JULY 2024

# Nutritional Guidelines

For Complete and Complementary
Pet Food for Cats and Dogs

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# Preface

A complete and balanced diet is essential for the health and well being of dogs and cats. Appropriate lifestage diets provide the nutrients needed for reproduction, growth and for a long, healthy, active adult life. They also prevent the nutrition related disorders which can occur due to nutritional deficiencies or excesses. Our knowledge of specific canine and feline nutrient requirements and their utilization is constantly improving from research.

The European Pet Food Industry Scientific Advisory Board (SAB), founded in 2010, consists of independent nutrition scientists in academia and private consulting from European countries. The functions of the SAB are to help FEDIAF access and critically evaluate relevant scientific literature. They also highlight where sufficient information is missing and where uncertainty or disagreement exists. Surveillance, exploration and discussion of nutritional research are used to determine the recommended nutrient levels and feeding practices utilized in these Nutritional Guidelines.

FEDIAF is unique in its approach of constant review of the nutrition research literature and frequent updating of the Nutritional Guidelines for consistency with current scientific data and knowledge. The recommended nutrient values in the 2024 Nutritional Guidelines are therefore based on up to date scientific principles and their practical use for safe and healthy pet foods.

*Dr Marge Chandler, Chair of the SAB*

# Acknowledgement

FEDIAF thanks everyone who has contributed to the quality of these Nutritional Guidelines, especially the Scientific Advisory Board members for reviewing the Guidelines and for the continuing scientific support to the group.

**Scientific Advisory Board:**

# 1. Glossary

## 1.1. 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 (Uauy-Dagach R et al. 2001).

**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 (*Oswalt M and Kemp SF al. 2007, Tang AW 2003, Wang J and Sampson HA 2007)*.

### B

**Basal metabolic rate (BMR).** 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 acclimatized *(Blaxter KL 1989b)*.

**Bioavailability.** The degree to which a nutrient is absorbed and becomes available at the site of action in the body *(Hoag SW and Hussain AS 2001)*.

### C

**Complementary pet food.** 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) No 767/2009)*. See also FEDIAF explanation in chapter 4.

**Complete pet food.** Pet food which, by reason of its composition, is sufficient for a daily ration *(Regulation (EC) No 767/2009)*.

## D

**Daily ration.** The average total quantity of feeding stuffs, 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 (EC) No 1831 2003)*.

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 1994)*.

**Digestible energy (DE).** Digestible energy is the gross energy less the gross energy of faeces resulting from the consumption of that pet food (*McDonald P et al. 2011a)*.

**Dry Matter (DM).** Residue after drying.

**Dry pet food.** Pet food with a moisture content of 14 % or less *(Longstanding industry definition)*.

## 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 et al. 1994)*.

## 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 7.6. "Adverse reactions to food" *(Halliwell REW 1992)*.

## G

**Gross energy (GE).** Gross energy is the total energy arising from complete combustion of a food in a bomb calorimeter *(McDonald P et al. 2011b)*.

## M

**Maintenance energy requirement (MER).** Maintenance energy requirement is the energy required to support energy equilibrium (where ME Maintenance Energy equals heat production) over a long period of time *(Blaxter KL 1989a)*.

**Metabolisable energy (ME).** Metabolisable energy is the digestible energy less the energy lost in urine and combustible gases *(McDonald P et al. 2011c)*.

**Minimum recommended level.**

Minimum recommended levels include a safety margin to prevent deficiencies due to animal variations and nutrient interactions. 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

## N

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

**Nutrient requirement.** 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 1994)*.

**Nutritional maximum limit.** Nutritional maximum limit 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.

## 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 *(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)*.

**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 1994, Halliwell REW 1992)*.

## R

**Recommended Allowance (RA).** The concentration or amount of a nutrient in a diet formulated to support a given physiological state. (NRC 2006j).

## S

**Semi-moist pet food.** Pet food with a moisture content of 14 % or more or less than 60 % *(Longstanding industry definition)*.

## W

**Wet pet food.** Pet food with a moisture content of 60 % or more *(Longstanding industry definition)*.

# 2. Introduction

FEDIAF represents the national pet food industry associations in the EU and from Norway, Switzerland and UK, promoting the views and interest of around 150 pet food companies in Europe (95% of the industry).

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 whenever there are new relevant technological, scientific or legislative developments in pet nutrition.

## 2.1. OBJECTIVES

**The objectives of FEDIAF's Guidelines for Complete and Complementary Pet Food 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, petcare 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.

## 2.2. 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.

# 3. Complete Pet Food

## 3.1. 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 product should be validated by chemical analysis of the finished product. It is recommended to use an officially recognised method (Chapter 5.).

### 3.1.1. 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 III-3a. & III-4a.), "units/1000kcal ME" (Tables III-3b. & III-4b.) and "units/MJ ME" (Tables III-3c. & III-4c.).

## 3.1.2. 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 6. for the different methods).

A feeding trial normally measures digestible energy. By subtracting the energy lost in the urine (urinary gross energy), the same trials allow also for determining the metabolisable 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: 1.25 kcal (5.23 kJ) $g^{-1}$ digestible crude protein for dogs and 0.86 kcal (3.60 kJ) $g^{-1}$ digestible protein for cats (Chapter 6.).

Alternatively, formulae given in ANNEX 7.2. 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 7.2.

## 3.1.3. Maximum levels of certain substances in complete pet food for cats and dogs

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

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

In addition, maximum permitted levels have been determined by the legislator for several nutrients if added as a nutritional additive (i.e. trace elements & vitamin D) (legal maximum). They are laid down in the Community Register of Feed Additives pursuant to Regulation 1831/2003/EC of the Parliament and the Council, concerning additives in feeding stuffs. The legal maximum levels apply to all life stages (EU Regulation 1831/2003 in conjunction with EU register of feed additives). A legal maximum only applies when the particular trace element or vitamin is added to the recipe as an additive, but relates to the 'total' amount present in the finished product (amount coming from the additive plus amount from feed materials (ingredients)). If the nutrient comes exclusively from feed materials, the legal maximum does not apply, instead the nutritional maximum, when included in the relevant tables, should be taken into account.

Both groups of maximum values are reported in the FEDIAF tables III-3a-c and III-4a-c and tables VII-17a-d and VII-18a-c. EU legal limits are reported on dry matter basis only to comply with Regulation 1831/2003/EC.

A non-exhaustive list of scientifically recognised analytical methods that can be used to assess the nutrient levels in pet food is available in chapter 5.

## 3.1.4. Product validation

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

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

# Table III-1. Nutrients

| | | | |
|---|---|---|---|
| **Major nutrients** | Protein | | |
| | Fat | | |
| | | | |
| **Fatty acids** | Linoleic acid | Arachidonic acid (**cats**) | |
| | Alpha-linolenic acid | Eicosapentaenoic acid (EPA) | |
| | | Docosahexaenoic acid (DHA) | |
| | | | |
| **Amino acids** | Arginine | Histidine | Isoleucine |
| | Cystine | Tyrosine | Lysine |
| | Phenylalanine | Threonine | Tryptophan |
| | Leucine | Methionine | Valine |
| | | | |
| **Minerals** | Calcium | Phosphorus | Potassium |
| | Sodium | Copper | Iron |
| | Chloride | Magnesium | Iodine |
| | Manganese | Zinc | Selenium |
| | | | |
| **Vitamins** | Vitamin A | Vitamin D | Vitamin E |
| | Vitamin B1 (Thiamine)* | Vitamin B2 (Riboflavin)* | Vitamin B5 (Pantothenic acid)* |
| | Vitamin B3 (Niacin)* | Vitamin B6 (Pyridoxine)* | Vitamin B7 (Biotin)* |
| | Vitamin B12* (Cyanocobalamin)* | Vitamin B9 (Folic acid)* | Vitamin K |
| | | | |
| **Vitamin-like substances** | Taurine (**cats**) | Choline | |
| | | | |
| **Remarks** | See section on analytical method pp. 34 for the appropriate method and other details. | | |
| | Routine analysis for energy calculation includes moisture, crude protein, crude fat, crude ash, crude fibre (Weende analysis) | | |

## 3.1.5. Repeat analyses

Once a product has been passed and the formula remains essentially unchanged, continued analyses are recommended to make sure that the product still meets the appropriate nutritional standards. Deviations may occur due to fluctuations in raw materials. The frequency of testing is the responsibility of the manufacturer.

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

## 3.1.6. 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 7.2. can be used as basis to calculate the amounts to feed.

# 3.2. TABLES WITH NUTRIENT RECOMMENDATIONS FOR COMPLETE DOG AND CAT FOOD

## 3.2.1. How to read the tables

Recommended minimum values are based on an average daily energy intake of either 95 kcal/kg$^{0.75}$ (398 kJ/kg$^{0.75}$) or 110 kcal/kg$^{0.75}$ (460 kJ/kg$^{0.75}$) for dogs and either 75 kcal/kg$^{0.67}$ (314 kJ/kg$^{0.67}$) or 100 kcal/kg$^{0.67}$ (418 kJ/kg$^{0.67}$) for cats.

