucine	g	1.35	-	0.32	-	0.54	-
Leucine	g	3.20	-	0.76	-	1.28	-
Lysine*	g	2.13	-	0.51	-	0.85	-
Methionine*	g	1.10	3.25 (N)	0.26	0.78 (N)	0.44	1.30 (N)
Methionine + cystine*	g	2.20	-	0.53	-	0.88	-
Phenylalanine	g	1.25	-	0.30	-	0.50	-
Phenylalanine + tyrosine*	g	4.78	-	1.14	-	1.91	-
Threonine	g	1.63	-	0.39	-	0.65	-
Tryptophan	g	0.40	4.25 (N)	0.10	1.02 (N)	0.16	1.70 (N)
Valine	g	1.60	-	0.38	-	0.64	-
Taurine (canned pet food)*	g	0.63	-	0.15	-	0.25	-
Taurine (dry pet food)*	g	0.25	-	0.06	-	0.10	-
Fat*	g	22.50	-	5.38	-	9.00	-
Linoleic acid (ω-6) *	g	1.38	-	0.33	-	0.55	-
Arachidonic acid (ω-6)	mg	50.00	-	11.95	-	20.00	-
Alpha-linolenic acid (ω-3) *	g	0.05	-	0.01	-	0.02	-
EPA + DHA (ω-3) *	g	0.03	-	0.01	-	0.01	-
Minerals							
Calcium*	g	2.50	-	0.60	-	1.00	-
Phosphorus	g	2.10	-	0.50	-	0.84	-
Ca / P ratio		1/1	1.5/1 (N)	1/1	1.5/1 (N)	1/1	1.5/1 (N)
Potassium	g	1.50	-	0.36	-	0.60	-
Sodium*	g	0.40 ^a	-	0.10 ^a	-	0.16 ^a	-
Chloride	g	0.60	-	0.14	-	0.24	-
Magnesium	g	0.13	-	0.03	-	0.05	-
Trace elements*							
Copper*	mg	2.50	(L)	0.60	(L)	1.00	2.80 (L)
Iodine*	mg	0.45	(L)	0.11	(L)	0.18	1.10 (L)
Iron*	mg	20.00	(L)	4.78	(L)	8.00	142.00 (L)
Manganese	mg	2.50	(L)	0.60	(L)	1.00	17.00 (L)
Selenium	µg	75.00	(L)	17.90	(L)	30.00	56.80 (L) ^a
Zinc	mg	18.80	(L)	4.48	(L)	7.50	22.70 (L)
Vitamins							
Vitamin A*	IU	2 250.00	Growth 100 000 (N) Reproduction 83 325 (N)	538.00	Growth 23 901 (N) Reproduction 19 917 (N)	900.00	Growth 40 000 (N) Reproduction 33 333 (N)
Vitamin D*	IU	70.00	(L) 7 500 (N)	16.70	(L) 1 793 (N)	28.00	227 (L) 3 000 (N)
Vitamin E*	IU	9.50	-	2.30	-	3.80	-
Thiamine	mg	1.40	-	0.33	-	0.55	-
Riboflavin*	mg	0.80	-	0.24	-	0.32	-
Pantothenic acid	mg	1.43	-	0.34	-	0.57	-
Vitamin B6 (Pyridoxine)	mg	0.63	-	0.15	-	0.25	-
Vitamin B12	µg	4.50	-	1.08	-	1.80	-
Niacin	mg	8.00	-	1.91	-	3.20	-
Folic acid	µg	188	-	44.90	-	75.00	-
Biotin*	µg	17.50	-	4.18	-	7.00	-
Choline	mg	600.00	-	143.00	-	240.00	-
Vitamin K*	µg	-	-	-	-	-	-

a. Reg organic selenium

Table VII-19_b Recommended nutrient levels for adult cats based on a MER of 100 kcal ME/kg^{0.67}

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	62.50		14.94		25.00	
Arginine*	g	2.50	-	0.60	-	1.00	-
Histidine	g	0.65	-	0.16	-	0.26	-
Isoleucine	g	1.08	-	0.26	-	0.43	-
Leucine	g	2.55	-	0.61	-	1.02	-
Lysine*	g	0.85	-	0.20	-	0.34	-
Methionine*	g	0.43	-	0.10	-	0.17	-
Methionine + cystine*	g	0.85	-	0.20	-	0.34	-
Phenylalanine	g	1.00	-	0.24	-	0.40	-
Phenylalanine + tyrosine*	g	3.83	-	0.92	-	1.53	-
Threonine	g	1.30	-	0.31	-	0.52	-
Tryptophan	g	0.33	-	0.08	-	0.13	-
Valine	g	1.28	-	0.31	-	0.51	-
Taurine (canned pet food)*	g	0.50	-	0.12	-	0.20	-
Taurine (dry pet food)*	g	0.25	-	0.06	-	0.10	-
Fat*	g	22.50	-	5.38	-	9.00	-
Linoleic acid (ω-6) *	g	1.25	-	0.30	-	0.50	-
Arachidonic acid (ω-6)	mg	15.00	-	3.59	-	6.00	-
Alpha-linolenic acid (ω-3) *	g	-	-	-	-	-	-
EPA + DHA (ω-3) *	g	-	-	-	-	-	-
Minerals							
Calcium*	g	1.48	-	0.35	-	0.59	-
Phosphorus	g	1.25	-	0.30	-	0.50	-
Ca / P ratio		1/1	2/1 (N)	1/1	2/1 (N)	1/1	2/1 (N)
Potassium	g	1.50	-	0.36	-	0.60	-
Sodium*	g	0.19 ^a	-	0.05 ^a	-	0.08 ^a	-
Chloride	g	0.29	-	0.07	-	0.11	-
Magnesium	g	0.10	-	0.02	-	0.04	-
Trace elements*							
Copper*	mg	1.25	(L)	0.30	(L)	0.50	2.80 (L)
Iodine*	mg	0.325	(L)	0.078	(L)	0.13	1.10 (L)
Iron*	mg	20.00	(L)	4.78	(L)	8.00	142.00 (L)
Manganese	mg	1.25	(L)	0.30	(L)	0.50	17.00 (L)
Selenium	µg	75.00	(L)	17.9	(L)	30.00	56.80 (L) ^b
Zinc	mg	18.80	(L)	4.48	(L)	7.50	22.70 (L)
Vitamins							
Vitamin A*	IU	833.00	100 000 (N)	199.00	23 901 (N)	333.00	40 000 (N)
Vitamin D*	IU	62.50	(L) 7 500 (N)	14.90	(L) 1 793 (N)	25.00	227 (L) 3 000 (N)
Vitamin E*	IU	9.50	-	2.30	-	3.80	-
Thiamine	mg	1.10	-	0.26	-	0.44	-
Riboflavin*	mg	0.80	-	0.19	-	0.32	-
Pantothenic acid	mg	1.44	-	0.34	-	0.58	-
Vitamin B6 (Pyridoxine)	mg	0.63	-	0.15	-	0.25	-
Vitamin B12	µg	4.40	-	1.05	-	1.76	-
Niacin	mg	8.00	-	1.91	-	3.20	-
Folic acid	µg	188.00	-	44.90	-	75.00	-
Biotin*	µg	15.00	-	3.59	-	6.00	-
Choline	mg	600.00	-	143.00	-	240.00	-
Vitamin K*	µg	-	-	-	-	-	-

a. Scientific data show that sodium levels up to 1.5% DM (3.75 g/1000 kcal ME; 0.90 g/MJ ME) are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.
b. Reg organic selenium

Table VII-19_c Recommended nutrient levels for adult cats based on a MER of 75 kcal ME/kg^{0.67}

Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels

Nutrient	UNIT	Per 1000 kcal ME		Per MJ ME		Per 100g DM	
		Min	Max	Min	Max	Min	Max
Protein*	g	83.30		19.92		33.30	
Arginine*	g	3.30	-	0.80	-	1.30	-
Histidine	g	0.87	-	0.21	-	0.35	-
Isoleucine	g	1.44	-	0.35	-	0.57	-
Leucine	g	3.40	-	0.81	-	1.36	-
Lysine*	g	1.13	-	0.27	-	0.45	-
Methionine*	g	0.57	-	0.14	-	0.23	-
Methionine + cystine*	g	1.13	-	0.27	-	0.45	-
Phenylalanine	g	1.33	-	0.32	-	0.53	-
Phenylalanine + tyrosine*	g	5.11	-	1.23	-	2.04	-
Threonine	g	1.73	-	0.41	-	0.69	-
Tryptophan	g	0.44	-	0.11	-	0.17	-
Valine	g	1.70	-	0.41	-	0.68	-
Taurine (canned pet food)*	g	0.67	-	0.16	-	0.27	-
Taurine (dry pet food)*	g	0.33	-	0.08	-	0.13	-
Fat*	g	22.50	-	5.38	-	9.00	-
Linoleic acid (ω-6) *	g	1.67	-	0.40	-	0.67	-
Arachidonic acid (ω-6)	mg	20.00	-	4.78	-	8.00	-
Alpha-linolenic acid (ω-3) *	g	-	-	-	-	-	-
EPA + DHA (ω-3) *	g	-	-	-	-	-	-
Minerals							
Calcium*	g	1.97	-	0.47	-	0.79	-
Phosphorus	g	1.67	-	0.40	-	0.67	-
Ca / P ratio		1/1	2/1 (N)	1/1	2/1 (N)	1/1	2/1 (N)
Potassium	g	2.00	-	0.48	-	0.80	-
Sodium*	g	0.25 ^a	-	0.06	-	0.10 ^a	-
Chloride	g	0.39	-	0.09	-	0.15	-
Magnesium	g	0.13	-	0.03	-	0.05	-
Trace elements*							
Copper*	mg	1.67	(L)	0.40	(L)	0.67	2.80 (L)
Iodine*	mg	0.43	(L)	0.10	(L)	0.17	1.10 (L)
Iron*	mg	26.70	(L)	6.37	(L)	10.70	142.00 (L)
Manganese	mg	1.67	(L)	0.40	(L)	0.67	17.00 (L)
Selenium	µg	100.00	(L)	23.90	(L)	40.00	56.80 (L) ^b
Zinc	mg	25.00	(L)	5.98	(L)	10.00	22.70 (L)
Vitamins							
Vitamin A*	IU	1 110.00	100 000 (N)	265.00	23 901 (N)	444.00	40 000 (N)
Vitamin D*	IU	83.30	(L) 7 500 (N)	19.90	(L) 1 793 (N)	33.30	227 (L) 3 000 (N)
Vitamin E*	IU	12.70	-	3.03	-	5.07	-
Thiamine	mg	1.47	-	0.35	-	0.59	-
Riboflavin*	mg	1.05	-	0.25	-	0.42	-
Pantothenic acid	mg	1.92	-	0.46	-	0.77	-
Vitamin B6 (Pyridoxine)	mg	0.83	-	0.20	-	0.33	-
Vitamin B12	µg	5.87	-	1.40	-	2.35	-
Niacin	mg	10.50	-	2.52	-	4.21	-
Folic acid	µg	253.00	-	60.50	-	101.00	-
Biotin*	µg	20.00	-	4.78	-	8.00	-
Choline	mg	800.00	-	191.00	-	320.00	-
Vitamin K*	µg	-	-	-	-	-	-

a. Scientific data show that sodium levels up to 1.5% DM (3.75 g/1000 kcal ME; 0.90 g/MJ ME) are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.
b. Reg organic selenium

