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

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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

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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(j)) 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(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 767/2009 on the placing on the market and use of feed (art. 2(c)).

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 et al., 1995; in: Animal Nutrition 5th Edit.

DM Dry Matter

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Dry pet food Pet food with a moisture content of less then 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. McEllhiney 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”.

Halliwell 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 et al, 1995. Animal Nutrition. 5th edition.

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 et al., 1995; in: Animal Nutrition 5th Edit.

Minimum recommended level See allowance for definition

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N

NRC National Research Council (USA) is a council is 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 scromboid 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. ≥ 70% DM digestibility; ≥ 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 the industry.

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 1831/2002/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 A1-3 and B1-3 of chapter III.

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.

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, there is no need for further analysis. However, bearing in mind the fluctuations in raw materials, it is recommended that regular analyses are conducted to make sure that the product still meets the appropriate nutritional standards and / or truly satisfies its claim of belonging to a family. 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

How to read the tables:

Values are expressed as follows: recommended minimum value. These values are based on an average daily energy intake of 110kcal/$kg^{0.75}$ (460kJ/$kg^{0.75}$) for dogs and 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.

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

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 ≥ 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%.

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

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.

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 $A_{1, 2, 3}$ – Minimum Recommended Nutrient Levels for Dogs

A_1	Minimum Recommended Nutrient Levels for dogs: unit per 100g of dry matter (DM)
A_2	Minimum Recommended Nutrient Levels for dogs: unit per 1000kcal of metabolizable energy (ME)
A_3	Minimum Recommended Nutrient Levels for dogs: unit per MJ of metabolizable energy (ME)

Table $B_{1, 2, 3}$ – Minimum Recommended Nutrient Levels for Cats

B_1	Minimum Recommended Nutrient Levels for cats: unit per 100g of dry matter (DM)
B_2	Minimum Recommended Nutrient Levels for cats: unit per 1000kcal of metabolizable energy (ME)
B_3	Minimum 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.
- When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter III. 3. Tables A4 and B4.

2.1 Table A_1
Minimum Recommended Nutrient Levels for Dogs – Unit per 100g dry matter

Nutrient	UNIT	Adult	Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	Maximum (L) = legal (N) = nutritional
		Minimum Recommended			
Protein*	**g**	**18.00**	**25.00**	**20.00**	-
Arginine*	g	0.52	**0.82**	**0.69**	-
Histidine	g	0.23	0.39	0.25	-
Isoleucine	g	0.46	0.65	0.50	-
Leucine	g	0.82	1.29	0.80	-
Lysine*	g	0.42	0.88	0.70	Growth: 2.80 (N)
Methionine*	g	0.31	0.35	0.26	-
Methionine + cysteine*	g	0.62	0.70	0.53	-
Phenylalanine	g	0.54	0.65	0.50	-
Phenylalanine + tyrosine*	g	0.89	1.30	1.00	-
Threonine	g	0.52	0.81	0.64	-
Tryptophan	g	0.17	0.23	0.21	-
Valine	g	0.59	0.68	0.56	-
Fat*	**g**	**5.50**	**8.50**	**8.50**	-
Linoleic acid (ω-6)*	g	1.32	1.30	1.30	Early growth: 6.50 (N)
Arachidonic acid (ω-6)	mg	-	30.00	30.00	-
Alpha-linolenic acid (ω-3)*	g	-	0.08	0.08	-
EPA + DHA (ω-3)*	g	-	0.05	0.05	-
Minerals	-	-	-	-	-
Calcium*	g	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	0.40	0.90	0.70	Adult: 1.60 (N)
Ca / P ratio		1/1	1/1	1/1	Adult: 2/1 (N) Early growth & reprod.: 1.6/1 (N) Late growth: 1.6/1[b] (N) or 1.8/1[a] (N)
Potassium	g	0.50	0.44	0.44	-
Sodium*	g	0.10	0.22	0.22	Adult: 1.80 (N)
Chloride	g	0.15	0.33	0.33	Adult: 2.25 (N)
Magnesium	g	0.07	0.04	0.04	-
Trace elements*	-	-	-	-	-
Copper*	mg	0.72	1.10	1.10	2.80 (L)
Iodine*	mg	0.11	0.15	0.15	1.10 (L)
Iron*	mg	3.60	8.80	8.80	142.00 (L)
Manganese	mg	0.58	0.56	0.56	17.00 (L)
Selenium*	µg	30.00	35.00	35.00	56.80 (L)
Zinc*	mg	7.2	10.00	10.00	28.40 (L)
Vitamins	-	-	-	-	-
Vitamin A*	IU	606.00	500.00	500.00	40,000.00 (N)
Vitamin D*	IU	55.20	55.20	50.00	227.00 (L) 320.00 (N)
Vitamin E*	IU	3.60	5.00	5.00	-
Thiamine	mg	0.23	0.14	0.14	-
Riboflavin*	mg	0.60	0.53	0.53	-
Pantothenic acid	mg	1.50	1.50	1.50	-
Vitamin B6 (Pyridoxine)	mg	0.15	0.15	0.15	-
Vitamin B12	µg	3.50	3.50	3.50	-
Niacin	mg	1.70	1.70	1.70	-
Folic acid	µg	27.00	27.00	27.00	-
Biotin*	µg	-	-	-	-
Choline	mg	170.00	170.00	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 dog 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 and the calcium-phosphorus ratio can be increased to 1.8/1.