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

For commercial dog and cat foods it is recommended that the nutrient levels are at or above the levels listed in the tables and do not exceed the nutritional or legal maximum. If the protein digestibility of ≥ 80% (mentioned under "2.2. Scope") cannot be guaranteed, it is recommended to increase the essential amino acid levels by a minimum of 10%.

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

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

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

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

**Table III-2. Conversion factors**

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

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

## Tables III-3$_{a,b,c}$. Recommended nutrient levels for complete dog food

| | |
|---|---|
| **3$_a$** | Recommended nutrient levels for complete dog food: unit per 100 g of dry matter (DM) |
| **3$_b$** | Recommended nutrient levels for complete dog food: unit per 1000 kcal of metabolisable energy (ME) |
| **3$_c$** | Recommended nutrient levels for complete dog food: unit per MJ of metabolisable energy (ME) |

## Tables III-4$_{a,b,c}$.Recommended nutrient levels for complete cat food

| | |
|---|---|
| **4$_a$** | Recommended nutrient levels for complete cat food: unit per 100 g of dry matter (DM) |
| **4$_b$** | Recommended nutrient levels for complete cat food: unit per 1000 kcal of metabolisable energy (ME) |
| **4$_c$** | Recommended nutrient levels for complete cat food: unit per MJ of metabolisable energy (ME) |

- The nutrient levels in the tables are minimum recommended nutrient levels for commercial pet food, not **minimum** requirements or optimal intake levels.
- The right column indicates the maximum recommended value.
- The legal **maximum** (L) is mandatory and always applies to all life stages.
- The nutritional maximum (N) is the highest level that is not supposed to cause any harmful effect. Unless the life stage is indicated it applies to all life stages.
- Values for adult cats and dogs in the tables are calculated from NRC (2006j) recommendations by assuming a moderate-sized lean adult dog of 15 kg bodyweight and a moderate-sized lean adult cat of 4 kg bodyweight including a correction for lower energy intake.
- When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1 and 3.3.2.
- Footnotes a-h are summarised below Table III-4$_c$.

# 3.2.2. Recommended nutrient levels for complete dog food

## TABLE III-3$_a$. Unit per 100 g dry matter (DM)

| Nutrient | UNIT | Minimum Recommended Level | | | | Maximum |
|---|---|---|---|---|---|---|
| | | Adult - based on MER of | | Early Growth (< 14 weeks) & Reproduction | Late Growth (≥ 14 weeks) | (L) = EU legal limit<br>(N) = nutritional |
| | | 95 kcal/kg$^{0.75}$ | 110 kcal/kg$^{0.75}$ | | | |
| **Protein*** | **g** | **21.00** | **18.00** | **25.00** | **20.00** | **-** |
| Arginine* | g | 0.60 | 0.52 | 0.82 | 0.74 | - |
| Histidine | g | 0.27 | 0.23 | 0.39 | 0.25 | - |
| Isoleucine | g | 0.53 | 0.46 | 0.65 | 0.50 | - |
| Leucine | g | 0.95 | 0.82 | 1.29 | 0.80 | - |
| Lysine* | g | 0.46 | 0.42 | 0.88 | 0.70 | Growth: 2.80 (N) |
| Methionine* | g | 0.46 | 0.40 | 0.35 | 0.26 | - |
| Methionine + cystine* | g | 0.88 | 0.76 | 0.70 | 0.53 | - |
| Phenylalanine | g | 0.63 | 0.54 | 0.65 | 0.50 | - |
| Phenylalanine + tyrosine* | g | 1.03 | 0.89 | 1.30 | 1.00 | - |
| Threonine | g | 0.60 | 0.52 | 0.81 | 0.64 | - |
| Tryptophan | g | 0.20 | 0.17 | 0.23 | 0.21 | - |
| Valine | g | 0.68 | 0.59 | 0.68 | 0.56 | - |
| **Fat*** | **g** | **5.50** | **5.50** | **8.50** | **8.50** | **-** |
| Linoleic acid (ω-6)* | g | 1.53 | 1.32 | 1.30 | 1.30 | Early Growth: 6.50 (N) |
| Arachidonic acid (ω-6)* | mg | - | - | 30.00 | 30.00 | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.08 | 0.08 | - |
| EPA + DHA (ω-3)* | g | - | - | 0.05 | 0.05 | - |
| **Minerals** | | | | | | |
| Calcium* | g | 0.58 | 0.50 | 1.00 | 0.80[a]<br>1.00[b] | Adult: 2.50 (N)<br>Early growth: 1.60 (N)<br>Late growth: 1.80 (N) |
| Phosphorus* | g | 0.46 | 0.40 | 0.90 | 0.70 | Adult: 1.60 (N)<br>[h] |
| Ca / P ratio | | 1/1 | | | | Adult: 2/1 (N)<br>Early growth & reprod.: 1.6/1 (N)<br>Late growth: 1.8/1[a] (N) or 1.6/1[b] (N) |
| Potassium | g | 0.58 | 0.50 | 0.44 | 0.44 | - |
| Sodium* | g | 0.12 | 0.10 | 0.22 | 0.22 | [c] |
| Chloride | g | 0.17 | 0.15 | 0.33 | 0.33 | [c] |
| Magnesium | g | 0.08 | 0.07 | 0.04 | 0.04 | - |
| **Trace elements*** | | | | | | |
| Copper* | mg | 0.83 | 0.72 | 1.10 | 1.10 | 2.80 (L) |
| Iodine* | mg | 0.12 | 0.11 | 0.15 | 0.15 | 1.10 (L) |
| Iron* | mg | 4.17 | 3.60 | 8.80 | 8.80 | 68.18 (L) |
| Manganese | mg | 0.67 | 0.58 | 0.56 | 0.56 | 17.00 (L) |
| Selenium* (wet diets) | µg | 27.00 | 23.00 | 40.00 | 40.00 | 56.80 (L)[d] |
| Selenium* (dry diets) | µg | 22.00 | 18.00 | 40.00 | 40.00 | 56.80 (L)[d] |
| Zinc* | mg | 8.34 | 7.20 | 10.00 | 10.00 | 22.70 (L) |
| **Vitamins** | | | | | | |
| Vitamin A* | IU | 702.00 | 606.00 | 500.00 | 500.00 | 40 000 (N) |
| Vitamin D* | IU | 63.90 | 55.20 | 55.20 | 50.00 | 227.00 (L)<br>320.00 (N) |
| Vitamin E* | IU | 4.17 | 3.60 | 5.00 | 5.00 | |
| Vitamin B1 (Thiamine)* | mg | 0.25 | 0.21 | 0.18 | 0.18 | - |
| Vitamin B2 (Riboflavin)* | mg | 0.69 | 0.60 | 0.42 | 0.42 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 1.64 | 1.42 | 1.20 | 1.20 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.17 | 0.15 | 0.12 | 0.12 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 3.87 | 3.35 | 2.80 | 2.80 | - |
| Vitamin B3 (Niacin)* | mg | 1.89 | 1.64 | 1.36 | 1.36 | - |
| Vitamin B9 (Folic acid)* | µg | 29.90 | 25.80 | 21.60 | 21.60 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - |
| Choline | mg | 189.00 | 164.00 | 170.00 | 170.00 | - |
| Vitamin K* | µg | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# TABLE III-3$_b$.
# Recommended nutrient levels for complete dog food
# Unit per 1000 kcal of metabolisable energy (ME)