VIII Changes versus Previous Versions

1. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2011 VS. THE NUTRITIONAL GUIDELINES 2008

a. Introductory section

- Clearer explanation about meaning of the tables - minimum recommended vs. optimum
- New definition about nutritional maximum limit
- Clearer explanation of the use of legal maximum of certain nutrients
- As a general principle it was agreed that no nutritional maximum level will be stated in the Guidelines for nutrients for which no data on potential adverse effects are available.
- Tables III-3_a to III-3_c Dogs

b. Throughout the guidelines

- Energy is expressed in kJ as well as in kcal
- Mistakes have been corrected e.g. some conversions from kcal to kJ
- Adapted all references to legislation to reflect the most recent legislation
- Tables III-4_a to III-4_c Cats
- Ca/P ratios for cat foods were adapted according to the recommendations by the research subgroup on calcium

c. Recommendation tables

- Titles “recommendations” have been changed to “minimum recommended nutrient levels for commercial foods” to reflect better the content
- Levels of both the nutritional and legal maximum are now presented in last column as follows:
 - N = nutritional maximum
 - L = legal maximum
- Updated references for vitamins A and E for dogs
- Updated references for calcium-phosphorus ratio for cats

e. Substantiation tables

f. Complementary pet foods

- Improved definitions

2. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2012 VS. THE NUTRITIONAL GUIDELINES 2011

a. Recommendation tables

- Maximum ratios moved to the right column where all nutritional maximums are listed
- Tables III-3_a to III-3_c Dogs
- The footnotes about the minimum calcium levels for puppies were adapted to reflect

the new recommendations by the research subgroup on calcium

- Corrections of recommended vitamin levels
- Tables III-4_a to III-4_c Cats
- Ca/P ratios for cat foods were adapted according to the recommendations by the research subgroup on calcium
- The minimum iodine recommendation for adult cats was adapted after re-evaluation of the literature
- Nutritional maximum for sodium has been deleted and replaced by a footnote

b. Substantiation tables

- Updated references for vitamin A in growing dogs
- Deleted references for calcium-phosphorus ratio for cats
- Adapted the substantiation and references for iodine recommendation for adult cats

c. Vitamin conversion tables

- Thiamine = thiamine Cl was added

3. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2013 VS. THE NUTRITIONAL GUIDELINES 2012

a. Recommendation tables

- Tables III-3_a to III-3_c Dogs
- Deletion of nutritional max. for zinc
- Tables III-4_a to III-4_c Cats
- Deletion of nutritional max. for zinc

b. Substantiation tables

- Updated references for selenium in growing dogs

c. New ANNEX 1: Body condition scores

d. ANNEX 2: Energy

- Adapted to the new recommendations for energy requirements of household dogs and cats in order to lower the risk of obesity
- Added paragraph 2.5 with a rationale for adapting nutrient levels at differing daily energy requirements

4. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2014 VS. THE NUTRITIONAL GUIDELINES 2013

a. Throughout the document: Numbering of sections and tables

b. Recommendation tables

• Tables III-3_a to III-3_c Dogs

- Inclusion of recommendations for dogs with a MER of 95kcal/kg^{0.75}
- Legal max values only displayed on dry matter basis to comply with EU legislation
- Met/Cys values increased to comply with NRC recommendations plus correction for energy intake
- Change of B-Vitamin recommendations with reference to NRC AI (where available)

• Tables III-4_a to III-4_c Cat

- Inclusion of recommendations for cats with a MER of 75kcal/kg^{0.67}
- Legal max values only displayed on dry matter basis to comply with EU legislation

- Change of B-Vitamin recommendations with reference to NRC AI (where available)

- Removal of Vit K recommendation

- Correction of Nutritional maximum value for Vitamin D

c. Substantiation tables

- Updated substantiation for total protein, total fat, B Vitamins and Vitamin K (cats)

d. ANNEX 2: Energy

- Updated paragraph 2.4.2 (cats)

- Updated table VII-9

- Updated paragraph 2.5

- New table VII-11 with recommended nutrient levels per kg metabolic bodyweight

e. NEW: ANNEX 9: Recommended Nutrient Levels by Lifestage and Maintenance Energy Requirement

5. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2016 VS. THE NUTRITIONAL GUIDELINES 2014

a. Glossary

- References for the definition of GE, DE and ME updated
- Reference for the definition of daily ratio updated to Reg (EU) 1831/2003

b. Sodium and chloride recommendations for dogs

- Nutritional maxima removed from Tables III-3_{a-c} & VII-18_{c-d}
- Footnote added with regard to know safe levels

c. Selenium legal limit dogs & cats

- Additional footnote added to Tables III-3_{a-c}, III-4_{a-c}, VII-18_{a-d}, VII-19_{a-c}

d. Vitamin D nutritional minimum for growth & reproduction in cats

- Value changed from 75 IU/100g DM to 28 IU/100g DM in Table III-4_a

- Value changed from 188 IU/1000kcal to 70 IU/1000kcal in Table III-4_b

- Value changed from 44.8 IU/MJ to 16.7 IU/MJ in Table III-4_c

- Values changed as per previous in Table VII-19_a

e. Potassium recommendations for late growth dogs

- Value per 1000 kcal corrected to 1.10g/1000kcal in Tables III-3_b & VII-18_b

f. Cysteine/Cystine

- References to cysteine are replaced by cystine in Tables III-3_{a-c}, VII-11 and on pages 71 & 72.

g. Energy requirements during lactation

- Factors in equation to estimate energy requirements during lactation in Table VII-8 corrected, i.e. for kcal factor 132 changed to 145, for MJ factor 550 changed to 607

6. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2017 VS. THE NUTRITIONAL GUIDELINES 2016

a. Acknowledgement – Scientific Advisory Board

- Prof. Ahlstrøm, Øystein removed
- Dr. Marge Chandler & Dr. Marta Hervera added

b. Legal maximum for Zinc

- Value changed from 28.40 mg/DM to 22.70 mg/DM in
 - Table III-3_a
 - Table III-4_a
 - Tables VII – 18_{a-d}
 - Tables VII -19_{a-c}

c. Cystine

- Explanation and reference to cystine added on page 24 and page 31

d. Sodium

- Adult dogs – reference to personal communication removed (page 27)
- Adult cats – reference to internal SAB report replaced by reference to publication from P Nguyen et al. (page 34)

e. Metabolizable Energy

- Section 2.2.2 updated to reflect latest findings for the calculation of energy in foods for cats and dogs



Fédération européenne de l'industrie des aliments pour animaux familiers

The European Pet Food Industry Federation

FEDIAF
European Pet Food Industry Federation

Av. Louise 89
B-1050 Bruxelles
Tel.: +32 2 536.05.20
www.fediaf.org

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/7521560>

Dog Nutrient Requirements: New Knowledge

Article in *Veterinary Research Communications* · September 2005

DOI: 10.1007/s11259-005-0008-2 · Source: PubMed

CITATIONS

3

READS

1,497

2 authors:



Pier Paolo Mussa

Università degli Studi di Torino

24 PUBLICATIONS 165 CITATIONS

[SEE PROFILE](#)



Liviana Prola

Università degli Studi di Torino

24 PUBLICATIONS 156 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



Conservation and Improvement of Local Avian Breeds [View project](#)

Dog Nutrient Requirements: New Knowledge

P.P. Mussa* and L. Prola

Department of Animal Production, Epidemiology and Ecology, Section of Nutrition, Via L. da Vinci, 44-10095 Grugliasco (TO), Italy

*Correspondence: E-mail: pierpaolo.mussa@unito.it

Mussa, P.P. and Prola, L., 2005. Dog nutrient requirements: New knowledge. *Veterinary Research Communications*, 29(Suppl. 2), 35–38

Keywords: dog, energy calculation, energy evaluation, energy requirements, nutrient requirements

Abbreviations: BW, body weight; DE, digestible energy; GE, gross energy; ME, metabolizable energy; Nfe, nitrogen-free extracts

INTRODUCTION

Dog nutrition was based on anecdotal knowledge from domestication until the beginning of last century. In 1943, McCay, in his book “Nutrition of the dog” quoted published studies and underlined that there was a real lack of information on this topic; more so than for other species. The result of this was that many animals grew old quickly and died early. The last 30 years have been characterised by a substantial increase in research into dog nutrition, particularly concerning nutritional requirements. The National Research Council (NRC) of the United States, considering this new information, has developed a new edition of Nutrient Requirements of the dog and cat.

When comparing the four editions of this book (issued in 1972, 1974, 1985 and 2003), several differences, both in form and in substance, are noticed. The earlier editions supplied general advice, while the 1985 edition specified minimum requirements of essential nutrients. Both these systems have advantages and disadvantages: improvements in the new edition include determination of minimum levels (to avoid lacks) and maximum levels (to avoid toxicity) of different nutrients and energy and providing a safety range. This concept is already being applied by pet food companies, but misunderstandings are still common about energy requirements. The main doubt is related to maintenance energy requirements (energy consumed by an adult animal with moderate physical activity in thermic neutrality conditions). Different results have been found by authors in this area. These differences are due, in part, to the extraordinary heterogeneity among canine breeds; only horses are almost comparable. For example, weight can vary between 1 and 100 kg; the coat can be very long or almost nonexistent; and character and spontaneous physical activity are highly variable. Finally, it is important to consider the life style imposed on the animal by the owner.

The aim of this paper is to compare the different systems for evaluating nutrient requirements, to obtain general rules useful for practical feeding and nutrition of dogs.

MAINTENANCE ENERGY REQUIREMENTS DETERMINATION

Determination of maintenance energy requirements, together with assessment of food energy content, is the keystone of rationing.

On surveying the rich literature about dog nutrition, it can be noted that relatively few works have been published about this very important topic, in comparison with those on mineral, vitamin and protein requirements.

Nutritional parameters proposed, such as McCay's (1943) parameters, are not reliable when applied to each canine breed. NRC (1985) suggested two equations that are still widely used but have been recently questioned by several authors. This topic has a wide practical interest, so, we have collected the most authoritative works published in the international literature, in order to verify possible differences and to understand the reasons for these differences.

In Table I, equations proposed by different authors are reported; and results of some equations applied to different body weight classes are shown in Graph I. Differences between maximum and minimum values are as high as 100%, obviously a very high percentage that can thwart rationing efficacy.

Why are these differences so large?

In the dog, there are several relevant variables influencing maintenance requirements. Evaluation of these is essential for the correct assessment of requirements.

The main variables to consider are as follows:

TABLE I
Metabolizable energy (kcal) requirements equations in dogs and indications of application

Author	Proposed equation	Indications
Patil and Bisby (2001)	$94 \times P^{0.75}$	Not active, old, neutered, quiet and sedentary dogs
Burger (1994)	$97 \times P^{0.75}$	
Manner (1991)*	$103 \times P^{0.75}$	
Finke (1991)	$103 \times P^{0.75}$	
German Society of Nutritional Physiology (1989)	$108 \times P^{0.75}$	
Finke (1991)	$117 \times P^{0.75}$	Normal dogs, dogs living in kennels or in group, young dogs
NRC (1974)	$132 \times P^{0.75}$	
Kendall <i>et al.</i> (1983)	$148 \times P^{0.75}$	Very active dogs, young and active dogs
Burger (1994)	$175 \times P^{0.75}$	
Patil and Bisby (2001)	$183 \times P^{0.75}$	Nervous and hyperactive dogs, Great Danes living outdoor, Terriers
Zentek and Meyer (1992)	$200 \times P^{0.75}$	

*Data obtained in metabolic room.

- *Environmental temperature*: Considering that the thermic neutrality temperature is about 25°C for short-haired dogs and 14°C for long-haired dogs, energetic requirements outside this range were calculated by Manner (1991). Hyperthermia is more dangerous than hypothermia because former has a smaller range of tolerability by the animal. Correction factors for low or high temperatures could be the following:

20°C: maintenance requirements \times 1

<10°C: maintenance requirements \times 1.1 (not for long-haired dogs)

0°C: maintenance requirements \times 1.25

-10°C: maintenance requirements \times 1.5

- *Digestive work*: The cost paid for utilization of nutrients; it is different depending on the nutrients digested. Energy related to digestive work is used to satisfy thermogenesis needs: the loss occurs only if the animal is in thermic neutrality or at a higher temperature, while if the animal is under thermic neutrality, energy is used to reach a right temperature.