2.1 Table A_2
Minimum Recommended Nutrient Levels for Dogs – Unit per 1000kcal of metabolizable energy

Nutrient	UNIT	Adult	Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	Maximum (L) = legal (N) = nutritional
		Minimum Recommended			
Protein*	**g**	**45.00**	**62.50**	**50.00**	-
Arginine*	g	1.30	**2.05**	**1.73**	-
Histidine	g	0.58	0.98	0.63	-
Isoleucine	g	1.15	1.63	1.25	-
Leucine	g	2.05	3.23	2.00	-
Lysine*	g	1.05	2.20	1.75	Growth: 7.00 (N)
Methionine*	g	0.78	0.88	0.65	-
Methionine + cysteine*	g	1.55	1.75	1.33	-
Phenylalanine	g	1.35	1.63	1.25	-
Phenylalanine + tyrosine*	g	2.23	3.25	2.50	-
Threonine	g	1.30	2.03	1.60	-
Tryptophan	g	0.43	0.58	0.53	-
Valine	g	1.48	1.70	1.40	-
Fat*	**g**	**13.75**	**21.25**	**21.25**	-
Linoleic acid (ω -6)*	g	3.30	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	1.25	2.50	2.00[a] 2.50[b]	Adult: 6.25 (N) Early growth: 4.00 (N) Late growth: 4.50 (N)
Phosphorus	g	1.00	2.25	1.75	Adult: 4.00 (N)
Ca / P ratio		1/1	1/1	1/1	Adult: 2/1 (N) Early growth & reprod.: 1.6/1 (N) Late growth: 1.6/1[b] (N) or 1.8/1[a] (N)
Potassium	g	1.25	1.10	1.50	-
Sodium*	g	0.25	0.55	0.55	Adult: 4.50 (N)
Chloride	g	0.38	0.83	0.83	Adult: 5.60 (N)
Magnesium	g	0.18	0.10	0.10	-
Trace elements*	-	-	-	-	-
Copper*	mg	1.80	2.75	2.75	7.10 (L)
Iodine*	mg	0.26	**0.38**	0.38	2.80 (L)
Iron*	mg	9.00	22.00	22.00	355.00 (L)
Manganese	mg	1.44	1.40	1.40	42.60 (L)
Selenium*	µg	75.00	87.50	87.50	142.00 (L)
Zinc*	mg	18.00	25.00	25.00	71.00 (L)
Vitamins	-	-	-	-	-
Vitamin A*	IU	1515.00	1250.00	1250.00	100,000.00 (N)
Vitamin D*	IU	138.00	138.00	125.00	568.00 (L) 800.00 (N)
Vitamin E*	IU	9.00	12.50	12.50	-
Thiamine	mg	0.56	0.35	0.35	-
Riboflavin*	mg	1.50	1.31	1.31	-
Pantothenic acid	mg	3.75	3.75	3.75	-
Vitamin B6 (Pyridoxine)	mg	0.38	0.38	0.38	-
Vitamin B12	µg	8.75	8.75	8.75	-
Niacin	mg	4.25	4.25	4.25	-
Folic acid	µg	67.50	67.50	67.50	-
Biotin*	µg	-	-	-	-
Choline	mg	425.00	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 2.0g/1000kcal and the calcium-phosphorus ratio can be increased to 1.8/1.

2.1 Table A_3
Minimum Recommended Nutrient Levels for Dogs – Unit per MJ of metabolizable energy

Nutrient	UNIT	Adult	Early Growth (< 14 weeks) & Reproduction	Late Growth (≥ 14 weeks)	Maximum (L) = legal (N) = nutritional
		Minimum Recommended			
Protein*	**g**	**10.76**	**14.94**	**11.95**	-
Arginine*	g	0.31	**0.49**	**0.41**	-
Histidine	g	0.14	0.23	0.15	-
Isoleucine	g	0.27	0.39	0.30	-
Leucine	g	0.49	0.77	0.48	-
Lysine*	g	0.25	0.53	0.42	Growth: 1.67 (N)
Methionine*	g	0.19	0.21	0.16	-
Methionine + cysteine*	g	0.37	0.42	0.32	-
Phenylalanine	g	0.32	0.39	0.30	-
Phenylalanine + tyrosine*	g	0.53	0.78	0.60	-
Threonine	g	0.31	0.48	0.38	-
Tryptophan	g	0.10	0.14	0.13	-
Valine	g	0.35	0.41	0.33	-
Fat*	**g**	**3.29**	**5.08**	**5.08**	-
Linoleic acid (ω -6)*	g	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	0.30	0.60	0.48[a] 0.60[b]	Adult: 1.49 (N) Early growth: 0.96 (N) Late growth: 1.08 (N)
Phosphorus	g	0.24	0.54	0.42	Adult: 0.96 (N)
Ca / P ratio		1/1	1/1	1/1	Adult: 2/1 (N) Early growth & reprod.: 1.6/1 (N) Late growth: 1.6/1[b] (N) or 1.8/1[a] (N)
Potassium	g	0.30	0.26	0.26	-
Sodium*	g	0.06	0.13	0.13	Adult: 1.08 (N)
Chloride	g	0.09	0.20	0.20	Adult: 1.34 (N)
Magnesium	g	0.04	0.02	0.02	-
Trace elements*	-	-	-	-	-
Copper*	mg	0.43	0.66	0.66	1.70 (L)
Iodine*	mg	0.06	**0.09**	0.09	0.68 (L)
Iron*	mg	2.15	5.26	5.26	84.90 (L)
Manganese	mg	0.34	0.33	0.33	10.20 (L)
Selenium*	µg	17.90	20.90	20.90	33.90 (L)
Zinc*	mg	4.30	5.98	5.98	17.00 (L)
Vitamins	-	-	-	-	-
Vitamin A*	IU	362.00	299.00	299.00	23,900.00 (N)
Vitamin D*	IU	33.00	33.00	29.90	136.00 (L) 191.00 (N)
Vitamin E*	IU	2.20	3.00	3.00	-
Thiamine	mg	0.13	0.08	0.08	-
Riboflavin*	mg	0.36	0.31	0.31	-
Pantothenic acid	mg	0.90	0.90	0.90	-
Vitamin B6 (Pyridoxine)	mg	0.09	0.09	0.09	-
Vitamin B12	µg	2.09	2.09	2.09	-
Niacin	mg	1.02	1.02	1.02	-
Folic acid	µg	16.10	16.10	16.10	-
Biotin*	µg	-	-	-	-
Choline	mg	102.00	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 0.48g/MJ and the calcium-phosphorus ratio can be increased to 1.8/1.