| Nutrient | UNIT | Minimum Recommended Level | | | | Maximum |
|---|---|---|---|---|---|---|
| | | Adult based on MER of | | Early Growth (< 14 weeks) & Reproduction | Late Growth (≥ 14 weeks) | (L) = EU legal limit (given only on DM basis, see table III-3$_a$)<br>(N) = nutritional |
| | | 95 kcal/kg$^{0.75}$ | 110 kcal/kg$^{0.75}$ | | | |
| **Protein*** | **g** | **52.10** | **45.00** | **62.50** | **50.00** | **-** |
| Arginine* | g | 1.51 | 1.30 | 2.04 | 1.84 | - |
| Histidine | g | 0.67 | 0.58 | 0.98 | 0.63 | - |
| Isoleucine | g | 1.33 | 1.15 | 1.63 | 1.25 | - |
| Leucine | g | 2.37 | 2.05 | 3.23 | 2.00 | - |
| Lysine* | g | 1.22 | 1.05 | 2.20 | 1.75 | Growth: 7.00 (N) |
| Methionine* | g | 1.16 | 1.00 | 0.88 | 0.65 | - |
| Methionine + cystine* | g | 2.21 | 1.91 | 1.75 | 1.33 | - |
| Phenylalanine | g | 1.56 | 1.35 | 1.63 | 1.25 | - |
| Phenylalanine + tyrosine* | g | 2.58 | 2.23 | 3.25 | 2.50 | - |
| Threonine | g | 1.51 | 1.30 | 2.03 | 1.60 | - |
| Tryptophan | g | 0.49 | 0.43 | 0.58 | 0.53 | - |
| Valine | g | 1.71 | 1.48 | 1.70 | 1.40 | - |
| **Fat*** | **g** | **13.75** | **13.75** | **21.25** | **21.25** | **-** |
| Linoleic acid (ω-6)* | g | 3.82 | 3.27 | 3.25 | 3.25 | Early Growth: 16.25 (N) |
| Arachidonic acid (ω-6)* | mg | - | - | 75.00 | 75.00 | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.20 | 0.20 | - |
| EPA + DHA (ω-3)* | g | - | - | 0.13 | 0.13 | - |
| **Minerals** | | | | | | |
| Calcium* | g | 1.45 | 1.25 | 2.50 | 2.00[a]<br>2.50[b] | Adult: 6.25 (N)<br>Early growth: 4.00 (N)<br>Late growth: 4.50 (N) |
| Phosphorus* | g | 1.16 | 1.00 | 2.25 | 1.75 | Adult: 4.00 (N)<br>[h] |
| Ca / P ratio | | 1/1 | | | | Adult: 2/1 (N)<br>Early growth & reprod.: 1.6/1 (N)<br>Late growth: 1.8/1[a] (N) or 1.6/1[b] (N) |
| Potassium | g | 1.45 | 1.25 | 1.10 | 1.10 | - |
| Sodium* | g | 0.29 | 0.25 | 0.55 | 0.55 | [c] |
| Chloride | g | 0.43 | 0.38 | 0.83 | 0.83 | [c] |
| Magnesium | g | 0.20 | 0.18 | 0.10 | 0.10 | - |
| **Trace elements*** | | | | | | |
| Copper* | mg | 2.08 | 1.80 | 2.75 | 2.75 | (L) |
| Iodine* | mg | 0.30 | 0.26 | 0.38 | 0.38 | (L) |
| Iron* | mg | 10.40 | 9.00 | 22.00 | 22.00 | (L) |
| Manganese | mg | 1.67 | 1.44 | 1.40 | 1.40 | (L) |
| Selenium* (wet diets) | µg | 67.50 | 57.50 | 100.00 | 100.00 | (L) |
| Selenium* (dry diets) | µg | 55.00 | 45.00 | 100.00 | 100.00 | (L) |
| Zinc* | mg | 20.80 | 18.00 | 25.00 | 25.00 | (L) |
| **Vitamins** | | | | | | |
| Vitamin A* | IU | 1 754 | 1 515 | 1 250 | 1 250 | 100 000 (N) |
| Vitamin D* | IU | 159.00 | 138.00 | 138.00 | 125.00 | (L)<br>800.00 (N) |
| Vitamin E* | IU | 10.40 | 9.00 | 12.50 | 12.50 | |
| Vitamin B1 (Thiamine)* | mg | 0.62 | 0.54 | 0.45 | 0.45 | - |
| Vitamin B2 (Riboflavin)* | mg | 1.74 | 1.50 | 1.05 | 1.05 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 4.11 | 3.55 | 3.00 | 3.00 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.42 | 0.36 | 0.30 | 0.30 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 9.68 | 8.36 | 7.00 | 7.00 | - |
| Vitamin B3 (Niacin)* | mg | 4.74 | 4.09 | 3.40 | 3.40 | - |
| Vitamin B9 (Folic acid)* | µg | 74.70 | 64.50 | 54.00 | 54.00 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - |
| Choline | mg | 474.00 | 409.00 | 425.00 | 425.00 | - |
| Vitamin K* | µg | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# TABLE III-3$_c$.
# Recommended nutrient levels for complete dog food
# Unit per MJ of metabolisable energy (ME)

| Nutrient | UNIT | Minimum Recommended Level | | | | Maximum |
|---|---|---|---|---|---|---|
| | | Adult based on MER of | | Early Growth (< 14 weeks) & Reproduction | Late Growth (≥ 14 weeks) | (L) = EU legal limit (given only on DM basis, see table III-3$_a$) (N) = nutritional |
| | | 95 kcal/kg$^{0.75}$ | 110 kcal/kg$^{0.75}$ | | | |
| **Protein*** | **g** | **12.50** | **10.80** | **14.94** | **11.95** | **-** |
| Arginine* | g | 0.36 | 0.31 | 0.49 | 0.44 | - |
| Histidine | g | 0.16 | 0.14 | 0.23 | 0.15 | - |
| Isoleucine | g | 0.32 | 0.27 | 0.39 | 0.30 | - |
| Leucine | g | 0.57 | 0.49 | 0.77 | 0.48 | - |
| Lysine* | g | 0.29 | 0.25 | 0.53 | 0.42 | Growth: 1.67 (N) |
| Methionine* | g | 0.28 | 0.24 | 0.21 | 0.16 | - |
| Methionine + cystine* | g | 0.53 | 0.46 | 0.42 | 0.32 | - |
| Phenylalanine | g | 0.37 | 0.32 | 0.39 | 0.30 | - |
| Phenylalanine + tyrosine* | g | 0.62 | 0.53 | 0.78 | 0.60 | - |
| Threonine | g | 0.36 | 0.31 | 0.48 | 0.38 | - |
| Tryptophan | g | 0.12 | 0.10 | 0.14 | 0.13 | - |
| Valine | g | 0.41 | 0.35 | 0.41 | 0.33 | - |
| **Fat*** | **g** | **3.29** | **3.29** | **5.08** | **5.08** | **-** |
| Linoleic acid (ω-6)* | g | 0.91 | 0.79 | 0.78 | 0.78 | Early Growth: 3.88 (N) |
| Arachidonic acid (ω-6)* | mg | - | - | 17.90 | 17.90 | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.05 | 0.05 | - |
| EPA + DHA (ω-3)* | g | - | - | 0.03 | 0.03 | - |
| **Minerals** | | | | | | |
| Calcium* | g | 0.35 | 0.30 | 0.60 | 0.48[a]<br>0.60[b] | Adult: 1.49 (N)<br>Early growth: 0.96 (N)<br>Late growth: 1.08 (N) |
| Phosphorus* | g | 0.28 | 0.24 | 0.54 | 0.42 | Adult: 0.96 (N)<br>[h] |
| Ca / P ratio | | 1/1 | | | | Adult: 2/1 (N)<br>Early growth & reprod.: 1.6/1 (N)<br>Late growth: 1.8/1[a] (N) or 1.6/1[b] (N) |
| Potassium | g | 0.35 | 0.30 | 0.26 | 0.26 | - |
| Sodium* | g | 0.07 | 0.06 | 0.13 | 0.13 | [c] |
| Chloride | g | 0.10 | 0.09 | 0.20 | 0.20 | [c] |
| Magnesium | g | 0.05 | 0.04 | 0.02 | 0.02 | - |
| **Trace elements*** | | | | | | |
| Copper* | mg | 0.50 | 0.43 | 0.66 | 0.66 | (L) |
| Iodine* | mg | 0.07 | 0.06 | 0.09 | 0.09 | (L) |
| Iron* | mg | 2.49 | 2.15 | 5.26 | 5.26 | (L) |
| Manganese | mg | 0.40 | 0.34 | 0.33 | 0.33 | (L) |
| Selenium* (wet diets) | µg | 16.10 | 13.70 | 23.90 | 23.90 | (L) |
| Selenium* (dry diets) | µg | 13.10 | 10.80 | 23.90 | 23.90 | (L) |
| Zinc* | mg | 4.98 | 4.30 | 5.98 | 5.98 | (L) |
| **Vitamins** | | | | | | |
| Vitamin A* | IU | 419.00 | 362.00 | 299.00 | 299.00 | 23 900 (N) |
| Vitamin D* | IU | 38.20 | 33.00 | 33.00 | 29.90 | (L)<br>191.00 (N) |
| Vitamin E* | IU | 2.49 | 2.20 | 3.00 | 3.00 | |
| Vitamin B1 (Thiamine)* | mg | 0.15 | 0.13 | 0.11 | 0.11 | - |
| Vitamin B2 (Riboflavin)* | mg | 0.42 | 0.36 | 0.25 | 0.25 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 0.98 | 0.85 | 0.72 | 0.72 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.10 | 0.09 | 0.07 | 0.07 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 2.31 | 2.00 | 1.67 | 1.67 | - |
| Vitamin B3 (Niacin)* | mg | 1.13 | 0.98 | 0.81 | 0.81 | - |
| Vitamin B9 (Folic acid)* | µg | 17.90 | 15.40 | 12.90 | 12.90 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - |
| Choline | mg | 113.00 | 97.80 | 102.00 | 102.00 | - |
| Vitamin K* | µg | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# 3.2.3. Recommended nutrient levels for complete cat food