Temperament: Influences spontaneous activity and, consequently, energy expenditure. "Spontaneous activity" is meant as the activity performed by an animal in its environment (this includes activities induced by such external stimuli as noises, presence/awareness of people, other animals and things). If NRC data (1973) obtained for dogs kept in different kennels are compared with those of Burger and Johnson (1991), obtained under very different conditions, it can be noted that these data fall in a very narrow range if spontaneous activity is considered. On the contrary, if this variable is not considered, values are very different and closer to Manner's results (1991), obtained under low activity conditions. Moreover, Finke (1991) found lower values than the NRC parameters (1985), working in normal kennel conditions with three different breeds: Beagle, Labrador and Siberian Husky. On the other hand, Kienzle and Rainbird (1991) confirmed the NRC data (1985) for medium and large breeds, working on seven different breeds. Spontaneous activity can increase requirements according to temperament, breed and individual differences.

Faults of this system lie in the subjectivity of the evaluation. Professional experience can decrease such faults.

ASSESSMENT OF FOOD ENERGY CONTENT

A further aspect of achievement of correct energy requirements is calculation of the overall energy amount provided by the ration. In practice, different energy transformation coefficients are used: 4.0–3.5 for protein, 9.0–8.5 for fat. The former were proposed by Atwater (1902), the latter are a derivation suggested by the fact that the quality of raw materials and technological processes affect digestibility and energy yield. Atwater's factors presume a very high digestibility (98% for carbohydrates, 96% for fat and 90% for protein) and they tend to overestimate energy content (Kendall *et al.*, 1982). On the other hand, modified coefficients can underestimate or overestimate energy content (Laflamme, 2001). For this reason, a new system has been proposed; starting from GE, it allows calculation of metabolizable energy by considering crude fibre ration content (Kienzle, 2002). The calculation

steps are the following:

1. GE determination: $GE \text{ (kcal)} = (5.7 \times \text{protein (g)}) + (9.4 \times \text{fat (g)}) + (4.1 \times (\text{Nfe (g)} + \text{fibre (g)}))$;
2. % energy digestibility determination: $91.2 - (1.43 \times \text{percent crude fibre on dry matter basis})$
3. digestible energy determination: $\text{digestible energy} - (1.04 \times \text{protein (g)})$.

CONCLUSIONS

Food intake is strictly related to the aforementioned parameters and it affects the intake of each nutrient. For this reason, it has a strategic importance in correct nutrition. Periodical weight controls supply indirect, but precise, information about requirements and efficacy of the nutritional plan. For correct evaluation of nutritional requirements, veterinarian knowledge is essential.

REFERENCES

- Atwater, W.O., 1902. Principles of nutrition and nutritive value of food. *Farmer's Bulletin*, **142**
- Burger, I.H., 1994. Energy needs of companion animals: Matching food intakes to requirements throughout the life cycle. *The Journal of Nutrition*, 2584S–2593S
- Burger, I.H. and Johnson, J.V., 1991. Dogs large and small: The allometry of energy requirements within a single species. *The Journal of Nutrition*, **121**(115), S18–S21
- Finke, M.D., 1991. Evaluation of energy requirements of adult kennel dogs. *The Journal of Nutrition*, **121**(115), S22–S29
- German Society of Nutritional Physiology, 1989. *Energy and Nutrient Requirements, No 5: The Dog* (Committee on Requirement Norms, DLG-Verlag, Frankfurt)
- Kendall, P.T., Blaza, S.E. and Smith, P.M., 1983. Comparative digestible energy requirements of adult Beagles and domestic cats for body weight maintenance. *The Journal of Nutrition*, **113**, 1946–1955
- Kendall, P.T., Holme, D.W. and Smith, P.M., 1982b. Methods of prediction of the digestible energy content of dog foods from gross energy value proximate analysis and digestive nutrient content. *Journal of Science Food Agriculture*, **33**(9), 823–831
- Kienzle, E., 2002. Further development in the prediction of metabolizable energy (ME) in pet food. *The Journal of Nutrition*, **132**, 1796S–1798S
- Kienzle, E. and Rainbird, A., 1991. Maintenance energy requirement of dogs: What is the correct value for the calculation of metabolic body weight in dogs? *The Journal of Nutrition*, **121**(115), S37–S39
- Laflamme, D.P., 2001. Determining metabolizable energy content in commercial pet foods. *Journal of Animal Physiology and Animal Nutrition*, **85**, 22–230
- Manner, K., 1991. Energy requirement for maintenance of adult dogs. *The Journal of Nutrition*, **121**(115), S37–S39
- McCay, C.L., 1943. *Nutrition of the Dog* (Comstock Publishing company, Inc., Ithaca, New York)
- National Research Council, 1974. *Nutrient Requirements of Dogs* (National Academy Press, Washington, DC)
- National Research Council, 1985. *Nutrient Requirements of Dogs* (National Academy Press, Washington, DC)
- National Research Council, 2003. *Nutrient Requirements of Dogs and Cats* (National Academy Press, Washington, DC)
- Patil, A.R. and Bisby, T.M., 2001. Comparison of maintenance energy requirements of client-owned dogs and kennel dogs. *The Purina Nutrition Forum* (St. Louis, MO, USA)
- Zentek, J. and Meyer, H., 1992. Energy intake of adult Great Danes. *Berliner und Muenchener Tieraerztliche Wochenschrift*, **105**(10), 325–327

AAFCO METHODS FOR SUBSTANTIATING NUTRITIONAL ADEQUACY OF DOG AND CAT FOODS

This section contains the minimum testing methods for the substantiation of nutritional adequacy claims, calorie content claims, and procedures for establishing pet food product families referenced in AAFCO Model Pet Food and Specialty Pet Food Regulations PF2, 4, 7, 8, 9 and/or 10. These methods represent minimum requirements. Companies may choose, or may need, to perform additional testing to substantiate their claims.

AAFCO Dog and Cat Food Nutrient Profiles

Introduction

The original Canine and Feline Nutrition Expert Subcommittees convened in 1990 were charged by the chair of the AAFCO Pet Food Committee to establish practical nutrient profiles for both dog and cat foods based on commonly used ingredients. These subcommittees established the "AAFCO Dog Food Nutrient Profiles" and the "AAFCO Cat Food Nutrient Profiles" that appeared in the Official Publication of the AAFCO in 1992 and 1993, respectively. The profiles were reviewed in 1994/95 and updates to the maximum concentrations for vitamin A in dog foods were implemented in 1996.

The National Research Council (NRC) in 2006 updated its published *Nutrient Requirements of Dogs* and *Nutrient Requirements of Cats* in a single publication that combined recommendations for both species.¹ In 2007 the AAFCO Pet Food Committee again formed Canine and Feline Nutrition Expert Subcommittees and charged these subcommittees with the task of revising the AAFCO Nutrient Profiles in consideration of the information in the 2006 NRC *Nutrient Requirements of Dogs and Cats* (2006 NRC). In addition, the subcommittees considered information in the NRC *Mineral Tolerance of Animals Second Revised Edition, 2005* (2005 *Mineral Tolerance of Animals*).² Finally, the subcommittees also reviewed and considered the recommended nutrient concentrations for dog and cat food products as published in February 2008 by the European Pet Food Industry Federation (Federation Europeenne de l'Industrie des Aliments pour Animaux Familiars (FEDIAF)), titled *F.E.D.I.A.F. Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs*, (FEDIAF Guidelines) that are roughly the European-equivalent to the AAFCO Dog and Cat Food Nutrient Profiles.³

The AAFCO Dog and Cat Food Nutrient Profiles were designed to establish practical minimum and some maximum nutrient concentrations for dog and cat foods, formulated from commonly used, non-purified, complex ingredients. The concentrations differ from minimum nutrient requirements traditionally developed by the NRC Committee on Animal Nutrition. Many of the NRC minimum nutrient requirements are based on research with purified diets and/or highly bioavailable nutrient sources that are not practical to use in commercial dog and cat foods. Therefore, unlike the previous NRC publications *Nutrient Requirements of Dogs* in 1985⁴ and *Nutrient Requirements of Cats* in 1986,⁵ the *Nutrient Requirements of Dogs and Cats* in 2006 contained two additional listings of nutrient concentrations for adequate intake and recommended allowance (RA) in addition to minimum requirements. The concentrations for RA's of nutrients in the 2006 NRC are at least equal to, or greater than, concentrations for adequate intakes and minimum requirements, respectively, and are defined as "the concentration or amount of a nutrient in a diet formulated to support a given physiological state." When appropriate,

the RA takes into consideration the bioavailability of the nutrient. Thus, the Canine and Feline Nutrition Expert Subcommittees of 2007 primarily used the RA in the 2006 *Nutrient Requirements of Dogs and Cats* in evaluating whether revision was needed to one or more of the minimum recommended concentrations in the profiles. Values for specific nutrient concentrations were added or modified where indicated and supported by recent scientific publications, practical experience, or unpublished data.

The AAFCO Dog and Cat Food Nutrient Profiles have been criticized and faulted for not explicitly indicating the apparent nutrient digestibility, sometimes called nutrient availability or bioavailability, required to make the listed concentrations adequate for meeting the animal's daily requirements. When a minimum requirement has been established for a particular nutrient, the expected apparent digestibility to meet the minimum requirement for that nutrient at the recommended concentration listed in an AAFCO Nutrient Profile can be calculated using the formula:

$$\frac{(\text{minimum requirement}) \times (\text{its apparent digestibility in the diet(s) used to establish the minimum requirement})}{(\text{recommended concentration in the AAFCO Profile})} \times 100.$$

In the above formula, the minimum requirement is expressed in the same units as in the AAFCO Nutrient Profile and digestibility is expressed in decimal equivalents. As an example, the NRC lists the minimum crude protein requirement for puppies to be met by formulas containing 18% crude protein on a dry matter basis with the digestibility of the protein sources estimated to be near 100%. The 2014 AAFCO Dog Food Nutrient Profile for Growth and Reproduction recommends the minimum crude protein concentration of dry matter to be 22.5%. Therefore, the expected apparent digestibility for crude protein in a diet formulated to meet the AAFCO Dog Food Nutrient Profile for Growth and Reproduction is at least 80% $[(18 \times (1.00)/22.5) \times 100]$.

For nutrients known to be essential, but that lack sufficient data to establish a minimum requirement, the typical digestibility for the nutrient in ingredients and food matrices similar to those used to establish the apparent amount to fulfill the animal's need for the nutrient should be ensured. The 2006 *Nutrient Requirements of Dogs and Cats* discusses average or typical apparent digestibility for such nutrients when explaining how a RA was set. As an example, for adult dogs there is no established minimum requirement for iron, although iron is considered essential for adult dogs. In setting the RA of 30 mg/kg in dietary dry matter for adult maintenance, the NRC subcommittee considered the apparent digestibility of iron to be 20%. However, the explanatory text in the publication notes that measured apparent digestibility of iron in the scientific literature has ranged from close to 100% to less than 10%, and is affected by numerous factors such as the specific source of iron, the concentration of other specific minerals or other ingredients in the diet, as well as the iron status of the animal.

The specific example for iron can be generalized to most essential minerals, and demonstrates the impossibility that any list of concentrations can invariably ensure that all nutrient requirements are fulfilled in all diet formulas without additional considerations. As stated for the previous editions of the AAFCO Dog and Cat Food Nutrient Profiles, formulating a product according to the Profiles is only one part of a nutritionally sound, scientific development that must consider all other aspects of the product. The fact that a dog or cat food is formulated to meet a specific AAFCO Profile should not deter or discourage the manufacturer from conducting appropriate feeding trials to further confirm and ensure the diet is nutritionally adequate for its intended use.

Indications regarding expected nutrient availability from some ingredient sources are given in footnotes. It is important to read the footnotes to the tables as they contain information critical to many of the recommended concentrations. Additionally, manufacturers must make allowances to nutrient concentrations prior to processing to account for losses during processing and subsequent storage. The recommended concentrations in the Profiles are those expected to be present at the time the formula is consumed by the animal.