2.2 Table B_1
Minimum Recommended Nutrient Levels for Cats – Unit per 100g dry matter

Nutrient	UNIT	Adult	Growth & / Reproduction*	Maximum (L) = legal (N) = nutritional
		Recommended minimum		
Protein*	**g**	**25.00**	**28.00 / 30.00**	-
Arginine*	g	1.00	1.07 / 1.11	Growth: 3.50 (N)
Histidine	g	0.30	0.33	-
Isoleucine	g	0.49	0.54	-
Leucine	g	1.17	1.28	-
Lysine*	g	0.34	0.85	-
Methionine*	g	0.17	0.44	Growth: 1.30 (N)
Methionine + cysteine*	g	0.34	0.88	-
Phenylalanine	g	0.46	0.50	-
Phenylalanine + tyrosine*	g	1.76	1.91	-
Threonine	g	0.60	0.65	-
Tryptophan*	g	0.15	0.16	Growth: 1.70 (N)
Valine	g	0.59	0.64	-
Taurine (canned pet food)*	g	0.20	0.25	-
Taurine (dry pet food)*	g	0.10	0.10	-
Fat	**g**	**9.00**	**9.00**	-
Linoleic acid (ω-6)	g	0.50	0.55	-
Arachidonic acid (ω-6)	mg	6.00	20.00	-
Alpha-linolenic acid (ω-3)	g	-	0.02	-
EPA + DHA (ω-3)*	g	-	0.01	-
Minerals	-	-	-	-
Calcium*	g	0.59	1.00	-
Phosphorus	g	0.50	0.84	-
Ca / P ratio*		**1/1**	**1/1**	Adult: 2/1 (N) Growth: 1.5/1 (N)
Potassium	g	0.60	0.60	-
Sodium*	g	0.08[a]	0.16	-
Chloride	g	0.11	0.24	-
Magnesium*	g	0.04	0.05	-
Trace elements*	-	-	-	-
Copper*	mg	0.50	1.00	2.80 (L)
Iodine*	mg	0.13	0.18	1.10 (L)
Iron	mg	8.00	8.00	142.00 (L)
Manganese	mg	0.50	1.00	17.00 (L)
Selenium	µg	30.00	30.00	56.80 (L)
Zinc	mg	7.50	7.50	28.40 (L)
Vitamins	-	-	-	-
Vitamin A*	IU	333.00	900.00	Adult & Growth: 40,000.00 (N) Reproduction: 33,333.00 (N)
Vitamin D*	IU	25.00	75.00	227.00 (L) 3,000.00 (N)
Vitamin E*	IU	3.80	3.80	-
Thiamine	mg	0.56	0.55	-
Riboflavin	mg	0.40	0.40	-
Pantothenic acid	mg	0.58	0.57	-
Vitamin B6 (Pyridoxine)*	mg	0.25	0.40	-
Vitamin B12	µg	2.25	2.00	-
Niacin	mg	4.00	4.00	-
Folic acid	µg	80.00	80.00	-
Biotin*	µg	7.50	7.00	-
Choline	mg	240.00	240.00	-
Vitamin K*	µg	10.00	10.00	-

[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.