## TABLE III-4$_a$.

## Unit per 100 g dry matter (DM)

| Nutrient | UNIT | Minimum Recommended Level | | | Maximum |
|---|---|---|---|---|---|
| | | Adult based on MER of | | Growth / Reproduction | (L) = EU legal limit<br>(N) = nutritional |
| | | 75 kcal/kg$^{0.67}$ | 100 kcal/kg$^{0.67}$ | | |
| **Protein*** | **g** | **33.30** | **25.00** | **28.00/30.00** | **-** |
| Arginine* | g | 1.30 | 1.00 | 1.07/1.11 | Growth: 3.50 (N) |
| Histidine | g | 0.35 | 0.26 | 0.33 | - |
| Isoleucine | g | 0.57 | 0.43 | 0.54 | |
| Leucine | g | 1.36 | 1.02 | 1.28 | |
| Lysine* | g | 0.45 | 0.34 | 0.85 | |
| Methionine* | g | 0.23 | 0.17 | 0.44 | Growth: 1.30 (N) |
| Methionine + cystine* | g | 0.45 | 0.34 | 0.88 | |
| Phenylalanine | g | 0.53 | 0.40 | 0.50 | |
| Phenylalanine + tyrosine* | g | 2.04 | 1.53 | 1.91 | |
| Threonine | g | 0.69 | 0.52 | 0.65 | |
| Tryptophan* | g | 0.17 | 0.13 | 0.16 | Growth: 1.70 (N) |
| Valine | g | 0.68 | 0.51 | 0.64 | |
| Taurine (canned pet food)* | g | 0.27 | 0.20 | 0.25 | |
| Taurine (dry pet food)* | g | 0.13 | 0.10 | 0.10 | |
| **Fat*** | **g** | **9.00** | **9.00** | **9.00** | |
| Linoleic acid (ω-6) | g | 0.67 | 0.50 | 0.55 | |
| Arachidonic acid (ω-6) | mg | 8.00 | 6.00 | 20.00 | |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.02 | |
| EPA + DHA (ω-3)* | g | - | - | 0.01 | |
| **Minerals** | | | | | |
| Calcium* | g | 0.53 [g] | 0.40 [g] | 1.00 [g] | |
| Phosphorus* | g | 0.35 [g] | 0.26 [g] | 0.84 [g] | [f] |
| Ca / P ratio | | | 1/1 | | Growth: 1.5/1 (N)<br>Adult: 2/1 (N) |
| Potassium | g | 0.80 | 0.60 | 0.60 | |
| Sodium* | g | 0.10 | 0.08 | 0.16 | [e] |
| Chloride | g | 0.15 | 0.11 | 0.24 | |
| Magnesium* | g | 0.05 | 0.04 | 0.05 | |
| **Trace elements*** | | | | | |
| Copper* | mg | 0.67 | 0.50 | 1.00 | 2.80 (L) |
| Iodine* | mg | 0.17 | 0.13 | 0.18 | 1.10 (L) |
| Iron* | mg | 10.70 | 8.00 | 8.00 | 68.18 (L) |
| Manganese | mg | 0.67 | 0.50 | 1.00 | 17.00 (L) |
| Selenium (wet diets) | µg | 35.00 | 26.00 | 30.00 | 56.80 (L)[d] |
| Selenium (dry diets) | µg | 28.00 | 21.00 | 30.00 | 56.80 (L)[d] |
| Zinc | mg | 10.00 | 7.50 | 7.50 | 22.70 (L) |
| **Vitamins** | | | | | |
| Vitamin A* | IU | 444.00 | 333.00 | 900.00 | Adult & Growth: 40 000 (N)<br>Reproduction: 33 333 (N) |
| Vitamin D* | IU | 33.30 | 25.00 | 28.00 | 227 (L)<br>3 000 (N) |
| Vitamin E* | IU | 5.07 | 3.80 | 3.80 | |
| Vitamin B1 (Thiamine)* | mg | 0.59 | 0.44 | 0.55 | |
| Vitamin B2 (Riboflavin) | mg | 0.42 | 0.32 | 0.32 | |
| Vitamin B5 (Pantothenic acid) | mg | 0.77 | 0.58 | 0.57 | |
| Vitamin B6 (Pyridoxine)* | mg | 0.33 | 0.25 | 0.25 | |
| Vitamin B12 (Cyanocobalamin)* | µg | 2.35 | 1.76 | 1.80 | |
| Vitamin B3 (Niacin)* | mg | 4.21 | 3.20 | 3.20 | |
| Vitamin B9 (Folic acid)* | µg | 101.00 | 75.00 | 75.00 | |
| Vitamin B7 (Biotin)* | µg | 8.00 | 6.00 | 7.00 | |
| Choline | mg | 320.00 | 240.00 | 240.00 | |
| Vitamin K* | µg | - | - | - | |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# TABLE III-4$_b$. Recommended nutrient levels for complete cat food Unit per 1000 kcal of metabolisable energy (ME)

| Nutrient | UNIT | Minimum Recommended Level | | | Maximum |
|---|---|---|---|---|---|
| | | Adult based on MER of | | Growth / Reproduction | (L) = EU legal limit (given only on DM basis, see table III-4$_a$) (N) = nutritional |
| | | 75 kcal/kg$^{0.67}$ | 100 kcal/kg$^{0.67}$ | | |
| **Protein*** | g | **83.30** | **62.50** | **70.00/75.00** | - |
| Arginine* | g | 3.30 | 2.50 | 2.68/2.78 | Growth: 8.75 (N) |
| Histidine | g | 0.87 | 0.65 | 0.83 | - |
| Isoleucine | g | 1.44 | 1.08 | 1.35 | |
| Leucine | g | 3.40 | 2.55 | 3.20 | |
| Lysine* | g | 1.13 | 0.85 | 2.13 | |
| Methionine* | g | 0.57 | 0.43 | 1.10 | Growth: 3.25 (N) |
| Methionine + cystine* | g | 1.13 | 0.85 | 2.20 | |
| Phenylalanine | g | 1.33 | 1.00 | 1.25 | |
| Phenylalanine + tyrosine* | g | 5.11 | 3.83 | 4.78 | |
| Threonine | g | 1.73 | 1.30 | 1.63 | |
| Tryptophan* | g | 0.44 | 0.33 | 0.40 | Growth: 4.25 (N) |
| Valine | g | 1.70 | 1.28 | 1.60 | |
| Taurine (canned pet food)* | g | 0.67 | 0.50 | 0.63 | |
| Taurine (dry pet food)* | g | 0.33 | 0.25 | 0.25 | |
| **Fat*** | g | **22.50** | **22.50** | **22.50** | |
| Linoleic acid (ω-6) | g | 1.67 | 1.25 | 1.38 | |
| Arachidonic acid (ω-6) | mg | 20.00 | 15.00 | 50.00 | |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.05 | |
| EPA + DHA (ω-3)* | g | - | - | 0.03 | |
| **Minerals** | | | | | |
| Calcium* | g | 1.33 [g] | 1.00 [g] | 2.50 [g] | |
| Phosphorus* | g | 0.85 [g] | 0.64 [g] | 2.10 [g] | [f] |
| Ca / P ratio | | | 1/1 | | Growth: 1.5/1 (N)<br>Adult: 2/1 (N) |
| Potassium | g | 2.00 | 1.50 | 1.50 | |
| Sodium* | g | 0.25 | 0.19 | 0.40 | [e] |
| Chloride | g | 0.39 | 0.29 | 0.60 | |
| Magnesium* | g | 0.13 | 0.10 | 0.13 | |
| **Trace elements*** | | | | | |
| Copper* | mg | 1.67 | 1.25 | 2.50 | (L) |
| Iodine* | mg | 0.43 | 0.33 | 0.45 | (L) |
| Iron* | mg | 26.70 | 20.00 | 20.00 | (L) |
| Manganese | mg | 1.67 | 1.25 | 2.50 | (L) |
| Selenium (wet diets) | μg | 87.50 | 65.00 | 75.00 | (L) |
| Selenium (dry diets) | μg | 70.00 | 52.50 | 75.00 | (L) |
| Zinc | mg | 25.00 | 18.80 | 18.80 | (L) |
| **Vitamins** | | | | | |
| Vitamin A* | IU | 1 110 | 833.00 | 2 250 | Adult & Growth: 100 000 (N)<br>Reproduction: 83 325 (N) |
| Vitamin D* | IU | 83.30 | 62.50 | 70.00 | (L)<br>7 500 (N) |
| Vitamin E* | IU | 12.70 | 9.50 | 9.50 | |
| Vitamin B1 (Thiamine)* | mg | 1.47 | 1.10 | 1.40 | |
| Vitamin B2 (Riboflavin) | mg | 1.05 | 0.80 | 0.80 | |
| Vitamin B5 (Pantothenic acid)* | mg | 1.92 | 1.44 | 1.43 | |
| Vitamin B6 (Pyridoxine)* | mg | 0.83 | 0.63 | 0.63 | |
| Vitamin B12 (Cyanocobalamin)* | μg | 5.87 | 4.40 | 4.50 | |
| Vitamin B3 (Niacin)* | mg | 10.50 | 8.00 | 8.00 | |
| Vitamin B9 (Folic acid)* | μg | 253.00 | 188.00 | 188.00 | |
| Vitamin B7 (Biotin)* | μg | 20.00 | 15.00 | 17.50 | |
| Choline | mg | 800.00 | 600.00 | 600.00 | |
| Vitamin K* | μg | - | - | - | |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# TABLE III-4$_c$. Recommended nutrient levels for complete cat food Unit per MJ of metabolisable energy (ME)