The established profiles are the “AAFCO Dog Food Nutrient Profiles” and “AAFCO Cat Food Nutrient Profiles” as the terms are applied in AAFCO model pet food regulations referring to nutritional adequacy. Under these model regulations, dog and cat foods substantiated for nutritional adequacy by reference to the AAFCO Dog and Cat Food Nutrient Profiles for a designated life stage(s) must be formulated to contain at least the minimum concentrations of nutrients specified in the Profiles, and, for some nutrients, not more than any maximum concentration listed for that specific nutrient in the Profiles as shown in this section. Products with their nutritional adequacy substantiated by AAFCO Feeding Protocols are not mandated to meet the minimum or maximum concentrations listed in the Profiles. Additionally, snacks, treats or products intended for intermittent or supplemental feeding only are not mandated to meet the concentrations in the Profiles unless their labeling references the Profiles.

The AAFCO Dog and Cat Food Nutrient Profiles and the AAFCO Feeding Protocols are the only methods recognized by AAFCO for substantiating the nutritional adequacy of "complete and balanced" dog or cat foods. If a product is substantiated by a feeding trial and does not meet the AAFCO Dog or Cat Food Nutrient Profiles, the label cannot reference the Profiles. An unqualified reference to an AAFCO Dog or Cat Food Nutrient Profile is an implied guarantee that the product contains the minimum concentrations for all nutrients in the profile and no more than any maximum concentration listed for a specific nutrient in the profile.

Minimum and some maximum nutrient concentrations were established in the Profiles for two categories; growth and reproduction (gestation/lactation), and adult maintenance. Maximum nutrient concentrations were established for nutrients where the potential for overuse or toxicity is of concern and likely to occur if attention is not paid to the concentrations of those nutrients. The absence of a maximum concentration should not be interpreted to mean that nutrients without a specific maximum content are safe at any concentration. Rather, it reflects the lack of information in dogs and cats on toxic concentrations of that nutrient. Establishing a maximum concentration implies safety below that concentration for long term consumption and to set a maximum arbitrarily might prove worse than no maximum at all.

The nutrient concentrations are expressed on a dry matter (DM) basis and at a specified caloric density. Diets should be corrected for caloric density as indicated below. Reference to the concentrations of nutrients on a product label in the guaranteed analysis must be expressed in the same units and order as given in the AAFCO Dog or Cat Food Nutrient Profiles. For the purposes of determining metabolizable energy (ME), use the methods specified in Model Regulation PF9.

**AAFCO DOG FOOD NUTRIENT PROFILES
BASED ON DRY MATTER ^a**

Nutrients	Units DM Basis	Growth & Reproduction Minimum	Adult Maintenance Minimum^b	Maximum
------------------	-------------------------------	--	--	----------------

Proposed Revisions Edited per Comments for 2014 Official Publication 4

Crude Protein	%	22.5	18.0	
Arginine	%	1.0	0.51	
Histidine	%	0.44	0.19	
Isoleucine	%	0.71	0.38	
Leucine	%	1.29	0.68	
Lysine	%	0.90	0.63	
Methionine	%	0.35	0.33	
Methionine-cystine	%	0.70	0.65	
Phenylalanine	%	0.83	0.45	
Phenylalanine-tyrosine	%	1.30	0.74	
Threonine	%	1.04	0.48	
Tryptophan	%	0.20	0.16	
Valine	%	0.68	0.49	
Crude Fat ^c	%	8.5	5.5	
Linoleic acid	%	1.3	1.1	
alpha-Linolenic acid	%	0.08	ND ^d	
Eicosapentaenoic + Docosahexaenoic acid	%	0.05	ND ^d	
(Linoleic + Arachidonic):(alpha-Linolenic + Eicosapentaenoic + Docosahexaenoic) acid Ratio				30:1
Minerals				
Calcium	%	1.2	0.5	1.8
Phosphorus	%	1.0	0.4	1.6
Ca:P ratio		1:1	1:1	2:1
Potassium	%	0.6	0.6	
Sodium	%	0.3	0.08	
Chloride	%	0.45	0.12	
Magnesium	%	0.06	0.06	
Iron ^e	mg/kg	88	40	
Copper ^f	mg/kg	12.4	7.3	
Manganese	mg/kg	7.2	5.0	
Zinc	mg/kg	100	80	
Iodine	mg/kg	1.0	1.0	11
Selenium	mg/kg	0.35	0.35	2
Vitamins & Other				
Vitamin A	IU/kg	5000	5000	250000
Vitamin D	IU/kg	500	500	3000
Vitamin E ^g	IU/kg	50	50	
Thiamine ^h	mg/kg	2.25	2.25	
Riboflavin	mg/kg	5.2	5.2	
Pantothenic acid	mg/kg	12	12	

Niacin	mg/kg	13.6	13.6	
Pyridoxine	mg/kg	1.5	1.5	
Folic acid	mg/kg	0.216	0.216	
Vitamin B ₁₂	mg/kg	0.028	0.028	
Choline	mg/kg	1360	1360	

- ^a Presumes a caloric density of 4000 kcal ME/kg, as determined in accordance with Model Regulation PF9. Formulations greater than 4000 kcal ME/kg must be corrected for energy density; formulations less than 4000 kcal ME/kg need not be corrected for energy. Formulations of low-energy density should not be considered adequate for reproductive needs based on comparison to the Profiles alone.
- ^b Recommended concentrations for maintenance of body weight at an average caloric intake for dogs of a given optimum weight.
- ^c Although a true requirement for crude fat per se has not been established, the minimum concentration was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density.
- ^d ND – Not Determined. While a minimum requirement has not been determined, sufficient amounts of omega-3 fatty acids are necessary to meet the maximum omega-6:omega-3 fatty acid ratio.
- ^e Average apparent digestibility for iron associated with recommended minimums is 20% of that consumed. Because of very poor apparent digestibility, iron from carbonate or oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration for iron.
- ^f Because of very poor apparent digestibility, copper from oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration for copper.
- ^g It is recommended that the ratio of IU of vitamin E to grams of polyunsaturated fatty acids (PUFA) be $\geq 0.6:1$. A diet containing 50 IU of vitamin E will have a ratio of $\geq 0.6:1$ when the PUFA content is 83 grams or less. Diets containing more than 83 grams of PUFA should contain an additional 0.6 IU of vitamin E for every gram of PUFA.
- ^h Because processing may destroy up to 90% of the thiamine in the diet, allowances in formulation should be made to ensure the minimum nutrient concentration for thiamine is met after processing.

**AAFCO DOG FOOD NUTRIENT PROFILES
BASED ON CALORIE CONTENT**

Nutrients	Units per 1000 kcal ME	Growth & Reproduction Minimum	Adult Maintenance Minimum ^a	Maximum
Crude Protein	g	56.3	45.0	
Arginine	g	2.50	1.28	
Histidine	g	1.10	0.48	
Isoleucine	g	1.78	0.95	
Leucine	g	3.23	1.70	
Lysine	g	2.25	1.58	
Methionine	g	0.88	0.83	
Methionine-cystine	g	1.75	1.63	

Proposed Revisions Edited per Comments for 2014 Official Publication 6

Phenylalanine	µg	2.08	1.13	
Phenylalanine-tyrosine	µg	3.25	1.85	
Threonine	µg	2.60	1.20	
Tryptophan	µg	0.50	0.40	
Valine	µg	1.70	1.23	
Crude Fat ^b	µg	21.3	13.8	
Linoleic acid	µg	3.3	2.8	
alpha-Linolenic	µg	0.2	ND ^c	
Eicosapentaenoic + Docosahexaenoic acid	µg	0.1	ND ^c	
(Linoleic+Arachidonic):(alpha- Linolenic+Eicosapentaenoic+ Docosahexaenoic) acid Ratio				30:1
Minerals				
Calcium	µg	3.0	1.25	4.5
Phosphorus	µg	2.5	1.00	4.0
Ca:P Ratio		1:1	1:1	2:1
Potassium	µg	1.5	1.5	
Sodium	µg	0.80	0.20	
Chloride	µg	1.10	0.30	
Magnesium	µg	0.10	0.15	
Iron ^d	mg	22	10	
Copper ^e	mg	3.1	1.83	
Manganese	mg	1.8	1.25	
Zinc	mg	25	20	
Iodine	mg	0.25	0.25	2.75
Selenium	mg	0.09	0.08	0.5
Vitamins & Others				
Vitamin A	IU	1250	1250	62500
Vitamin D	IU	125	125	750
Vitamin E ^f	IU	12.5	12.5	
Thiamine ^g	mg	0.56	0.56	
Riboflavin	mg	1.3	1.3	
Pantothenic acid	mg	3.0	3.0	
Niacin	mg	3.4	3.4	
Pyridoxine	mg	0.38	0.38	
Folic acid	mg	0.054	0.054	
Vitamin B ₁₂	mg	0.007	0.007	
Choline	mg	340	340	

^a Recommended concentrations for maintenance of body weight at an average caloric intake for dogs of a given optimum weight.

^b Although a true requirement for crude fat per se has not been established, the minimum concentration was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density.

- ^c ND – Not Determined. While a minimum requirement has not been determined, sufficient amounts of omega-3 fatty acids are necessary to meet the maximum omega-6:omega-3 fatty acid ratio.
- ^d Average apparent digestibility for iron associated with recommended minimums is 20% of that consumed. Because of very poor apparent digestibility, iron from carbonate or oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration for iron.
- ^e Because of very poor apparent digestibility, copper from oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration for copper.
- ^f It is recommended that the ratio of IU of vitamin E to grams of polyunsaturated fatty acids (PUFA) be $\geq 0.6:1$. A diet containing 50 IU of vitamin E will have a ratio of $\geq 0.6:1$ when the PUFA content is 83 grams or less. Diets containing more than 83 grams of PUFA should contain an additional 0.6 IU of vitamin E for every gram of PUFA.
- ^g Because processing may destroy up to 90% of the thiamine in the diet, allowances in formulation should be made to ensure the minimum nutrient concentration for thiamine is met after processing.

CHANGES TO AND RATIONALE FOR NUTRIENT CONCENTRATIONS - DOG FOODS

CALORIC DENSITY

The 2007 AAFCO Canine Nutrition Expert Subcommittee (CNES) chose to set the presumed caloric density for dog food products at 4000 kcal metabolizable energy (ME) per kilogram (kg) dry matter (DM) for both the nutrient concentrations per kg DM and the nutrient amounts per 1000 kcal ME in order to be consistent with the presumed caloric density used in the 2006 *Nutrient Requirements of Dogs and Cats*¹ and in the current AAFCO Cat Food Nutrient Profiles. Prior to the 2014 revisions to the Profiles, the presumed caloric density for dog foods was set at 3500 kcal ME/kg DM for nutrient concentrations per kg DM and at 4500 kcal ME/kg DM for nutrient amounts per 1000 kcal ME, although mathematical conversion between the two tables was accomplished using 3500 kcal/kg DM as the caloric density. The presumed caloric density is not a minimum or a maximum content that a product must meet to reference the profiles, but it does dictate the factor used to convert between expressions of nutrient content per kg DM versus per 1000 kcal ME and the minimum concentrations of required nutrients in complete and balanced products. Because the denominator for converting from concentrations per kg DM to amounts per 1000 kcal ME has increased from 3.5 to 4.0, values in the per 1000 kcal ME table in some instances may appear less than corresponding values listed prior to 2014 even though DM concentrations may not have changed or even increased slightly. Corrections to amounts of nutrients in formulations differing in caloric density from the presumed value of 4000 kcal ME/kg DM are discussed below.

PROTEIN

The minimum concentration of protein for growth and reproduction was increased slightly from 22% to 22.5% DM consistent with the RA for growth established by the 2006 NRC.¹ The minimum concentration in the AAFCO Dog Food Nutrient Profile for Adult Maintenance was not changed from the previous value of 18%.

The CNES established minimum recommended amounts for the essential amino acids methionine and phenylalanine consistent with the RA proposed by the NRC in addition to the previous minimum recommended amounts of methionine plus cystine

and phenylalanine plus tyrosine. The CNES felt it prudent to include specific minimums for methionine and phenylalanine because although some, or all, of the requirement for cystine and tyrosine can be met from excess methionine and phenylalanine, respectively, the reverse is not true. Some of the previous recommendations for dietary concentrations of essential amino acids in the Dog Food Nutrient Profile for Adult Maintenance (i.e., histidine, lysine, threonine and tryptophan) were greater than the corresponding RA in the 2006 NRC and the CNES elected to retain the previously recommended amounts for these amino acids in the current Dog Food Nutrient Profile for Adult Maintenance.