2.2 Table B_2
Minimum Recommended Nutrient Levels for Cats – Unit per 1000kcal of metabolizable energy

Nutrient	UNIT	Adult	Growth & / Reproduction*	Maximum (L) = legal (N) = nutritional
		Recommended minimum		
Protein*	**g**	**62.50**	**70.00 / 75.00**	-
Arginine*	g	2.50	2.68 / 2.78	Growth: 8.75 (N)
Histidine	g	0.75	0.83	-
Isoleucine	g	1.24	1.35	-
Leucine	g	2.93	3.20	-
Lysine*	g	0.85	2.13	-
Methionine*	g	0.43	1.10	Growth: 3.25 (N)
Methionine + cysteine*	g	0.85	2.20	-
Phenylalanine	g	1.15	1.25	-
Phenylalanine + tyrosine*	g	4.40	4.78	-
Threonine	g	1.50	1.63	-
Tryptophan*	g	0.37	0.40	Growth: 4.25 (N)
Valine	g	1.47	1.60	-
Taurine (canned pet food)*	g	0.50	0.63	-
Taurine (dry pet food)*	g	0.25	0.25	-
Fat	**g**	**22.50**	**22.50**	-
Linoleic acid (ω-6)	g	1.25	1.38	-
Arachidonic acid (ω-6)	mg	15.00	50.00	-
Alpha-linolenic acid (ω-3)	g	-	0.05	-
EPA + DHA (ω-3)*	g	-	0.03	-
Minerals	-	-	-	-
Calcium*	g	1.48	2.50	-
Phosphorus	g	1.25	2.10	-
Ca / P ratio*		1/1	1/1	Adult: 2/1 (N) Growth: 1.5/1 (N)
Potassium	g	1.50	1.50	-
Sodium*	g	0.19 [a]	0.40	-
Chloride	g	0.29	**0.60**	-
Magnesium*	g	0.10	0.13	-
Trace elements*	-	-	-	-
Copper*	mg	1.25	2.50	7.10 (L)
Iodine*	mg	0.325	0.45	2.80 (L)
Iron	mg	20.00	20.00	355.00 (L)
Manganese	mg	1.25	2.50	42.60 (L)
Selenium	µg	75.00	75.00	142.00 (L)
Zinc	mg	18.80	18.80	71.00 (L)
Vitamins	-	-	-	-
Vitamin A*	IU	833.00	2,250.00	Adult & Growth: 100,000.00 (N) Reproduction: 83,325.00 (N)
Vitamin D*	IU	62.50	188.00	568.00 (L) 7,500.00 (N)
Vitamin E*	IU	9.50	9.50	-
Thiamine	mg	1.40	1.38	-
Riboflavin	mg	1.00	1.00	-
Pantothenic acid	mg	1.44	1.43	-
Vitamin B6 (Pyridoxine)*	mg	0.63	1.00	-
Vitamin B12	µg	5.63	5.00	-
Niacin	mg	10.00	10.00	-
Folic acid	µg	200.00	200.00	-
Biotin*	µg	18.80	17.50	-
Choline	mg	600.00	600.00	-
Vitamin K*	µg	25.00	25.00	-

[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.

2.2 Table B_3
Minimum Recommended Nutrient Levels for Cats – Unit per MJ of metabolizable energy (ME)

Nutrient	UNIT	Adult	Growth & / Reproduction*	Maximum (L) = legal (N) = nutritional
		Recommended minimum		
Protein*	**g**	**14.94**	**16.73 / 17.93**	-
Arginine*	g	0.60	0.64/0.66	Growth: 2.09 (N)
Histidine	g	0.18	0.20	-
Isoleucine	g	0.30	0.32	-
Leucine	g	0.70	0.76	-
Lysine*	g	0.20	0.51	-
Methionine*	g	0.10	0.26	Growth: 0.78 (N)
Methionine + cysteine*	g	0.20	0.53	-
Phenylalanine	g	0.27	0.30	-
Phenylalanine + tyrosine*	g	1.05	1.14	-
Threonine	g	0.36	0.39	-
Tryptophan*	g	0.09	0.10	Growth: 1.02 (N)
Valine	g	0.35	0.38	-
Taurine (canned pet food)*	g	0.12	0.15	-
Taurine (dry pet food)*	g	0.06	0.06	-
Fat	**g**	**5.38**	**5.38**	-
Linoleic acid (ω-6)	g	0.30	0.33	-
Arachidonic acid (ω-6)	mg	3.59	11.95	-
Alpha-linolenic acid (ω-3)	g	-	0.01	-
EPA + DHA (ω-3)*	g	-	0.01	-
Minerals	-	-	-	-
Calcium*	g	0.35	0.60	-
Phosphorus	g	0.30	0.50	-
Ca / P ratio*		1/1	1/1	Adult: 2/1 (N) Growth: 1.5/1 (N)
Potassium	g	0.36	0.36	-
Sodium*	g	0.05[a]	0.10	-
Chloride	g	0.07	0.14	-
Magnesium*	g	0.02	0.03	-
Trace elements*	-	-	-	-
Copper*	mg	0.30	0.60	1.70 (L)
Iodine*	mg	0.078	0.11	0.68 (L)
Iron	mg	4.78	4.78	84.90 (L)
Manganese	mg	0.30	0.60	10.20 (L)
Selenium	µg	17.90	17.90	33.90 (L)
Zinc	mg	4.48	4.48	17.00 (L)
Vitamins	-	-	-	-
Vitamin A*	IU	199.00	538.00	Adult & Growth: 23,901.00 (N) Reproduction: 19,917.00 (N)
Vitamin D*	IU	14.90	44.80	136.00 (L) 1,793.00 (N)
Vitamin E*	IU	2.30	2.30	-
Thiamine	mg	0.33	0.33	-
Riboflavin	mg	0.24	0.24	-
Pantothenic acid	mg	0.34	0.34	-
Vitamin B6 (Pyridoxine)*	mg	0.15	0.24	-
Vitamin B12	µg	1.34	1.20	-
Niacin	mg	2.39	2.39	-
Folic acid	µg	47.80	47.80	-
Biotin*	µg	4.48	4.18	-
Choline	mg	143.00	143.00	-
Vitamin K*	µg	5.98	5.98	-

[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 data from the pet food industry.