| Nutrient | UNIT | Minimum Recommended Level | | | Maximum |
|---|---|---|---|---|---|
| | | Adult based on MER of | | Growth / Reproduction | (L) = EU legal limit (given only on DM basis, see table III-4$_a$) (N) = nutritional |
| | | 75 kcal/kg$^{0.67}$ | 100 kcal/kg$^{0.67}$ | | |
| **Protein*** | g | **19.92** | **14.94** | **16.73/17.93** | - |
| Arginine* | g | 0.80 | 0.60 | 0.64/1.00 | Growth: 2.09 (N) |
| Histidine | g | 0.21 | 0.16 | 0.20 | - |
| Isoleucine | g | 0.35 | 0.26 | 0.32 | |
| Leucine | g | 0.81 | 0.61 | 0.76 | |
| Lysine* | g | 0.27 | 0.20 | 0.51 | |
| Methionine* | g | 0.14 | 0.10 | 0.26 | Growth: 0.78 (N) |
| Methionine + cystine* | g | 0.27 | 0.20 | 0.53 | |
| Phenylalanine | g | 0.32 | 0.24 | 0.30 | |
| Phenylalanine + tyrosine* | g | 1.23 | 0.92 | 1.14 | |
| Threonine | g | 0.41 | 0.31 | 0.39 | |
| Tryptophan* | g | 0.11 | 0.08 | 0.10 | Growth: 1.02 (N) |
| Valine | g | 0.41 | 0.31 | 0.38 | |
| Taurine (canned pet food)* | g | 0.16 | 0.12 | 0.15 | |
| Taurine (dry pet food)* | g | 0.08 | 0.06 | 0.06 | |
| **Fat*** | g | **5.38** | **5.38** | **5.38** | |
| Linoleic acid (ω-6) | g | 0.40 | 0.30 | 0.33 | |
| Arachidonic acid (ω-6) | mg | 4.78 | 3.59 | 11.95 | |
| Alpha-linolenic acid (ω-3)* | g | - | - | 0.01 | |
| EPA + DHA (ω-3)* | g | - | - | 0.01 | |
| **Minerals** | | | | | |
| Calcium* | g | 0.32 [g] | 0.24 [g] | 0.60 [g] | |
| Phosphorus* | g | 0.20 [g] | 0.15 [g] | 0.50 [g] | [f] |
| Ca / P ratio | | | 1/1 | | Growth: 1.5/1 (N)<br>Adult: 2/1 (N) |
| Potassium | g | 0.48 | 0.36 | 0.36 | |
| Sodium* | g | 0.06 | 0.05 | 0.10 | [e] |
| Chloride | g | 0.09 | 0.07 | 0.14 | |
| Magnesium* | g | 0.03 | 0.02 | 0.03 | |
| **Trace elements*** | | | | | |
| Copper* | mg | 0.40 | 0.30 | 0.60 | (L) |
| Iodine* | mg | 0.10 | 0.08 | 0.11 | (L) |
| Iron* | mg | 6.37 | 4.78 | 4.78 | (L) |
| Manganese | mg | 0.40 | 0.30 | 0.60 | (L) |
| Selenium (wet diets) | µg | 20.90 | 15.50 | 17.90 | (L) |
| Selenium (dry diets) | µg | 16.70 | 12.50 | 17.90 | (L) |
| Zinc | mg | 5.98 | 4.48 | 4.48 | (L) |
| **Vitamins** | | | | | |
| Vitamin A* | IU | 265.00 | 199.00 | 538.00 | Adult & Growth: 23 901 (N)<br>Reproduction: 19 917 (N) |
| Vitamin D* | IU | 19.90 | 14.90 | 16.70 | (L)<br>1 793 (N) |
| Vitamin E* | IU | 3.03 | 2.30 | 2.30 | |
| Vitamin B1 (Thiamine)* | mg | 0.35 | 0.26 | 0.33 | |
| Vitamin B2 (Riboflavin) | mg | 0.25 | 0.19 | 0.19 | |
| Vitamin B5 (Pantothenic acid)* | mg | 0.46 | 0.34 | 0.34 | |
| Vitamin B6 (Pyridoxine)* | mg | 0.20 | 0.15 | 0.15 | |
| Vitamin B12 (Cyanocobalamin)* | µg | 1.40 | 1.05 | 1.08 | |
| Vitamin B3 (Niacin)* | mg | 2.52 | 1.91 | 1.91 | |
| Vitamin B9 (Folic acid)* | µg | 60.50 | 44.90 | 44.90 | |
| Vitamin B7 (Biotin)* | µg | 4.78 | 3.59 | 4.18 | |
| Choline | mg | 191.00 | 143.00 | 143.00 | |
| Vitamin K* | µg | - | - | - | |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# Footnotes

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

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

c. Scientific data show that sodium levels up to 1.5 % DM (3.75 g/1000 kcal or 0.89 g/MJ ME) and chloride levels up to 2.35 % DM (5.87 g/1000 kcal or 1.40 g/MJ ME) are safe for healthy dogs. Higher levels may still be safe, but no scientific data are available.

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

e. Scientific data show that sodium levels up to 1.5 % DM (3.75 g/1000 kcal ME or 0.89 g/MJ ME) are safe for healthy cats. Higher levels may still be safe, but no scientific data are available.

f. High intake of highly bioavailable inorganic phosphorus compounds (Pi; such as sodium dihydrogen phosphate), ≥1.5g/1000 kcal ME can affect indicators of kidney function in cats (Alexander J et al. 2019, Dobenecker B et al. 2018a, Dobenecker B et al. 2018b). Studies evaluating the intake of 1 g Pi/1000 kcal ME show this level can be fed to healthy adult cats without detectable adverse effects on renal health: one 30-week-long study with diets containing 1 g sodium tripolyphosphate /1000 kcal (Coltherd JC et al. 2021) and one 5 year long study with diets containing 1 g Pi/1000 kcal ME in the form of potassium monophosphate (50%) and sodium pyrophosphate (50%) (Reynolds et al. 2024). More research is needed to understand the impact of different sources and nutrient interactions.

g. The bioavailability of minerals should be carefully considered in diet formulas where the concentration of these nutrients is close to the recommended amounts. For example, in high fiber diets and in formulas where plant based raw materials rich in phytate are used as the main source of phosphorus.

h. High intake of inorganic phosphorus compounds affects the calcium and phosphorus homeostasis in dogs (Siedler S 2018, Dobenecker B et al. 2021). More research is warranted to further define the impact of different phosphorus sources and nutrient interactions as well as the role in renal, skeletal and cardiovascular health.

# 3.3. SUBSTANTIATION OF NUTRIENT RECOMMENDATION TABLES FOR COMPLETE DOG AND CAT FOOD

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 and NRC (NRC 2006).

## 3.3.1. Substantiation of nutrient recommendations for complete dog food

### 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 2006j increased by 20 % to compensate for the lower energy requirement of household dogs (see ANNEX 7.2.) compared to the energy intake assumed by NRC.

### PROTEIN

#### Total protein

**Total protein (Adult dogs)** The RA by NRC *(2006d)* of 25 g/1000 kcal (6 g/MJ) for adult dogs is based on *Sanderson SL et al.* (2001). However, the diet in this study had a high protein digestibility and the energy intake was around 130 kcal (550 kJ)/kg $BW^{0.75}$.