Minimum concentrations of some essential amino acids in the Dog Food Nutrient Profile for Growth and Reproduction were increased, usually to match the NRC RA for growth (i.e., arginine, leucine, methionine, methionine-cystine, phenylalanine-tyrosine and valine). Although the NRC RA for total crude protein during lactation is essentially identical to the RA for growth (22.0% versus 22.5%), several of the RA for essential amino acids during lactation are greater than the RA for growth. In some cases (i.e., histidine, isoleucine, lysine, phenylalanine, and threonine) the difference was small and the CNES elected to set the recommended amount in the Growth and Reproduction Profile at the larger NRC RA for lactation. For other essential amino acids (i.e., leucine and valine) the RA proposed by the NRC for lactation is substantially more than the RA for growth, and in the case of leucine and valine the concentrations are equal to, or greater than, the corresponding RA for the cat during lactation, an obligate carnivore with protein requirements generally greater than those for the dog. The NRC ad hoc committee indicated that it set the RA based on, "lowest concentrations of each of the essential amino acids from digestible protein in commercial dry expanded diets that have been shown to sustain normal gestation and lactation for bitches."¹ The CNES chose not to increase the recommended concentrations for leucine and valine to those of the NRC RA for lactation based on lack of documented problems with the previous concentrations in the AAFCO Dog Food Nutrient Profile for Growth and Reproduction and the relative disparity in the RA between canine versus feline protein requirements. The CNES did not elect to change the tryptophan concentration in the Dog Food Nutrient Profile for Growth and Reproduction for two reasons. The CNES had access to feeding studies and a publication showing that the minimum requirement for tryptophan in Labrador retriever puppies was less than the current concentration in AAFCO Dog Food Nutrient Profile for Growth and Reproduction and that the tryptophan concentration of 0.2% DM already provided approximately a 25% safety margin.⁶ The CNES was also aware that it was nearly impossible to formulate a product at the minimum protein concentration to contain more than 0.2% tryptophan on a DM basis from typical ingredients without including crystalline tryptophan in the formula.

Insufficient data were available to demonstrate detrimental effects of high protein intake in the normal dog to allow for any definitive maximum concentrations for protein or amino acids to be established. The CNES is aware of the findings regarding excess lysine at some concentration between 2.0% and 4.0% lysine/kg DM to produce depression in growth of puppies and clinical signs associated with arginine deficiency when arginine is present at 0.4% DM, and that FEDIAF has established a concentration of 2.8% lysine in DM as a maximum.^{3,7} However, this information was available prior to the establishment of the original AAFCO Nutrient Profiles and did not result in a maximum lysine content being established by the 1990 Expert Subcommittee. Furthermore, the 2007 CNES notes that the minimum recommended arginine content for growth and reproduction is 2.5 times the concentration of 0.4% arginine/kg DM required to produce the noted adverse effects in combination with lysine at more than 2.0%/kg DM.

FAT/FATTY ACIDS

The CNES increased the minimum recommended amount for total fat in the AAFCO Dog Food Nutrient Profiles by 0.5% to 8.5% for Growth and Reproduction and 5.5% for Adult Maintenance. These concentrations are consistent with the RA for total fat in the 2006 NRC and the FEDIAF Guidelines. The CNES also increased the minimum recommended linoleic acid concentration in the Growth and Reproduction Profile from 1.0% to 1.3% and in the Adult Maintenance Profile from 1.0% to 1.1%, again consistent with the RA in the 2006 NRC. The CNES did not set a minimum recommended concentration for arachidonic acid in either profile, but did establish minimum recommended concentrations for some fatty acids in the n-3 (omega-3) series in the Growth and Reproduction Profile, specifically, alpha-linolenic acid at 0.08%, and the combination of eicosapentaenoic plus docosahexaenoic acids at 0.05% of DM. Because the scientific evidence to date indicates that these n-3 fatty acids are needed for the development of the nervous and visual systems during fetal and neonatal life stages, the CNES did not feel there was scientific justification for setting a specific minimum recommended concentrations for n-3 fatty acids for adult maintenance. A recommendation in a comment to list quantities of alpha-linolenic acid and eicosapentaenoic plus docosahexaenoic acids for adult maintenance as being not determined (ND) was accepted by the AAFCO Pet Food Committee.

The CNES did not establish maximum concentrations for fat or fatty acids despite the NRC listing a safe upper limit (SUL) for total crude fat, linoleic acid, and the combination of eicosapentaenoic plus docosahexaenoic acids. The CNES felt it likely that insufficiencies in other nutrients will occur in a conventional formula before an inclusion of 33% crude fat in DM is reached. Also, although some differences in delayed hypersensitivity reactions were noted in studies cited by the NRC as the basis for setting the SUL for eicosapentaenoic plus docosahexaenoic acids, the 2007 CNES noted that those differences are not unequivocally undesirable or detrimental.^{8,9} The CNES did elect to set a maximum for the ratio of the sum of linoleic plus arachidonic acids to the sum of alpha-linolenic, eicosapentaenoic, and docosahexaenoic acids at 30:1 given the modulating effects of n-3 fatty acids on n-6 metabolism and the predominant contribution of these fatty acids to the n-6 and n-3 fatty acid contents, respectively, in conventional dog food formulas.

CALCIUM & PHOSPHORUS

The CNES decreased the recommended minimum concentration of calcium and phosphorus in the Adult Maintenance Profile by 0.1% to 0.5% and 0.4%, respectively. The current recommended minimum concentrations are 0.1% more than the RA for calcium and phosphorus on a DM basis for adult maintenance in the 2006 NRC but consistent with the concentrations in the FEDIAF Guidelines. The CNES increased the minimum calcium and phosphorus concentrations in the Growth and Reproduction Profile to 1.2% and 1.0%, respectively, consistent with the 2006 NRC RA and FEDIAF Guidelines. The CNES recommended that the calcium and phosphorus in growth formulas for the large-bred or large-size dogs be allowed to decrease to 0.9% and 0.75%, respectively, while still being judged to meet the Growth and Reproduction Nutrient Profile. However, based on comments and a publication¹⁰ demonstrating that some diets containing 0.88% to 1.04% Ca on a DM basis (2.2 to 2.6 g Ca/1000 kcal ME) when fed to medium- or large-breed puppies produced inhibited growth in 10-week growth studies compared to diets containing between 1.3 to 1.8% Ca, the AAFCO Pet Food Committee elected to keep the minimum recommended calcium and phosphorus concentrations in the Growth and Reproduction Nutrient Profile at 1.2% and 1.0%, respectively, for all dog food products that substantiate nutritional adequacy

based on being formulated to meet the nutrient content of the Dog Food Nutrient Profile for Growth and Reproduction.

Because of concerns for excess calcium to produce detrimental effects in growing dogs of large and giant breeds,¹⁰⁻¹³ the 2007 CNES deemed that additional restriction to the maximum limit for calcium was warranted and lowered the maximum calcium concentration to 1.8% DM. The CNES did not believe it necessary to decrease the previous maximum calcium concentration of 2.5% for adult dogs or growing dogs of small or moderate size breeds. However, the AAFCO Pet Food Committee felt that only one maximum value should be established, especially to ensure all life stage products were properly formulated. Thus, the AAFCO Pet Food Committee elected to set the maximum calcium for all dog foods formulated to meet the Dog Food Nutrient Profiles at 1.8% DM. The CNES retained the maximum phosphorus concentration of 1.6% DM for both profiles, as well as the minimum and maximum values of 1:1 and 2:1, respectively, for the calcium to phosphorus ratio.

OTHER MACROMINERALS

POTASSIUM

The 2007 CNES elected to retain the recommended minimum potassium concentration at 0.6% DM for both Profiles. Although the RA in the 2006 NRC and some concentrations in the FEDIAF Guidelines are less than 0.6% DM for potassium, the CNES felt that the potassium concentration did not warrant changing especially given that potential toxicosis of potassium was not a practical concern. Thus, a maximum concentration for potassium was not established.

SODIUM & CHLORIDE

The 2007 CNES did not change the minimum recommendation for sodium or chloride in the Growth and Reproduction Nutrient Profile as the values are slightly above the 2006 NRC RA. The 2007 CNES made an editorial increase in the recommended minimum concentrations for sodium and chloride in the Adult Maintenance Nutrient Profile to match the 2006 NRC RA. For sodium the increase was from 0.06% to 0.08% DM and for chloride from 0.09 to 0.12% DM. The recommended minimum concentrations for sodium and chloride in both dog food nutrient profiles continue to reflect the 1:1.5 sodium to chloride ratio of salt previously used by the 1990 CNES to justify recommended chloride concentrations. As noted by the 1990 CNES, because palatability and food consumption would decline due to excess sodium before adverse health effects were observed, setting a maximum concentration for sodium was not of practical concern.

MAGNESIUM

The 2007 CNES increased the minimum recommended concentration for magnesium from 0.04 to 0.06% in Adult Maintenance and Growth and Reproduction Nutrient Profiles to match the 2006 NRC RA for adult maintenance and peak lactation, respectively. The 2007 CNES deleted the maximum recommended concentration for magnesium due to lack of data specific to dogs in both the 2006 NRC and the 2005 *Mineral Tolerances of Animals*. The only comment regarding maximum magnesium content in the 2006 NRC was that a SUL for magnesium in the diets of dogs was greater than 1.7% DM.

MICROMINERALS

IRON

The 2007 CNES made an editorial change to the minimum concentration for iron in the Growth and Reproduction Nutrient Profile to make the concentration consistent with a presumed caloric density of 4000 kcal ME/kg DM which makes the recommended concentration consistent with the RA from the 2006 NRC and the

FEDIAF Guidelines for same life stages. The 2007 CNES decreased the recommendation for adult maintenance from 80 to 40 mg/kg DM based on considerations that the RA of the 2006 NRC was 30 mg/kg DM and the FEDIAF Guidelines concentration was 36 mg/kg DM. The 2007 CNES deleted the maximum concentration for iron based on one scientific and one practical regulatory consideration. First, the 2006 NRC indicated that appropriate data for setting a SUL for iron in dog foods are not available. The previous maximum concentration was stated to be based on tolerance data in swine. The 2005 *Mineral Tolerance of Animals* indicated that the listed tolerance of 3000 mg/kg DM for swine needed to be confirmed by long-term studies and all other tolerances for iron listed in that publication are 6 times less than 3000 mg/kg DM. Second, the implied safety of a maximum concentration presumes some amount of apparent digestibility and, as noted above, the apparent digestibility of iron in any given diet or combination of ingredients can vary from less than 10% to near 100%. Some sources of iron are considered unavailable and used for their technical effects (i.e., color) on the product and not for their nutrient contribution of iron to the animal. Such unavailable sources will still contribute iron to an analytical result for determining product content, and thus a maximum concentration set for available sources of iron might prohibit use of unavailable sources for coloring, whereas a maximum concentration set for unavailable colorants might permit use of unsafe amounts of available sources on the basis of analytical content. Thus, the 2007 CNES elected to delete the previous maximum of 3000 mg/kg DM and not list any other value as a maximum for iron. Manufacturers should note that iron is toxic at some amount greater than the recommended quantities, but the exact amount is unknown for dogs.

COPPER

The minimum concentration for copper in the Adult Maintenance Nutrient Profile was not changed from the previous amount of 7.3 mg/kg DM, the concentration being consistent with that of the FEDIAF Guidelines and slightly more than the 2006 NRC RA of 6.0 mg/kg. The 2007 CNES increased the minimum recommended concentration in the Growth and Reproduction Nutrient Profile to 12.4 mg/kg DM, consistent with the 2006 NRC RA for peak lactation and slightly more than FEDIAF Guidelines and the NRC RA for growth. Because of poor bioavailability, the use of copper oxide as a nutritional source is excluded.¹⁵ The 2007 CNES deleted the copper maximum concentration for many of the same science-based reasons cited above for deleting the maximum for iron content.