3.1 Table A4 – 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$^{0.75}$.

FEDIAF has adjusted the protein level to take into account a digestibility of 75% and added a 20% to account for lower energy intakes for pet dogs, giving a RA of 40g/1000kcal (9.56g/MJ). This value has been increased to 45g/1000kcal (10.8g/MJ) to cover requirements of older dogs. [b, c]

This is equivalent to 18g per 100g DM (10.8g/MJ). If formulating below 18g protein/100g it is particularly important to ensure that the amino acid profile meets FEDIAF guidelines for adult maintenance.

[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.*

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.

[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*

If carbohydrate is absent or at a very low level, the protein requirement is much higher, and may be double. [a, b, c]

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]

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.

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).

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.

Rationen mit unterschied-lichen 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.*

[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.*

[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..*

[a] *Czarnecki GL, Hirakawa DA, Baker DH. (1985) Antagonism of arginine by excess dietary lysine in the growing dog. J. Nutr. 1985; 1115: 743-752.*

[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.*

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

[a] *For details and references see ANNEX 2 – taurine.*

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.*

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.

[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) Polyunsa- turated 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.*

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.

NRC 2006

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] *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] *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.

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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.

[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 Sympoqium Proceedings. G. Reinhardt & D. Carye edits. Wimington, 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.*

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] *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 grate 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] It is reasonable to set the safe nutritional maximum at 1.8% DM. [b]

[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.*

[b] *Kienzle E. Personal communication.*

Chloride

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

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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).

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Copper

Copper (General) 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 by low. [a, b, c]

[a] *Wedekind K., Combs Jr. G. Selenium in pet foods: Is bioavailablity 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) A pet food containing 5mg zinc per 100g DM is sufficient to meet the requirements for growing puppies. [a]

[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.*

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).

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] *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.*

[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 P, Salt C, Raila J, et al. Safety evaluation of vitamin A in growing dogs. Br. J. Nutr. Published on line 28 February 2012.*

[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.*

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 DS. Vitamin K. in: Vitamin & mineral supplementation for dogs & cats - A monograph on micronutrients Veterinary Practice Publishing Company 1989: p. 95.*

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

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

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

3.2 TABLE B4 – Substantiation of nutrient recommendations for cats

PROTEIN

Total protein

Amino acids (Adult cats) Except for sulphur containing amino acids, the amino acid values recommended for adult cats are the levels recommended by NRC 2006 increased by 15% to compensate for the lower energy requirement of household cats 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. 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*

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.*

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

[a] *Burger IH, Smith P. Aminosäurenbedarf erwachsener Katzen. In: Ernährung, Fehlernährung, und Diätetik bei Hund und Katze – Proceedings of the International Symposium Hannover (DE),*

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.

Tryptophan

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

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]

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 ≥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]

Taurine

Taurine Studies have shown that the bioavailability is lower when cats are fed a heated-processed 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]

FAT

Omega 3 and 6 fatty acids

Omega 3 fatty acids (Growth & Reproduction) The study by Pawlosky et al. suggests that juvenile

[a] *Taylor TP, et al. Amino Acids 1998; 15, 221-234.*

[b] *Herwill A. MS thesis Univ California, Davis, CA USA. 1994*

[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.*

[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.*

[a] *Pawlosky RJ, Denkins Y, Ward G, et al. Retinal and brain accretion of long-chain polyunsaturated fatty acids in developing felines:*

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.

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.

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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.

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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 5.258kcal 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) In one study with healthy adult cats, no adverse effects were seen when feeding a food with 1.5 % of sodium (DM). [a] nutritional maximum should be set at 1.8% DM. [b]

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

[b] *Kienzle Personal communication*

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.

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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 et al. Doctoral Thesis, University of Utrecht 1993*

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).

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Copper

Copper (General) 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] 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]

[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.*

[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 40,000 IU/100g DM is about 50% of the maximum NOAEL reported by Sea 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.

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]

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

[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.*

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

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.*

Vitamin K

Vitamin K Vitamin K does not need to be added unless the diet contains antimicrobial or anti-vitamin compounds, or contains more than 25% fish on a DM basis. [a]

[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.*

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 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.*

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.

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
Phenylanaline	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Tyrosine	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54
Threnonine	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 2nd 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 15th 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 15th 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 14th ed. (1984) 3.069-3.070 AOAC 15th ed. (1990) 920.155 & 928.04 AOAC 16th 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 16th ed. (1998) 9.1.01
Vitamin A	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 VDLUFA method 13.1.2 2nd ISO/CD 14565
Vitamin D*	VDLUFA method 13.8.1 D3 AOAC 15th ed. (1990) 982.29 BS EN 12821 : 2000
Vitamin E	Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 2nd 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 16th 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 16th ed. (1998) M 985.32 EN 14663: 2005
Folic Acid	AOAC 16th 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
Vitamine 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/VI/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

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	**Cr_2O_3**	Chromic oxide
kcal	Kilocalorie		

1. INDICATOR METHOD

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).

2. Protocol

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 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; faeces and possibly urine will be collected during at least four days (96 hours) for dogs and five days (120 hours) for cats.

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 chromic oxide (Cr203) free of soluble chromium shall be mixed with the food.

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 BW0.75 for dogs and about 60kcal (250kJ) ME per kg BW for cats] (See ANNEX 2 - Energy).

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.

2.6 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.

2.7 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.

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.

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.

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

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.