FEDIAF protein levels are based on NRC *(2006d)* recommendations, but have been adjusted to take into account i) an apparent crude protein digestibility of 80%, ii) lower energy intakes for dogs and iii) requirements of older dogs *(Finco DR et al. 1994, Williams CC et al. 2001).*

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

**Total protein (Reproduction)** The recommendation for protein assumes the diet contains some carbohydrate to decrease the risk of hypoglycaemia in the bitch and neonatal mortality. If carbohydrate is absent or at a very low level, the protein requirement is much higher, and may be double *(Kienzle E et al. 1985, Kienzle E et al. 1989, Romsos DR et al. 1981).*

**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 % dry matter *(NRC 2006d).*

#### 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 0.01 g of arginine is required *(NRC 2006g).* See ANNEX 7.4.

## Lysine

**Lysine (nutritional maximum for puppies)** Czarnecki et al. *(1985)* 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 and 2 % from a supplement).

It was concluded that the highest no-effect-level of lysine for puppies was 2.91 % DM (energy density 4156 kcal/kg or 17.39 MJ/kg). This is equivalent to 7.0 g/1000 kcal (1.67 g/MJ) or 2.8 % DM (at 4 kcal/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. <100 mg/kg dry matter *(Sanderson SL et al. 2001)*. 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 7.3.

**Methionine** In the case of lamb and rice foods, the methionine level may have to be increased. For further information see taurine section ANNEX 7.3.

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

## 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 *(Biourge V et al. 2002, NRC 2006g)*.

# FAT

## Total fat

**Total fat (All life stages)** Dogs fed foods containing normal levels of protein may 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, mainly pancreatitis, as reviewed by NRC (2006j); more studies are needed to assess effects of high fat in complete maintenance diets.

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

## Omega-3 and 6 fatty acids

**Omega-3 and Omega-6 poly-unsaturated long chain fatty acids (Growth & Reproduction)** During gestation and early life after birth, DHA and arachidonic acid (AA) are selectively accumulated within the brain and retina *(Heinemann KM et al. 2006)*. 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 *(Bauer JE et al. 2004)*. Although very young puppies have the capacity to convert some ALA into DHA, after weaning puppies lose this capacity *(Bauer JE et al. 2006a)*.

Moreover, electroretinograms have revealed improved vision in puppies from mothers fed omega-3 long chain poly-unsaturated fatty acids and fed the same food after weaning *(Bauer JE et al. 2006b, Heinemann KM et al. 2005a, Heinemann KM et al. 2005b)*. Consequently it is preferable to have small amounts of DHA and/or EPA, as well as AA in foods for growth and reproduction to supply enough for neonatal nutritional modifications.

**Omega-3 fatty acids (Adult dogs)** Although there is increasing evidence of beneficial effects of omega-3 fatty acids (*Hadley KB et al. 2017*), the current information is insufficient to recommend a specific level of omega-3 fatty acids for adult dogs .

**Omega-3 vs. 6 FA (Adult dogs)** The effects of omega-3 fatty acids depend on the level as well as on the ratio of omega-6 to omega-3 fatty acids. Very high levels of long chain omega-3 fatty acids can decrease cellular immunity, particularly in the presence of a low level of omega-6 fatty acids *(Hall JA et al. 1999, Wander RC et al. 1997)*.

# MINERALS

## Calcium

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

**Calcium (RA for puppies)** A calcium level of 0.8 g/100 g DM has been shown to be adequate for growing dogs *(Goodman SA et al. 1998, Jenkins KJ et al. 1960a, Jenkins KJ et al. 1960b, Lauten SD et al. 2002)*. However, this level has been reported to be marginal for some breeds *(Alexander JE et al. 1988)* particularly during the fast growing phase (particularly breeds with lower energy requirements) *(Laflamme DP 2001)*.

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

**Calcium (Maximum for puppies)** High intake of calcium has an adverse effect on skeletal development in large breed dogs, particularly during the early growth phase *(Hazewinkel HAW et al. 1985, Schoenmakers I et al. 2000)*. Therefore a strict nutritional maximum is recommended for foods intended for large breed puppies.

Weber et al. *(2000a, b)* showed that when feeding a balanced food, a calcium level of 1.6 % DM from 9 weeks of age does not cause side effects.

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% *(Laflamme DP 2001, Weber M et al. 2000a, Weber M et al. 2000b)*.

## Phosphorus

**Phosphorus** AAFCO introduced a nutritional maximum for both Ca (6.25 g/1000 kcal) and P (4 g/1000 kcal) in 1992 out of concern for the risk of nutrient excess (Dzanis DA, 1994). FEDIAF adopted the same nutritional maximums for both Ca and P. P excess, especially in case of an inverse Ca / P ratio (Ca:P ≤0.4:1), was demonstrated to cause adverse effects in adult dogs in the work of LaFlamme GH and Jowsey J (1972) and Schneider P et al. (1980). While the current SUL of Ca and P for adult dogs is extrapolated from puppies, the work of Stockman J et al. (2017) demonstrated these values being appropriate. In this study a diet providing 7.1 g/1000 kcal of total Ca and 4.5 g/1000 kcal of total P (Ca:P 1.6:1) , was well tolerated over a period of 40 weeks, with no adverse effects noted (Stockman J et al., 2017).

## Sodium

**Sodium (All life stages)** Studies in dogs have demonstrated that 45.4 mg / MJ (0.19 g / 1000 kcal) sodium is adequate for all life stages *(Czarnecki-Maulden GL et al. 1989)*.

**Sodium (Adult dogs)** Studies in dogs have demonstrated that foods containing 2% of sodium (DM) may result in a negative potassium balance *(Boemke W et al. 1990)*.

# TRACE ELEMENTS

## General

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

## Copper

**Copper** Owing to its low availability copper oxide should not be considered as a copper source *(Fascetti AJ et al. 1998)*.

## Iodine

**Iodine** From studies by Castillo et al. *(2001a, b)* low nutritional maximum for iodine in dogs (0.4 mg/100 g DM) 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.

## 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 *(NRC 2006a)*.

In addition, the amount of inert iron is not to be taken into consideration for the calculation of the total iron content of the feed for EU legal maximum.

## Selenium

**Selenium (Growth)** The minimum requirement for selenium in growing puppies has been determined at 0.21 mg per kg dry matter *(Wedekind K and Combs Jr GE 2000, Wedekind KJ et al. 2004)*. However, a safety margin has to be added because the availability of selenium in pet food may be low *(Wedekind KJ et al. 1998, Wedekind K and Combs Jr GE 2000, Wedekind KJ et al. 2004)*.

**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. Therefore, the recommended allowance for cats is used for dogs until more information becomes available.

## Zinc

**Zinc (Growth)** Based on a study with a purified diet, 5 mg zinc per 100 g DM is sufficient to meet the requirements for growing puppies *(Booles D et al. 1991)*. Considering potential factors present in practical pet foods that could decrease zinc availability, doubling the minimum recommended level may be considered safe.

# VITAMINS

## Vitamin A

**Vitamin A** The FEDIAF maximum is based on the studies reported by Hathcock JN et al. *(1990)*, Goldy GG et al. *(1996)* and Cline JL et al. *(1997)* in adult dogs. The value is 80 % of the dose that Goldy GG et al. *(1996)* 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 JL et al. *(1997)* over one year (no detrimental effects on bone health). Furthermore Hathcock JN et al. *(1990)* 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 *(Schweigert F and Bok V 2000, Schweigert FJ et al. 1990, Schweigert FJ et al. 1991)*. 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 100 g DM (4 kcal/g or 16.74 kJ/g) *(Morris PJ et al. 2012, Zentek J et al. 2009)*.

## Vitamin D

**Vitamin D** Studies in Great Dane puppies showed that a dietary vitamin D level of 435 IU/100 g DM can affect Ca absorption and may stimulate endochondral ossification disturbances *(Tryfonidou MA et al. 2002a, Tryfonidou MA et al. 2002b)*.

Therefore, 320 IU per 100 g DM should be the nutritional maximum for growing giant breed dogs *(NRC 2006l)*. Based on differences in cholecalciferol metabolism between giant breed and small breed puppies *(Tryfonidou MA et al. 2002b)*, 425 IU/100 g DM can be considered a safe nutritional maximum for small breed puppies.

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 *(Hall JA 1996, Hall JA et al. 2003, Hendriks WH et al. 2002)*.

## B Vitamins

**B Vitamins** The recommended minimum of B Vitamins corresponds to NRC *(2006i)*. Adequate Intake (AI) based on bioavailable forms coming from a vitamin premix at the point of consumption. When no AI level has been identified (and for Vitamin B1), the recommended minimum was based on the NRC Recommended Allowance.

## Vitamin B2 (Riboflavin)

**Riboflavin** Based on erythrocyte glutathione reductase activity coefficient (EGRAC) Cline JL et al. *(1996)* determined that the riboflavin requirement for the adult dog at maintenance is 66.8 µg/kg BW per day, when feeding a semi-purified diet. This corresponds with about 0.6 mg/100 g DM for practical pet foods by including a safety margin of 25%.