MANGANESE

The minimum concentration for manganese in the Adult Maintenance Nutrient Profile was not changed from the previous amount of 5.0 mg/kg DM, the amount being slightly more than the 2006 NRC RA of 4.8 and slightly less than the FEDIAF Guidelines of 5.6 mg/kg DM. The 2007 CNES increased the minimum recommended concentration in the Growth and Reproduction Nutrient Profile to 7.2 mg/kg DM, consistent with the 2006 NRC RA for peak lactation and slightly more than FEDIAF Guidelines concentrations and NRC RA for growth.

ZINC

The 2006 NRC RA for zinc in growth, reproduction, and adult maintenance formulations was less than the previous concentration in the Dog Food Nutrient Profiles of 120 mg/kg DM and the 2007 CNES decreased the recommended minimum concentration to 100 mg/kg DM in the Growth and Reproduction Nutrient Profile and to 80 mg/kg DM in the Adult Maintenance Nutrient Profile consistent with the 2006 NRC RA and FEDIAF Guidelines concentrations. Both the 2005 *Mineral Tolerance of Animals* and the 2006 *Nutrient Requirements of Dogs and Cats* state there is not enough data available to set a tolerance or SUL for zinc in dog foods. The 2007 CNES

elected to delete the previous maximum concentration of 1000 mg/kg DM that was based on the maximum tolerance concentration recommended for swine rations. The CNES noted that the swine tolerance of 1000 mg/kg DM was the greatest concentration for any tolerance for zinc listed in the 2005 *Mineral Tolerance of Animals*.

IODINE

The 2006 NRC RA for iodine in dog foods is 0.88 mg/kg DM. The FEDIAF Guideline concentrations range from 0.9 to 1.5 mg/kg DM. In considering the basis for these various recommended concentrations the 2007 CNES felt a recommended minimum concentration of 1.0 mg/kg to be prudent and adequate to support adult maintenance as well as growth and reproduction.

The 2007 CNES revised the maximum concentration for iodine based on the following considerations. Although neither the 2005 *Mineral Tolerances for Animals* nor the 2006 *Nutrient Requirements of Dogs and Cats* established a tolerance or SUL for iodine in diets for dogs, both publications cite data that indicate a commercial formulation containing 5.6 mg iodine/kg diet had adverse effects on thyroid function.^{16,17} FEDIAF also notes these studies, but faulted the studies for using a diet deficient in calcium, phosphorus and potassium, and fed in excessive quantities. The 2008 FEDIAF Guidelines indicate a maximum concentration for iodine of 11 mg/kg DM when other minerals are within acceptable concentrations and the products are fed in appropriate quantities. The tolerances for iodine in the 2005 *Mineral Tolerances of Animals* that have been established for various species range from 5 mg/kg DM in diets for horses to 400 mg/kg DM in diets for swine. Given that the NRC tolerance for horses is 10 times less than the general maximum concentration of 50 mg iodine/kg DM recommended by AAFCO, the 2007 CNES felt the value of 50 mg/kg DM to no longer be appropriate for setting a maximum concentration for iodine in dog foods. The 2007 CNES acknowledges that additional studies may allow further refinement of a maximum amount of iodine in foods for dogs, but until such data are available the CNES felt it prudent to adopt the FEDIAF position and set 11 mg iodine per kg DM as the maximum concentration of iodine in dog foods.

SELENIUM

The recommended minimum concentration of selenium was increased to 0.35 mg/kg DM in Adult Maintenance and Growth and Reproduction Nutrient Profiles consistent with the 2006 NRC RA for selenium. The 2007 CNES notes there is a difference between added selenium and total selenium content. The approval of food additives for addition of selenium to animal feeds limits the total amount of selenium that may be added to feed to 0.3 mg/kg from all approved sources on an as-fed basis (90% DM feeds), roughly equivalent to 0.333 mg/kg on a DM basis. The recommended minimum concentration of 0.35 mg selenium/kg DM in dog foods is the sum of selenium from all ingredients in the product, both approved food additives used specifically to add selenium to the product, as well as selenium contained as a constituent of other ingredients. As there is generally more than 0.05 mg selenium/kg DM in ingredients used to supply protein and fat to typical pet food formulations, the 2007 CNES believes the limitation of 0.3 mg selenium/kg DM from approved selenium additives will not hinder a manufacturer's ability to meet the minimum recommended concentration of 0.35 mg selenium/kg DM.

Both the 2006 NRC and the 2005 *Mineral Tolerance of Animals* state no data are available upon which to establish a SUL or tolerance for selenium in diets for dogs. Both NRC publications cite the fifth edition of *Trace Elements in Human and Animal Nutrition* published in 1986 for information indicating a dietary concentration of 5 mg/kg DM resulted in toxicity in dogs.¹⁸ The 2007 CNES acknowledges the NRC has indicated in the years since the publication of the first edition of *Mineral Tolerance of*

Domestic Animals set a tolerance of 2.0 mg of selenium per kg DM for all species in 1980 that the value has been challenged as an underestimate of the true tolerance for several species, and that during 1980 to 2005 greater tolerances for selenium have been established for some species. Although the true tolerance for dogs may be greater than 2, but less than 5, mg selenium/kg DM, the 2007 CNES believes it to be prudent to retain the maximum concentration for selenium at 2.0 mg/kg DM until such time as empirical data permit a greater and more definitive maximum to be established.

VITAMINS

The 2007 CNES did not believe there were data sufficient to change any of the recommended minimum concentrations for the fat soluble vitamins or the maximum concentration for vitamin A. The 2007 CNES decreased the maximum vitamin D concentration in consideration of the SUL and maximums set by the 2006 NRC and FEDIAF Guidelines based on the studies conducted by Tryfondidou et al.^{19,20} The maximum vitamin D concentration was reduced to 3000 IU/kg DM (750 IU/1000 kcal ME) which is 6 times the recommended minimum concentration and 1000 IU/kg less than the amount shown to produce disruption of endochondrial ossification in growing Great Dane puppies. The 2007 CNES noted that the 2006 *Nutrient Requirements of Dogs and Cats* had not established a SUL for vitamin E based on there being no information on vitamin E toxicity in dogs, and so deleted the maximum concentration for vitamin E in the Dog Food Nutrient Profiles. The 2007 CNES increased the minimum concentrations of thiamine, riboflavin and pyridoxine consistent with the RA of the 2006 NRC. For pantothenic acid, niacin, folic acid, vitamin B₁₂ and choline, the 2007 CNES elected to set the recommended concentrations in the AAFCO Dog Food Nutrient Profiles equal to the 2006 NRC adequate intake (AI) recommendation based on indications that the AI already provided a margin of safety above the minimum requirements for these compounds.

**AAFCO CAT FOOD NUTRIENT PROFILES
BASED ON DRY MATTER ^a**

Nutrients	Units DM Basis	Growth & Reproduction Minimum	Adult Maintenance Minimum ^b	Maximum
Crude Protein	%	30.0	26.0	
Arginine	%	1.24	1.04	
Histidine	%	0.33	0.31	
Isoleucine	%	0.56	0.52	
Leucine	%	1.28	1.24	
Lysine	%	1.20	0.83	
Methionine	%	0.62	0.20	1.5
Methionine-cystine	%	1.10	0.40	
Phenylalanine	%	0.52	0.42	
Phenylalanine-tyrosine	%	1.92	1.53	
Threonine	%	0.73	0.73	
Tryptophan	%	0.25	0.16	1.7
Valine	%	0.64	0.62	
Crude Fat ^c	%	9.0	9.0	

Linoleic acid	%	0.6	0.6	
alpha-Linolenic acid	%	0.02	ND ^d	
Arachidonic acid	%	0.02	0.02	
Eicosapentaenoic + Docosahexaenoic acid	%	0.012	ND ^d	
Minerals				
Calcium	%	1.0	0.6	
Phosphorus	%	0.8	0.5	
Potassium	%	0.6	0.6	
Sodium	%	0.2	0.2	
Chloride	%	0.3	0.3	
Magnesium ^e	%	0.08	0.04	
Iron ^f	mg/kg	80	80	
Copper (extruded) ^g	mg/kg	15	5	
Copper (canned) ^g	mg/kg	8.4	5	
Manganese	mg/kg	7.6	7.6	
Zinc	mg/kg	75	75	
Iodine	mg/kg	1.8	0.6	9.0
Selenium	mg/kg	0.3	0.3	
Vitamins & Others				
Vitamin A	IU/kg	6668	3332	333300
Vitamin D	IU/kg	280	280	30080
Vitamin E ^h	IU/kg	40	40	
Vitamin K ⁱ	mg/kg	0.1	0.1	
Thiamine ^j	mg/kg	5.6	5.6	
Riboflavin	mg/kg	4.0	4.0	
Pantothenic acid	mg/kg	5.75	5.75	
Niacin	mg/kg	60	60	
Pyridoxine	mg/kg	4.0	4.0	
Folic acid	mg/kg	0.8	0.8	
Biotin ^k	mg/kg	0.07	0.07	
Vitamin B ₁₂	mg/kg	0.020	0.020	
Choline	mg/kg	2400	2400	
Taurine (extruded)	%	0.10	0.10	
Taurine (canned)	%	0.20	0.20	

^a Presumes an energy density of 4000 kcal ME/kg as determined in accordance with Regulation PF9. Formulations greater than 4000 kcal ME/kg must be corrected for energy density; formulations less than 4000 kcal ME/kg need not be corrected for energy. Formulations of low-energy density should not be considered adequate for growth or reproductive needs based on comparison to the Profiles alone.

^b Recommended concentrations for maintenance of body weight at an average caloric intake for cats of a given optimal weight.

^c Although a true requirement for crude fat per se has not been established, the minimum concentration was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density.

- ^d ND – Not Determined.
- ^e If the mean urine pH of cats fed *ad libitum* is not below 6.4, the risk of struvite urolithiasis increases as the magnesium content of the diet increases.
- ^f Because of very poor bioavailability, iron from carbonate or oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration.
- ^g Because of very poor bioavailability, copper from oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration.
- ^h Add 10 IU Vitamin E above the minimum concentration for each gram of fish oil per kilogram of diet.
- ⁱ Vitamin K does not need to be added unless the diet contains more than 25% fish on a dry matter basis.
- ^j Because processing and specific ingredients may destroy up to 90% of the thiamine in the diet, allowances in formulation should be made to ensure the minimum nutrient concentration is met after processing.
- ^k Biotin does not need to be added unless the diet contains antimicrobial or anti-vitamin compounds.

**AAFCO CAT FOOD NUTRIENT PROFILES
BASED ON CALORIE CONTENT**

Nutrients	Units per 1000 kcal ME	Growth & Reproduction Minimum	Adult Maintenance Minimum ^a	Maximum
Crude Protein	g	75	65	
Arginine	g	3.10	2.60	
Histidine	g	0.83	0.78	
Isoleucine	g	1.40	1.30	
Leucine	g	3.20	3.10	
Lysine	g	3.00	2.08	
Methionine	g	1.55	0.5	3.75
Methionine-cystine	g	2.75	1.00	
Phenylalanine	g	1.30	1.05	
Phenylalanine-tyrosine	g	4.80	3.83	
Threonine	g	1.83	1.83	
Tryptophan	g	0.63	0.40	4.25
Valine	g	1.55	1.55	
Crude Fat ^b	g	22.5	22.5	
Linoleic acid	g	1.40	1.40	
alpha-Linolenic acid	g	0.05	ND ^c	
Arachidonic acid	g	0.05	0.05	
Eicosapentaenoic + Docosahexaenoic acid	g	0.03	ND ^c	
Minerals				
Calcium	g	2.5	1.5	
Phosphorus	g	2.0	1.25	
Potassium	g	1.5	1.5	

Sodium	g	0.5	0.5	
Chloride	g	0.75	0.75	
Magnesium ^d	g	0.20	0.10	
Iron ^e	mg	20.0	20.0	
Copper (extruded) ^f	mg	3.75	1.25	
Copper (canned) ^f	mg	2.10	1.25	
Manganese	mg	1.90	1.90	
Zinc	mg	18.8	18.8	
Iodine	mg	0.45	0.15	2.25
Selenium	mg	0.075	0.075	
Vitamins & Others				
Vitamin A	IU	1667	833	83325
Vitamin D	IU	70	70	7520
Vitamin E ^g	IU	10	10	
Vitamin K ^h	mg	0.025	0.025	
Thiamine ⁱ	mg	1.40	1.40	
Riboflavin	mg	1.00	1.00	
Pantothenic acid	mg	1.44	1.44	
Niacin	mg	15	15	
Pyridoxine	mg	1.0	1.0	
Folic acid	mg	0.20	0.20	
Biotin ^j	mg	0.018	0.018	
Vitamin B ₁₂	mg	0.005	0.005	
Choline	mg	600	600	
Taurine (extruded)	g	0.25	0.25	
Taurine (canned)	g	0.50	0.50	

^a Recommended concentrations for maintenance of body weight at an average caloric intake for cats of a given optimal weight.