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

2.10 Calculation of Digestible and Metabolizable 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) =	$\{1 - \frac{(\text{GE of faeces} \times \% Cr_2O_3 \text{ in food})}{(\text{GE of food} \times \% Cr_2O_3 \text{ in faeces})}\} \times \text{GE of food}$
DP (% food) =	$\{1 - \frac{(\text{\% CP in faeces} \times \% Cr_2O_3 \text{ in food})}{(\text{\% CP in food} \times \% Cr_2O_3 \text{ in faeces})}\} \times \text{CP in food}$

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

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	ME (kcal or kJ/g) = DE - 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

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. Protocol

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 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.

2.3 Food

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

2.4 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 BW0.75 for dogs and about 60kcal (250-293kJ) ME per kg BW for cats] (See ANNEX 2 - Energy).

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.

2.6 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.

2.7 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.

2.8 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.

2.9 Analytical Determination

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

Food, faeces and urine (if collected) shall be assayed for gross energy (bomb calorimetry). If urine is not collected, food and faeces also shall be assayed for crude protein.

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

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) =	(GE of food consumed - GE of faeces collected) / amount of food consumed

DP (% of food) =	(CP of food consumed - CP of faeces collected) x100 / amount of food consumed

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 =	[(GE of food consumed - GE of faeces collected) - (grams protein consumed - grams protein in faeces) x correction factor for energy loss in urine] / 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 =	$\frac{(a \times b) - (c \times d) - [(b \times e) - (d \times f)]/100x\ g \times 1000}{b}$

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

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

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

With urine collection

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

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

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. 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, 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.

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.

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).

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 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 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 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	**Ribs & other bony prominences** Visible from a distance & easily palpable with no overlaying fat. **Abdomen** Severe abdominal tuck when viewed from the side, exaggerated hourglass shape when viewed from above. **Tail base** Prominent, raised bone structures with no tissue between the skin and bone. Obvious loss of muscle mass and no discernible body fat.	<4%	- ≥40%
2. Very Thin		**Ribs & other bony prominences** Visible & easily palpable with no fat layer under the skin. **Abdomen** Strong abdominal tuck when viewed from the side, accentuated hourglass shape when viewed from above. **Tail base** Prominent, raised bone structures with no tissue between the skin and bone. Minimal loss of muscle mass.	4-10%	-30-40%
3. Thin	2	**Ribs & other bony prominences** discernible & easily palpable with minimal fat cover. **Abdomen** pronounced abdominal tuck when viewed from the side, marked hourglass shape when viewed from above. **Tail base** Raised bony structures with little tissue between skin and bone.	5-15%	-20-30%
4. Ideal		**Ribs & other bony prominences** Easily palpable with minimal fat cover. **Abdomen** Abdominal tuck when viewed from the side, slightly marked hourglass shape when viewed from above. **Tail base** Raised bony structures with little subcutaneous tissue.	10-20%	-10-15%
5. Ideal	3	**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. **Abdomen** abdominal tuck when viewed from the side and well proportioned lumbar waist (hourglass shape) when viewed from above. **Tail base** smooth contour or some thickening, bony structures palpable under a thin layer of subcutaneous fat.	15-25%	0%
6. Slightly overweight		**Ribs & other bony prominences** palpable with moderate fat cover. **Abdomen** less obvious abdominal tuck when viewed from the side, hourglass shape less pronounced when viewed from above. **Tail base** smooth contour or some thickening, bony structures remain palpable under moderate layer of subcutaneous fat.	20-30%	+10-15%
7. Overweight	4	**Ribs & other bony prominences** difficult to palpate, thick fat cover. **Abdomen** little abdominal tuck when viewed from the side or waist, and back slightly broadened when viewed from above. **Tail base** Smooth contour or some thickening, bony structures remain palpable under subcutaneous fat.	25-35%	+20-30%

Score		Location Feature	Estimated body fat (%)	% BW below or above BCS 5
9-point	5-point			
8. Obese		**Ribs & other bony prominences** Ribs are very difficult to palpate, with thick layer of fat. Other bony prominences are distended with extensive fat deposit. **Tail base** Appears thickened, difficult to palpate bony structures. **General** ventral bulge under abdomen, no waist, and back markedly broadened when viewed from above. Fat deposits over lumbar area and neck.	30-40%	+30-45%
9. Grossly Obese	5	**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. **Tail base** Appears thickened, bony structures almost impossible to palpate. **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	>40%	>45%

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

Table 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

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2. ENERGY

1. Introduction

The feeding guide, more than anything else on a pet food label, draws the attention of the consumer, to who 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.

2. 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

3. 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

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 1.

Table 1
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

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. The metabolizable energy can also be predicted by calculation from the average analysis using one of the equations hereafter. However, since the digestibility can differ between pet foods, a single equation can not be supposed to predict the ME of all pet food products.

a) Atwater factors For processed pet foods "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

The factors developed by Atwater in 1902 work well for human food ingredients such as meat, fish and purified starch products) and can also be used for processed pet foods with a very high digestibility, milk substitutes and liquids for enteral nutrition (NRC 2006a).

kcal ME /100g =	% crude protein x 4.0 + % crude fat x 9.0 + % NFE x 4.0
kJ ME /100g =	% crude protein x 16.74 + % crude fat x 37.66 + % NFE x 16.74

More accurate predictive equations for pet foods are discussed below:

Predictive Equations for ME in foods for dogs and cats For calculation of ME in prepared pet foods for cats and dogs (dry and wet) the following 4-step-calculation can be used (NRC 2006a):

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

This calculation is not suitable for milk substitutes and liquid preparations for enteral nutrition and may be inaccurate for foods with a crude fibre content of more than 8 percent.

b) 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^{-1} digestible crude protein (5.23kJ g^{-1}) for dogs and 0.9kcal g^{-1} (3.77kJ g^{-1}) for cats (NRC 2006a). FEDIAF recommends that members who wish to use feeding trials should employ the quantitative collection protocol published on pages 39-43.