## Vitamin B7 (Biotin)

**Biotin** For healthy dogs biotin does not need to be added to the food unless the food contains antimicrobial or anti-vitamin compounds *(Kronfeld DS 1989a, Kronfeld DS 1989b)*.

## Vitamin K

**Vitamin K** Vitamin K does not need to be added unless diet contains antimicrobial or anti-vitamin compounds *(Kronfeld DS 1989c, NRC 2006j)*.

# 3.3.2. Substantiation of nutrient recommendations for complete cat food

## PROTEIN

## Amino acids

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

## 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 0.02 g of arginine is required *(NRC 2006f)*.

**Arginine (Kittens)** Taylor TP et al. *(1996)* found that 45 g/kg diet (470 kcal/100 g) was associated with a small decrease in growth rate. NRC therefore sets a prudent maximum of 3.5 g/100 g DM (400 kcal/100 g).

## Methionine-Cystine

**Methionine-Cystine (Adult cats)** The recommended values are based on a study by Burger IH and Smith P *(1987)* showing that adult cats need 0.16 g methionine (without cystine) per MJ ME to maintain a positive N-balance. After adding a safety margin of 20 % this corresponds to 0.34 % DM or 0.85 g per 1000 kcal ME methionine and cystine.

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

## Lysine

**Lysine (Adult cats)** The recommended values are based on a study by Burger IH and Smith P *(1987)* showing that adult cats need 0.16 g lysine per MJ ME to maintain a positive N-balance. After adding a safety margin of 20 % this corresponds to 0.34 % DM or 0.85 g per 1000 kcal ME.

## Tryptophan

**Tryptophan (Kittens)** *Taylor TP et al. (1998)* fed 15 g/kg in a diet containing 450 kcal/100 g with no ill effects. *Herwill AM (1994)* fed levels up to 60 g/kg in a diet containing 470 kcal/100 g. Twenty was satisfactory but food intake decreased at 40 g/kg; much more severe effects were observed at 60 g/kg. Therefore the maximum can be set at 2 g per 470 kcal or 1.7 g per 100 g DM (400 kcal/100 g).

## Phenylalanine-Tyrosine

**Phenylalanine-Tyrosine (All life stages)** Diets with a moderate level of phenylalanine and tyrosine but higher than the minimum requirement for growth may cause discolouring of black hair in kittens *(Anderson PJB et al. 2002, Yu S et al. 2001)*. This is corrected by feeding a food containing ≥1.8 % DM of phenylalanine or a combination of tyrosine and phenylalanine *(Anderson PJB et al. 2002)*. To maximise black hair colour, the tyrosine level should be equal or higher than that of phenylalanine *(NRC 2006f)*.

## Taurine

**Taurine** Studies have shown that the bioavailability is lower when cats are fed a heat treated canned food *(Hickman MA et al. 1990, Hickman MA et al. 1992)*. 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 *(Douglass GM et al. 1991, Earle KE et al. 1991)*.

# FAT

## Total fat

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

## Omega-3 and 6 fatty acids

**Omega-3 fatty acids (Growth & Reproduction)** The study by Pawlosky RJ et al. *(1997)* suggests that for juvenile felines it is important that the status of DHA in the nervous system is maintained for optimal retinal function. However, young felines have a low synthetic capacity to produce DHA. Therefore it is recommended to have small amounts of DHA and/or EPA in foods for growth and reproduction.

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

# MINERALS

## Calcium

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

## Sodium

**Sodium (Adult cats)** Based on plasma aldosterone concentration, Yu S and Morris JG *(1999)* concluded that the minimum requirement of sodium for maintenance of adult cats is 0.08 % DM at 5.26 kcal ME/g (22kJ). This corresponds with 0.076 % at 4 kcal ME/g after adding a safety margin of about 25 %.

Scientific data show that sodium levels up to 3.75 g/1000 kcal ME are safe for healthy cats *(Burger I 1979, Nguyen P et al. 2016)*. Higher levels may still be safe, but no scientific data are available.

**Sodium (Growth)** Based on plasma aldosterone concentration Yu et Morris *(1997)* recommended that a food for kittens should contain a minimum of 0.16 % DM of sodium at 5.258 kcal ME/g (22kJ). This corresponds with 0.16 % at 4 kcal ME/g after adding a safety margin of about 30%.

## Magnesium

**Magnesium** Studies have demonstrated that 10 mg/MJ will maintain adult cats. This value has been doubled to accommodate interactions with other dietary factors *(Pastoor FJH et al. 1995)*.

## Phosphorus

Studies suggest intake of some sodium containing inorganic phosphorus compounds may dose dependently and differentially influence post-prandial blood phosphorus and phosphorus regulating hormones as compared to diets in which phosphorus is provided by cereals and bone meal *(Coltherd JC et al. 2018)*.

# TRACE ELEMENTS

## General

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

## Copper

**Copper** Owing to its low availability copper oxide should not be considered as a copper source *(Fascetti AJ et al. 1998)*.

## Iodine

**Iodine** Based on the Tc99m thyroid to salivary ratio, Wedekind KJ et al. *(2009)* have estimated that the minimum requirement of iodine for the cat is 0.46 mg/kg DM; but closer analysis of the data indicated that iodine requirements may be closer to 1.1 mg/kg DM.

The recommended allowance, therefore, has been set at 1.3 mg/kg DM, taking into account a safety margin of 20 %. This corresponds with the minimum requirement stated by NRC *(NRC 2006e)*.

## 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 *(NRC 2006a)*.

In addition, the amount of inert iron is not to be taken into consideration for the calculation of the total iron content of the feed for EU legal maximum..

# VITAMINS

## Vitamin A

**Vitamin A (Adult cats)** The FEDIAF maximum is based on the study reported by Seawright AA et al. *(1967)* in kittens. The FEDIAF maximum of 40,000 IU/100 g DM is about 50 % of the maximum NOAEL reported by Seawright AA et al. *(1967)* 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 AA et al. *(1967)* 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 100 g DM. Therefore, FEDIAF's maximum of 40,000 IU/100 g DM can be considered safe for growing kittens.

Freytag TL et al. *(2003)* reported that feeding a food with 100,000 IU/100 g DM to pregnant queens caused fatal malformations in kittens. The next lowest value of 2000 IU/100 g DM caused no adverse effects. From these data NRC recommended not to exceed 33,330 IU/100 g DM in food intended for reproduction *(NRC 2006m)*.

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

## Vitamin D

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

## 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 *(Hendriks WH et al. 2002)*.

## B Vitamins

**B Vitamins** The recommended minimum of B Vitamins corresponds to NRC *(NRC 2006i)*. Adequate Intake (AI) based on bioavailable forms coming from a vitamin premix at the point of consumption. When no AI level has been identified, the recommended minimum was based on the NRC Recommended Allowance.

## Vitamin B6 (Pyridoxine)

**Vitamin B6 (All life stages)** Requirements of vitamin B6 increase with increasing protein content of the food *(Bai SC et al. 1991, Bai SC et al. 1989)*.

## Vitamin B7 (Biotin)

**Biotin** For healthy cats biotin does not need to be added to the food unless the food contains antimicrobial or anti-vitamin compounds *(Kronfeld DS 1989a, Kronfeld DS 1989b)*.

## Vitamin K

**Vitamin K** Usually vitamin K does not need to be added. However there is some indication that canned pet food for cats being high in fish, may increase the risk of prolonged coagulation times; therefore it has been suggested to supplement high fish diets with vitamin K *(Kronfeld DS 1989c, NRC 2006j, Strieker MJ et al. 1996)*.

# 4. 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:

   o Products intended to be mixed with other food components in the household to form a complete feed.

   o 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:

   o Products used to complement foods, e.g. snacks supplying higher levels of omega-3 & omega-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:

   o Dog chews

## 4.1. 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.

## 4.2. 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.

## 4.3. REPEAT ANALYSIS

When a validation procedure is recommended the same rules should apply for complementary and complete pet food.