^b Although a true requirement for crude fat per se has not been established, the minimum concentration was based on recognition of crude fat as a source of essential fatty acids, as a carrier of fat-soluble vitamins, to enhance palatability, and to supply an adequate caloric density.

^c ND – Not Determined.

^d If the mean urine pH of cats fed *ad libitum* is not below 6.4, the risk of struvite urolithiasis increases as the magnesium content of the diet increases.

^e Because of very poor bioavailability, iron from carbonate or oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration.

^f Because of very poor bioavailability, copper from oxide sources that are added to the diet should not be considered in determining the minimum nutrient concentration.

^g Add 10 IU Vitamin E above the minimum concentration for each gram of fish oil per kilogram of diet.

^h Vitamin K does not need to be added unless the diet contains more than 25% fish on a dry matter basis.

ⁱ Because processing and specific ingredients may destroy up to 90% of the thiamine in the diet, allowances in formulation should be made to ensure the minimum nutrient concentration is met after processing.

^j Biotin does not need to be added unless the diet contains antimicrobial or anti-vitamin compounds.

CHANGES TO AND RATIONALE FOR NUTRIENT CONCENTRATIONS - CAT FOODS

CALORIC DENSITY

The 2007 AAFCO Feline Nutrition Expert Subcommittee (FNES) retained the presumed caloric density for cat food products at 4000 kcal ME/kg DM for both the nutrient concentrations per kg DM and the nutrient amounts per 1000 kcal ME. As discussed below and in the footnotes to the Tables of the AAFCO Cat Food Nutrient Profiles, products with a caloric density greater than 4000 kcal ME/kg should have nutrient concentrations corrected for energy density. Nutrient concentrations in products with energy densities less than 4000 kcal ME/kg should not be corrected.

PROTEIN

The 2007 FNES did not change the minimum concentrations of crude protein in the Cat Food Nutrient Profiles, the current values being equal to or greater than the corresponding 2006 NRC RA and FEDIAF Guidelines.^{1,3} The FNES made modifications to concentrations for some essential amino acids to bring the recommended concentrations in line with the RA in the 2006 NRC and the FEDIAF Guidelines. Minor increases between 0.02 to 0.04% in amounts of histidine, isoleucine and leucine were made in the Growth and Reproduction Profile. The amount for methionine and methionine plus cystine was decreased for adult maintenance. Significant increases were made to the recommended phenylalanine and phenylalanine plus tyrosine concentrations to bring the recommendations in line with the RA in the 2006 NRC which are based on studies establishing the requirements for maximum nitrogen retention and black hair color.^{21,22}

Because of work showing an adverse effect of high concentrations of methionine, the maximum concentration of 1.5% was retained.²³ The FNES also set a maximum of 1.7% for tryptophan based on the work of Herwill and the recommendations in the 2006 NRC and FEDIAF Guidelines.^{1,3,24}

FAT/FATTY ACIDS

The 2007 FNES retained the minimum recommended concentrations of crude fat at 9% DM and at 0.02% for arachidonic acid. The minimum concentration for linoleic acid was increased to 0.6% in both Cat Food Nutrient Profiles consistent with the corresponding 2006 NRC RA and FEDIAF Guidelines. Similar to the CNES, the FNES established minimum recommended concentrations for some fatty acids in the n-3 (omega-3) series in the Growth and Reproduction Profile, specifically, alpha-linolenic acid at 0.02%, and the combination of eicosapentaenoic plus docosahexaenoic acids at 0.012%, of DM. The FNES notes that the NRC¹ stated no requirement for alpha-linolenic acid in adult cats had been demonstrated and that although a theoretical argument could be made for the adult cat to require eicosapentaenoic plus docosahexaenoic acids on a similar order of magnitude as arachidonic acid given the low delta-6 desaturase activity in the species, no objective data were available to support the establishment of any required concentrations. Although the FNES did not feel there was data sufficient for setting minimum recommended concentrations for n-3 fatty acids for adult cats, a recommendation in a comment to list quantities of alpha-linolenic acid and eicosapentaenoic plus docosahexaenoic acids for adult maintenance as being not determined (ND) was accepted by the AAFCO Pet Food Committee.

MINERALS

The 2007 FNES increased the recommended concentrations for copper in canned formulas in the Growth and Reproduction Nutrient Profile and for iodine and selenium

in both Cat Food Nutrient Profiles. The recommended copper concentration in canned products for growth and reproduction was increased from 5.0 to 8.4 mg/kg DM to match the 2006 NRC RA for gestation and lactation.

For iodine the 2007 FNES increased the recommended concentration in the Growth and Reproduction Nutrient Profile to match the 2006 NRC RA and the FEDIAF Guidelines. The recommended concentration of iodine for adult maintenance was increased to match the amount recommended in the FEDIAF Guidelines rather than the 2006 NRC RA in consideration of the findings of Wedekind *et al.*²⁵ The 2007 FNES also set a maximum for iodine content in cat foods based on the findings of Wedekind *et al.*²⁵

The 2007 FNES increased the recommended concentrations for selenium in the Cat Food Nutrient Profiles from 0.1 to 0.3 mg/kg to match the recommendations of the 2006 NRC RA and the FEDIAF Guidelines. The 2007 FNES elected to delete the maximum recommended amount of zinc from the Cat Food Nutrient Profiles noting that the 2006 NRC indicated the safe upper limit of zinc for cats was > 600 mg/kg DM for at least short periods of time and that the swine tolerance of 1000 mg/kg DM was the greatest concentration for any tolerance for zinc listed in the 2005 *Mineral Tolerance of Animals*. The FNES retained the recommended concentrations set by the 1990 FNES for all other minerals in the Cat Food Nutrient Profiles.

VITAMINS & OTHERS

The 2007 FNES decreased the recommended minimum concentrations for vitamins A and D in the Cat Food Nutrient Profiles based on the 2006 NRC RA. The 2007 FNES increased the maximum concentration for vitamin D in the Cat Food Nutrient Profiles based on the work of Sih *et al.* and the SUL in the 2006 NRC.²⁶

The 2007 FNES increased the recommended concentration of vitamin E to more closely coincide with the recommendations of the 2006 NRC and the FEDIAF Guidelines. The recommended concentration of vitamin K in diets containing 25% or more DM derived from fish was unchanged from previous values consistent with the FEDIAF Guidelines.

Recommended concentrations of thiamine and pantothenic acid in the Cat Food Nutrient Profiles were increased to match the 2006 NRC RA. The recommended concentrations of the remaining water soluble vitamins and for taurine were unchanged from the previous values, several being equal to or greater than the 2006 NRC RA (riboflavin, niacin, pyridoxine, folic acid and taurine) with previous recommended concentrations for biotin, vitamin B12 and choline being between the 2006 NRC AI and RA.

REFERENCES

¹ National Research Council. Nutrient Requirements of Dogs and Cats. Washington, DC: National Academy Press, 2006.

² National Research Council. Mineral Tolerance of Animals Second Revised Edition, 2005. Washington, DC: National Academy Press, 2005.

³ Federation Europeenne de l'Industrie des Alimentis pour Animaux Familiers F.E.D.I.A.F. Nutritional Guidelines for Complete and Complementary Pet Food for Cats and Dogs, 2008.

⁴ National Research Council. Nutrient Requirements of Dogs. Washington, DC: National Academy Press, 1985.

⁵ National Research Council. Nutrient Requirements of Cats. Washington, DC: National Academy Press, 1986.

⁶ Czarnecki-Maulden, GL and ER Skoch. Is the tryptophan requirement valid for growing dogs fed canned food? FASEB J 15 (4): A266, 2001.

⁷ Czarnecki-Maulden GL, Hirakawa DA, Baker DH. Antagonism of arginine by excess dietary lysine in the growing dog. *J Nutr* 1985; 115:743-752.

⁸ Hall JA, Wander RC, Gradin JL, Du S-H, Jewell DE. Effect of dietary n-6-to-n-3 fatty acid ratio on complete blood and total white blood cell counts, and T-cell subpopulations in aged dogs. *Am J Vet Res* 1999; 60:319-327.

⁹ Wander RC, Hall JA, Gradin JL, Du S-H, Jewell DE. The ratio of dietary (n-6) to (n-3) influences immune system function, eicosanoid metabolism, lipid peroxidation and vitamin E status in aged dogs. *J Nutr* 1997; 127:1198-1205.

¹⁰ Laflamme D. Effect of breed size on calcium requirements for puppies. *Comp. Contin. Educ. Pract. Vet.* 23 (9(A)):66-69, 2001.

¹¹ Hedhammer AF, Wu F, Krook L, Schryver HF, deLahunta A, Whalen JP, Kallfelz FA, Nunez EA, Hintz HF, Sheffy BE, Ryan GD. Overnutrition and skeletal disease: An experimental study in growing Great Dane dogs. *Cornell Vet* 1974; 64(Suppl. 5):9-160.

¹² Goedegebuure SA, Hazewinkel HA. 1986. Morphological findings in young dogs chronically fed a diet containing excess calcium. *Vet Pathol* 1986; 23:594-605.

¹³ Hazewinkel HA, van den Brom WE, Van't Klooster A, Voorhout G, van Wees A. Calcium metabolism in Great Dane dogs fed diets with various calcium and phosphorus levels. *J Nutr* 1991; 121(Suppl 11):S99-106.

¹⁴ Drobatz KJ, Casey KK. Eclampsia in dogs: 31 cases (1995-1998). *J Am Vet Med Assoc* 2000; 217:216-219.

¹⁵ Czarnecki-Maulden GL, Rudnick RC, Chausow DG. Copper bioavailability and requirement in the dog: Comparison of copper oxide and copper sulfate (abs). *FASEB J* 1993;7(3):A306.

¹⁶ Castillo V, Lalia J, Junco M, Sartorio G, Marquez A, Rodriguez M, Pisarev M. Changes in thyroid function in puppies fed a high iodine commercial diet. *Vet J* 2001; 161:80-84.

¹⁷ Castillo V, Pisarev M, Lalia J, Rodriguez M, Cabrin R, Marquez A. Commercial diet induced hyperthyroidism due to high iodine. A histological and radiological analysis. *Vet Q* 2001; 23:218-223.

¹⁸ Levander O. Selenium. In: Trace Elements in Human and Animal Nutrition, 5th edition, Volume 2. Mertz W, editor. Orlando Press, Orlando Florida, 2006; pp. 209-279.

¹⁹ Tryfonidou MA. Involvement of vitamin D3 metabolism in calcium homeostasis and skeletal development in growing dogs. Thesis, Faculty of Veterinary Medicine, Utrecht University, 2002.

²⁰ Tryfonidou MA, Stevenhagen JJ, van den Bend GJCM, Oosterlaken-Dijksterhuis MA, DeLuca HF, Mol JA, van den Brom WE, van Leeuwen JPTM, Hazewinkel HAW. Moderate cholecalciferol supplementation depresses intestinal calcium absorption in growing dogs. *J. Nutr.* 132:2644-2650, 2002.