4. 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.

4.1 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 $kg^{0.75}$, 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).

4.2 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.

4.3 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.

4.4 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).

4.5 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).

5. 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.

5.1 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).

5.1.1 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 2
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 2 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 2 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 2, whereas older dogs (> 7 years of age) which are still playing and running will need more energy than indicated.

Table 3 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 2 to estimate the energy requirements of adult dogs.

Table 3
DER Recommendations for adult dogs

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).

5.1.2 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 4 provides equations to calculate the average energy needs of lactating bitches at different stages of lactation.

Table 4
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	132/kg BW$^{0.75}$ + 24n x kg BW x L	550 /kg BW$^{0.75}$ + 100n x kg BW x L
	5 to 8 puppies	132/kg BW$^{0.75}$ + (96 + 12n) x kg BW x L	550 /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.

5.2 Cats

Owing to the small variation in adult body weights, the energy needs of cats can be expressed per kg BW instead of per kg metabolic weight. In addition, if metabolic weight is used to calculate MER with 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; Edtstadtler-Pietsch 2003).

The equation of 100kcal (418kJ) ME per kg$^{0.67}$ proposed by NRC 2006 corresponds with a daily energy intake of about 60-70kcal (250-290kJ) ME per kg body weight. Although NRC specifies that this equation 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). Therefore it is justified to recommend a range that starts at 80kcal (335kJ) ME per kg$^{0.67}$ [about 50-60kcal (210-250kJ) ME per kg body weight]. Particularly for neutered cats and cats living indoors energy requirements may be substantially lower.

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 5
Average daily energy requirements of adult cats

Gender - Activity	kcal ME/kg$^{0.67}$	kcal ME/kg BW	kJ ME/kg$^{0.67}$	kJ ME/kg BW
Intact male & female	80	50-60	335	210-250
Neutered, indoor cats	52-87	35-55	215-365	145-230
Active cats	100	60-70	418	250-290

NRC 2006 a & c, Riond et al. 2003, Wichert et al. 2007.

Table 6
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	585kcal/kg$^{0.67}$ BW
Lactation	< 3 kittens	100kcal/kg$^{0.67}$ + 18 x kg BW x L	418kcal/kg$^{0.67}$ + 75 x kg BW x L
	3-4 kittens	100kcal/kg$^{0.67}$ + 60 x kg BW x L	418kcal/kg$^{0.67}$ + 250 x kg BW x L
	> 4 kittens	100kcal/kg$^{0.67}$ + 70 x kg BW x L	418kcal/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.

6. Impact of energy requirement on product formulation

Balanced nutrition ensuring adequate intake of energy, protein, minerals and vitamins is essential for the health and longevity of cats and dogs. In order to achieve the recommended nutrient intake at different levels of energy intake (see Tables 2, 3 & 5), products must be formulated to match the nutrient requirements. The FEDIAF recommendations (Section III Tables A_{1-3} & B_{1-3}) are principally based on NRC (2006) as well as on other peer reviewed scientific publications as referenced in the substantiation tables. Major

differences between the recommendations by FEDIAF and NRC are those for adult dogs. These are based on daily energy requirements of 110kcal/kgBW$^{0.75}$ (460kJ/kgBW$^{0.75}$) for an average household dog, whereas the NRC standard assumes a daily energy intake of about 130kcal/kgBW$^{0.75}$ (544kJ/kgBW$^{0.75}$). Since the daily intake of all essential nutrients should be the same despite a lower daily energy need, a systematic adjustment is applied to all essential nutrients to guarantee adequate nutrient intake (see Table 7).

Table 7
Impact of energy requirement on nutrient intake and minimum recommendations

	15kg dog	
	Moderately active	**Active**
MER	110kcal/kgBW$^{0.75}$	130kcal/kgBW$^{0.75}$
DER	838kcal	1000kcal
DM intake (with a food of 4kcal/gDM)	210g	250g
Total daily nutrient requirement (nutrient x)	15mg	
Minimum recommendation for nutrient x in finished product to meet daily requirement	18mg/1000kcal	15mg/1000kcal

The target nutrient density (units/1000kcal) can be calculated using the following equation in order to meet the minimum nutrient requirements.

$$\text{Units/1000kcal} = \frac{\text{Nutrient requirement per day (Units/kg metabolic BW)} \times 1000}{\text{DER (kcal/kg metabolic BW)}}$$

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3. TAURINE

Introduction

Taurine (2-Aminoethanesulfonic acid = NH_2CH_2-CH_2-SO_3H) 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.

1. 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 µmol/L (Pion et al. 1987, Douglas et al. 1991) or the whole blood concentration 200 µmol/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.

2. 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 (<40µmol/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. 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 38.

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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.