²¹ Williams JM, Morris JG, Rogers QR. Phenylalanine requirements of kittens and the sparing effect of tyrosine. *J. Nutr.* 117:1102-1107, 1987.

²² Anderson PJB, Rogers QR, Morris JG. Cats require more dietary phenylalanine or tyrosine for melanin deposition in hair than for maximal growth. *J. Nutr.* 132:2037-2042, 2002.

²³ Fau D, Smalley KA, Rogers QR, Morris JG. Effect of excess dietary methionine on weight gain and plasma amino acids in kittens. *J Nutr* 1987; 117:1838-1843.

²⁴ Herwill A. Effect of excess L-tyrosine and L-tryptophan added to a low protein diet for growing kittens. M.S. thesis, University of California, Davis, 1994.

²⁵ Wedekind KJ, Blumer ME, Huntington CE, Spate V, Morris JS. Feline iodine requirement is lower than the 2006 NRC recommended allowance. *J Anim. Physiol. Anim. Nutr.* 94:527-539, 2010.

²⁶ Sih TR, Morris JG, Hickman A. Chronic ingestion of high concentrations of cholecalciferol in cats. Am J Vet Res 62:1500-1506, 2001.

Correcting for Moisture Content

The values given in the Profiles are listed in terms of dry matter (DM). However, the values listed in the guaranteed analysis on dog and cat food labels are given on an "as is" or "as fed" (AF) basis, and values reported from laboratories may be given on either an AF or DM basis. The difference between a value reported on a DM basis versus an AF basis is proportional to the moisture (water) content of the food. The greater the moisture content of a food, the greater the food's DM values for nutrients would be compared to the corresponding AF values. This discrepancy makes direct comparison between the guaranteed analysis values on a food label and the Profile table values impossible without first correcting one or the other set of values so that both are on an equal-moisture basis.

One method of correcting for moisture is the adjustment of the values listed in the guaranteed analysis or reported from a laboratory on an AF basis to a DM basis before comparing with the Profile values. This is done by dividing each AF value by the proportion of DM in the food [(100 - % moisture)/100]. The examples shown below use the guaranteed analysis values, but these adjustments are equally valid for actual laboratory results reported on an AF basis.

**Example A1: A Dry Dog Food Making a Growth Claim
Moisture-Adjusted Guaranteed Analysis Values**

Nutrient	Guaranteed Analysis Values	Dog Food Nutrient Profile Minimum Values for Growth	Moisture - Adjusted Guaranteed Analysis Values	Moisture-Adjusted Guaranteed Analysis vs. Profile Values
Crude Protein:	min. 21%	22.5%	23.3%	OK
Crude Fat:	min. 8%	8.5%	8.9%	OK
Crude Fiber:	max. 4%		4.4%	
Moisture:	max. 10%	0%	0%	
Calcium:	min. 1.1%	1.2%	1.2%	OK
Phosphorus:	min. 0.9%	1.0%	1.0%	OK

Directly comparing the guaranteed values in Example A1 for crude protein, crude fat, calcium, and phosphorus to the minimum values for growth given in the Dog Food Nutrient Profile indicates this food would appear to be deficient. However, this comparison is not valid because the values for the food are listed on a 10% moisture (90% DM) basis but the Profile values are given on a 0% moisture (100% DM) basis. To put both sets of values on an equal-moisture basis, the guaranteed values were adjusted to 100% DM by dividing each value by the proportion of DM in the food (0.90). With this correction, it becomes apparent that the moisture-adjusted guaranteed analysis values of the reported nutrients do, in fact, meet the minimum recommended concentrations of the Dog Food Nutrient Profile for Growth and Reproduction.

As an alternative method to converting the guaranteed values to a DM basis, the Profile values can be adjusted to match the moisture content of the food. This can be

achieved by simply multiplying each Profile value by the proportion of DM in the food (0.9 in example A1). Such calculations yield the following:

**Example A2: A Dry Dog Food Making a Growth Claim
Moisture-Adjusted Profile Values**

Nutrient	Guaranteed Analysis Values	Dog Food Nutrient Profile Minimum Values for Growth	Moisture-Adjusted Profile Values for Growth	Guaranteed Analysis vs. Moisture-Adjusted Profile Values
Crude Protein:	min. 21%	22.5%	20.25%	OK
Crude Fat:	min. 8%	8.5%	7.65%	OK
Crude Fiber:	max. 4%			
Moisture:	max. 10%	0%	10%	
Calcium:	min. 1.1%	1.2%	1.08%	OK
Phosphorus:	min. 0.9%	1.0%	0.9%	OK

Correcting for Energy Density

The values given in the Profiles presume an energy density of 4000 kcal ME/kg DM. Some dog and cat foods will have energy densities close to this amount. However, many products may have DM energy densities considerably greater than the presumed values. When these more energy-dense products are fed, the dog or cat will require less of the food to meet its caloric requirements. Under these circumstances, the concentrations of the other nutrients in the food should be increased proportionately, so that the dog or cat will receive the needed amount of each nutrient in the smaller amount of food. Therefore, when the energy density of the dog or cat food exceeds 4000 kcal ME/kg DM the nutrient concentrations should be corrected for caloric content before valid comparisons to the appropriate AAFCO Nutrient Profile are made.

Conversely, products could be much lower in energy density than 4000 kcal ME/kg DM. Theoretically, a lower concentration of the other nutrients should be required, assuming that the dog or cat is allowed, and able, to consume enough of the product to meet its caloric needs and that those caloric needs are typical for the average dog or cat of the specific life stage. Because this assumption does not always hold true, the nutrient content should not be decreased in less energy-dense products, that is, the nutrient concentrations in such products should not be corrected for energy density. In fact, if the food is intended to supply significantly fewer calories in somewhat smaller amounts of food than typically consumed by the average weight and specific life stage of the animal, the concentrations of some nutrients per 1000 kcal ME may need to be increased compared to amounts listed in the tables to ensure the animal is provided adequate amounts of those essential nutrients in the quantity of food containing the targeted consumption of daily calories. Furthermore, unless a product meeting the definition for a “lite” or “low calorie” product as specified in Model Regulation PF10 has successfully passed the appropriate AAFCO Feeding Protocols, the product should not be considered adequate for growth or reproduction, regardless of the concentrations of the other nutrients.

The first step in correcting for energy density is to determine the actual energy density of the food. The determination should be done in accordance with Model

Regulation PF9. After determining the energy density of the food, the nutrient values can be converted to a per 4000 kcal ME/kg DM or a per 1000 kcal ME basis and compared to the values in the appropriate AAFCO Nutrient Profile.

**Example B1: A Canned Cat Food Making a Growth Claim:
Moisture and Energy Adjusted Guaranteed Analysis Values**

Nutrient	Guaranteed Analysis Values	Moisture - Adjusted Guaranteed Analysis Values	Moisture & Energy- Adjusted Guaranteed Analysis Values	Growth & Reproduction Cat Food Profile Values per kg DM	Status of Energy Adjusted Guaranteed Analysis vs. Profile Values
Crude Protein:	min. 9%	36%	32.1%	30.0	OK
Crude Fat:	min. 7%	28%	25.0%	9.0	OK
Crude Fiber:	max. 1%				
Moisture:	max. 75%	0%	0%		
Ash:	max. 2%				
Calcium:	min. 0.25%	1.0%	0.89%	1.0	Low
Phosphorus:	min. 0.2%	0.8%	0.71%	0.8	Low
Energy: ^a	1120 kcal ME/kg AF	4480 kcal ME/kg DM	4000 kcal ME/kg DM	4000 kcal ME/kg DM	

^a Energy = (3.5 x g Crude Protein) + (8.5 x g Crude Fat) + (3.5 x g Nitrogen Free Extract^b (CHO))
= (3.5 x 90) + (8.5 x 70) + (3.5 x 60) = 1120

^b % Nitrogen Free Extract = 100- (% Crude Protein + % Crude Fat + % Crude Fiber + % Moisture + % Ash)

A cursory examination of the values listed in the guaranteed analysis compared to the minimum values given in the Cat Food Nutrient Profiles expressed as per kg DM containing 4000 kcal ME revealed that a direct comparison would not be valid. Because the food in Example B1 was 75% moisture (25% DM), the major reason for the discrepancy was likely due to water content. By first dividing the guaranteed values by the proportion of DM (0.25), the moisture-adjusted guaranteed values were derived. Comparing these corrected values with the Profile values, this food appeared to meet the minimums for a growth claim.

However, in this example, direct comparison of the moisture-adjusted guaranteed values with the Profile values was premature. The high DM crude fat content of the food compared to the Profile value (25% vs. 9.0%) was an indication that the food was probably more energy-dense than the Profile value of 4000 kcal ME/kg DM. When calculated, in fact, it was found to be 4480 kcal ME/kg DM (1120 kcal ME/kg AF). Therefore a second adjustment to account for the differences in energy density was warranted. This was achieved by dividing each moisture-adjusted guaranteed value by 4480 (the DM energy density of the food) and then multiplying the result by 4000 (the standard energy density). This second manipulation revealed that the energy-adjusted guaranteed analysis values for the calcium and phosphorus were, in fact, below minimum concentrations for growth.

As demonstrated with the moisture correction methods above, an alternative to correcting the values of the food to meet the Profile energy density is correcting the Profile values to meet the food's energy density. Below, each Profile value was

divided by 4000, and the result was multiplied by the appropriate value for energy density (1120 in this example).

**Example B2: A Canned Cat Food Making a Growth Claim:
Energy Adjusted Profile DM Values**

Nutrient	Guaranteed Analysis Values	Cat Food Nutrient Profile Minimum Values for Growth	Energy Adjusted Profile Values	Guaranteed vs. Energy Adjusted Profile Values (Columns 2 vs. 4)
Crude Protein:	min. 9%	30.0%	8.4%	OK
Crude Fat:	min. 7%	9.0%	2.5%	OK
Crude Fiber:	max. 1%			
Moisture:	max. 75%			
Ash:	max. 2%			
Calcium:	min. 0.25%	1.0%	0.28%	Low
Phosphorus:	min. 0.2%	0.8%	0.22%	Low
Energy	1120 kcal ME/kg AF	4000 kcal ME/kg DM	1120 kcal ME/kg AF	

Note that although the energy-adjusted minimum for crude fat calculated out to be 2.5%, a much higher concentration of crude fat (in this case 7%) predefined the higher energy density and dictated the need for energy adjustment in the first place. Because for the most part a higher concentration of crude fat predetermines what the higher energy density will be, the energy-adjusted Profile minimum value for crude fat should always be met and will often be grossly exceeded.

The last method for correcting for energy density is to convert the guaranteed values for the food to a per 1000 kcal basis, and to compare these values with those listed in the appropriate Profile based on Calorie Content. This is accomplished by dividing the AF values in the guaranteed analysis by the AF energy density (1120 kcal ME/kg in this example) and then multiplying the result by 1000 kcal ME/kg. The result is the values appearing in the fourth column of Example B3 below with the conclusion being identical to that reached in Examples B1 and B2 above.

**Example B3: A Canned Cat Food Making a Growth Claim:
Energy Adjusted Guaranteed Analysis Values**

Nutrient	Guaranteed Analysis Value	Amount per kg (1000 g) As-Fed	Product Amount per 1000 kcal ME	Profile Amount per 1000 kcal ME	Status
Crude Protein	9%	90 g	80.4 g	75	OK
Crude Fat	7%	70 g	62.5 g	22.5	OK
Crude Fiber	1%	10 g			
Moisture	75%	750 g			
Ash	2%	20 g			
Calcium	0.25%	2.5 g	2.2 g	2.5	Low
Phosphorus	0.20%	2.0 g	1.9 g	2.0	Low

Proposed Revisions Edited per Comments for 2014 Official Publication 24

Nitrogen Free Extract (CHO) ^a	(8%)	60 g			
Energy ^b		1120 kcal			

^a % Nitrogen Free Extract = 100- (% Crude Protein + % Crude Fat + % Crude Fiber + % Moisture + % Ash)

^b Energy = (3.5 x 90) + (8.5 x 70) + (3.5 x 60) = 1120