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	-	-

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

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4. ADVERSE REACTIONS TO FOOD

1. Introduction

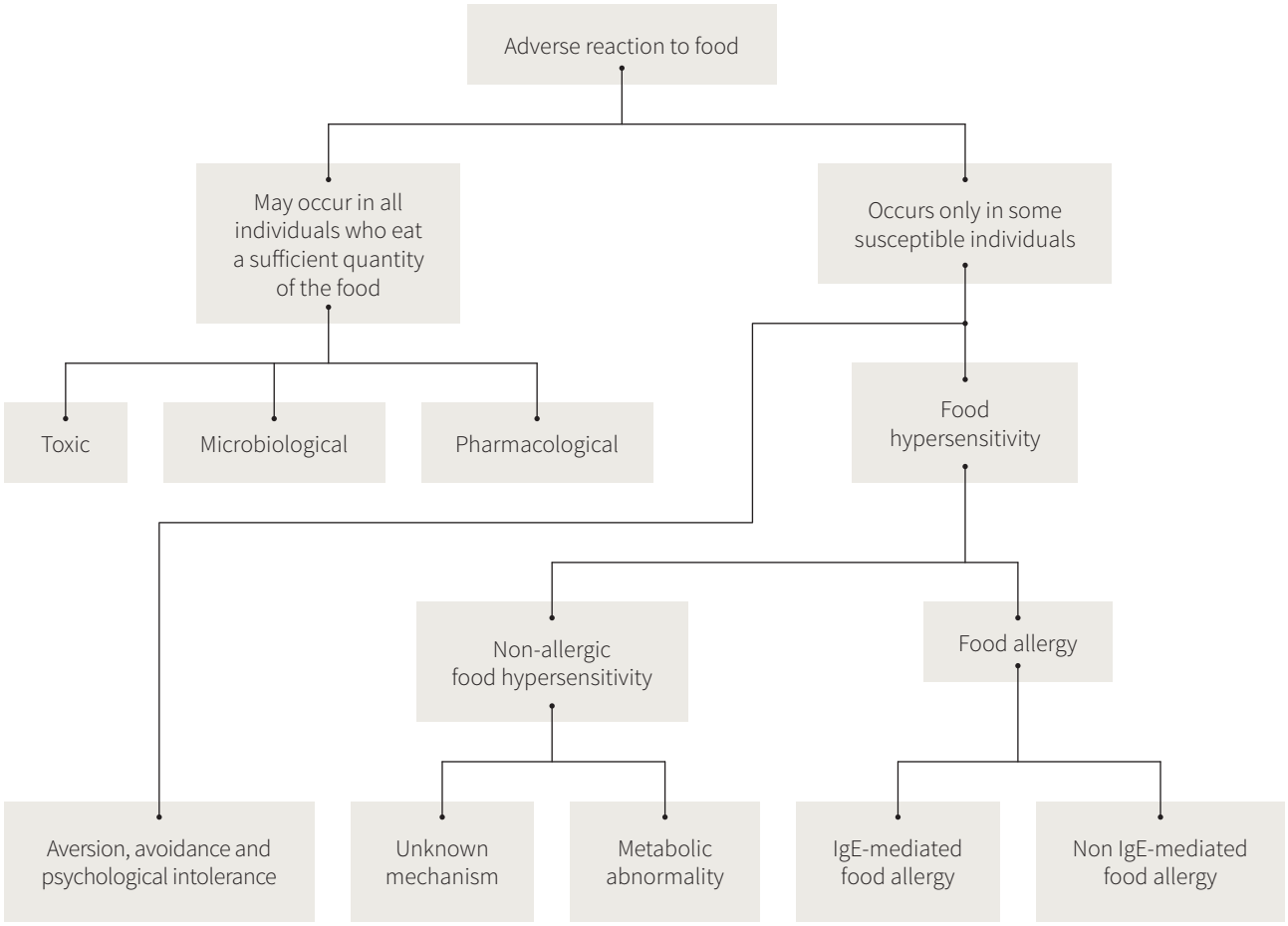
Adverse food reactions in cats and dogs are mainly expressed by pruritus and gastrointestinal signs. Acute anaphylactic reactions such as those seen in a minority of people who are allergic to nuts and some other foods have not been reported in relation to pet food.

2. Definitions

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).

A classification of adverse reactions to food



Source: ILSI Monograph Food Allergy 2003

2.2 Food allergy

Allergy Immune-mediated reaction resulting in one or more of the clinical signs described under 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 un-stated immunologic significance (Wasserman 1983).

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).

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 scromboid fish (tuna or salmon).

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

3. Food allergy in man

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.

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.

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.

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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

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).

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.

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.

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).

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7.2 Chocolate toxicity

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.

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 LD_{50} 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 1. 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.

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).

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).

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7.3 Toxicity of onions and garlic in cats & dogs

Background

It has been known since 1930 that dogs are very sensitive to onions (Allium spp) whether raw, cooked or dehydrated.

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), haemolytic anaemia, haemoglobinuria, increased serum bilirubin and possibly methaemoglobinaemia (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 [a], 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 (Yamato 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.

[a] Eccentrocytes are 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.

Table 2
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.

Toxic agents

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).

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). Anti-oxidant 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).

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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.

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

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

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
- 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 A_1 to A_3 Dogs

d. Minimum calcium levels for puppies were adapted to reflect the recommendations by the research subgroup on calcium

- Tables B_1 to B_3 Cats
  - Ca/P ratios for cat foods were adapted according to the recommendations by the research subgroup on calcium

e. Substantiation tables

- Updated references for vitamins A and E for dogs
- Updated references for calcium-phosphorus ratio for cats

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 A_1 to A_3 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 B_1 to B_3 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 substation 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 A_1 to A_3 Dogs
  - Deletion of nutritional max. for zinc
- Tables B_1 to B_3 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 6 with a rationale for adapting nutrient levels at differing daily energy requirements

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