# 5. Analytical Methods

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

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

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

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

| Nutrient | Method Reference(S) |
|---|---|
| **Sampling** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54<br>ISO/DIS 6497 |
| **Moisture** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54<br>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 |
| **Cystine/Cystein** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Phenylalanine** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Tyrosine** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Threonine** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Valine** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Tryptophan** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54<br>2$^{nd}$ ISO/CD 13904 |
| **Fat (crude)** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Linoleic Acid** | VDLUFA method 5.6.2<br>B.S.I method BS684: section 2.34 :<br>ISO 5509-1997<br>AOAC 15$^{th}$ ed. (1990) 969.33 & 963.22 |
| **Arachidonic Acid** | VDLUFA method 5.6.2<br>B.S.I method BS684: section 2.34 :<br>ISO 5509-1997<br>AOAC 15$^{th}$ ed. (1990) 969.33 & 963.22 |
| **Fiber (crude)** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Ash (crude)** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54 |
| **Calcium** | Regulation (EC) 152/2009 O.J. 26/02/2009 L 54<br>ISO/DIS 6869 |

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

| Nutrient | Method Reference(S) |
|---|---|
| **Vitamin B5 (Pantothenic acid)** | AOAC 945.74 /42.2.05 (1990)<br>USP XXIII, 1995, M 91 |
| **Vitamin B3 (Niacin)** | AOAC 944.13 /45.2.04 (1990)<br>USP XXIII, 1995, M 441 |
| **Vitamin B6 (Pyridoxine)** | AOAC 16$^{th}$ ed. (1998) M 985.32<br>EN 14663: 2005 |
| **Vitamin B9 (Folic acid)** | AOAC 16$^{th}$ ed. (1998) M 944.12<br>Biacore AB: Folic Acid Handbook; BR 1005-19 |
| **Vitamin B7 (Biotin)** | USP XXI, 1986, M 88<br>Biacore AB: Biotin Kit Handbook; BR 1005-18 |
| **Vitamin B12 (Cyanocobalamin)** | USP XXIII, 1995, M171<br>AOAC 952.20<br>Biacore AB: Vitamin B12 Handbook; BR 1004-15 |
| **Choline** | AOAC Int. Vol 82, No. 5, 1999 pp 1156-1162<br>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.

# 6. Feeding Test Protocols

## Table VI-1. Abbreviations

| | | | |
|---|---|---|---|
| **GE** | Gross energy | **CP** | Crude protein |
| **DE** | Digestible energy | **DP** | Digestible protein |
| **ME** | Metabolisable energy | **BW** | Body weight |
| **kJ** | Kilojoule | **$Cr_2O_3$** | Chromium III oxide |
| **kcal** | Kilocalorie | | |

## 6.1. INDICATOR METHOD

### 6.1.1. Introduction

This feeding protocol has been designed in order to determine ME and nutrient digestibility of cat & dog foods in a way not harmful for cats and dogs and is adapted from the "AAFCO dog and cat food metabolisable energy protocols - Indicator Method" *(AAFCO 2007)*.

### 6.1.2. Protocol

#### 6.1.2.1. Animals

A minimum of six fully grown animals at least one year of age shall complete the test. The animals shall be in good health and of known weight, sex and breed. Animals shall be individually housed during the trial (collection period).

#### 6.1.2.2. 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 HMR 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.

#### 6.1.2.3. Food

Food type, flavour, and production codes representing the composite feed shall be recorded. The food source shall remain constant throughout the test period. The indicator shall be uniformly mixed in a quantity of food sufficient to feed all animals for the duration of the pre-collection and collection periods. If chromic oxide is used, approximately 0.25 % of a high quality chromium III oxide ($Cr_20_3$) free of soluble chromium shall be mixed with the food.

### 6.1.2.4. Food allowances

The amount of food presented to each animal may be based upon existing data on the quantity of food required to maintain body weight, or the estimated daily maintenance energy requirements (about 110 kcal (460 kJ) ME per kg $BW^{0.75}$ for dogs and about 100 kcal ME per kg BW power 0.67 for cats) (See ANNEX 7.2. - Energy).

### 6.1.2.5. Times of feeding

Animals shall be fed at least once daily and at the same time each day. Water shall be available at all times. Food shall be fed as is, or per normal feeding instructions for the product. The excess food shall be weighed back after feeding.

### 6.1.2.6. Pre-trial termination

If, during the pre-collection phase, the food is continually rejected or results in minimal consumption by a majority of the animals, the trial shall not proceed into the collection phase.

### 6.1.2.7. 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 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 metabolisable energy. Every effort should be made to avoid collecting contaminants such as hair.

### 6.1.2.8. Sample preparation

**Food** The food shall be blended to ensure a uniform consistency and an adequate quantity used for appropriate assays. Ample quantities of the remaining sample should be frozen and retained until assay results have been reviewed and found acceptable.

**Faeces** Faeces shall be analysed 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 stabilise 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.

## 6.1.2.9. Analytical determination

Prepared samples shall be used for analysis. AOAC approved analytical methodology shall be used when available or one of the recommended analytical methods listed in Table V-1. 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, crude 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 D 1970)*). Since controlled sample acid 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.

## 6.1.2.10. Calculation of digestible energy and digestible nutrients

**Digestible energy & protein** The determination is based on assays of the gross energy or crude protein consumed minus the energy or crude protein in the faeces.

$$\text{DE (kcal or kJ/g)} = \frac{\{1 - (\text{GE of faeces} \times \%\,Cr_2O_3 \text{ in food})\} \times \text{GE of food}}{(\text{GE of food} \times \%\,Cr_2O_3 \text{ in faeces})}$$

$$\text{DP (\% food)} = \frac{\{1 - (\%\,\text{CP in faeces} \times \%\,Cr_2O_3 \text{ in food})\}\ \%\,\text{CP in food}}{(\%\,\text{CP in food} \times \%\,Cr_2O_3 \text{ in faeces})}$$

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

## 6.1.2.11. Calculation of metabolisable energy

**Metabolisable 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 E et al. 1998):*

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

## 6.2. QUANTITATIVE COLLECTION METHOD

### 6.2.1. Introduction

This feeding protocol has been designed in order to determine ME and nutrient digestibility of cat & dog foods in a way not harmful for cats and dogs and is adapted from the "AAFCO dog and cat food metabolisable energy protocols – Quantitative Collection Method" *(AAFCO 2011).*

### 6.2.2. Protocol

#### 6.2.2.1. Animals

A minimum of six fully grown animals at least one year of age shall complete the test. The animals shall be in good health and of known weight, sex and breed. Animals shall be individually housed during the trial (collection period).

#### 6.2.2.2. Feeding procedures

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

The first phase shall be the pre-collection period of at least three days for dogs and five days for cats *(Nott HMR 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.

#### 6.2.2.3. Food

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

#### 6.2.2.4. Food allowances

The amount of food presented to each animal may be based upon existing data on the quantity of food required to maintain body weight or the estimated daily maintenance energy requirements (about 110 kcal (460 kJ) ME per kg $BW^{0.75}$ for dogs and about 100 kcal ME per kg BW power 0.67 for cats, See ANNEX 7.2. - Energy).

#### 6.2.2.5. Times of feeding

Animals shall be fed at least once daily and at the same time each day. Water shall be available at all times. Food shall be fed as is, or per normal feeding instructions for the product. The excess food shall be weighed back after feeding.

### 6.2.2.6. Pre-trial termination

If, during the pre-collection phase, the food is continually rejected or results in minimal consumption by a majority of the animals, the trial shall not proceed into the collection phase.

### 6.2.2.7. 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 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.

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

### 6.2.2.8. Sample preparation

**Food** The food shall be blended to ensure a uniform consistency and an adequate quantity used for appropriate assays. Ample quantities of the remaining sample should be frozen and retained until assay results have been reviewed and found acceptable.

**Faeces** Faeces shall be analysed 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.

### 6.2.2.9. Analytical determination

Prepared samples shall be used for analysis. AOAC approved analytical methodology shall be used when available or one of the methods in Table V-1. 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.

## 6.2.2.10. Calculation of digestible energy and digestible nutrients

**Digestible energy & protein** The determination is based on assays of the gross energy or crude protein consumed minus the energy or crude protein in the faeces.

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

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

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

## 6.2.2.11. Calculation of metabolisable energy

**Metabolisable energy** The determination is based on assays of the gross energy consumed minus the energy lost in faeces and in the urine.

### Without urine collection

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

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

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

### Example 1:

a. Gross energy of food........................................................= 4.35 kcal/g or 18.2 kJ/g
b. Amount of food consumed ..........................................= 1250 g
c. Gross energy of faeces .................................................. = 1.65 kcal/g or 6.90 kJ/g
d. Amount of faeces collected .........................................= 600 g
e. Protein in food ..................................................................= 24 %
f. Protein in faeces................................................................ = 9 %
g. Correction factor (dog). . ..................................................= 1.25 kcal/g or 5.23 kJ/g

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

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

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

| | |
|---|---|
| ME = | 3312 kcal/kg or 13.9 MJ/kg |

**With urine collection**

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

**Example 2:**

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

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

| | |
|---|---|
| ME (kcal/kg) = | $\frac{[(4.35 \times 1250 - 1.65 \times 600) – (0.25 \times 1230)] \times 1000}{1250}$ |

| | |
|---|---|
| ME (MJ/kg) = | $\frac{18.2 \times 1250 – 6.9 \times 600 – 1.05 \times 1230}{1250}$ |

| | |
|---|---|
| ME = | 3312 kcal/kg or 13.86 MJ/kg |

# 7. Annexes

## 7.1. BODY CONDITION SCORE

### 7.1.1. Introduction

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

### 7.1.2. Validated Body Condition Score

A body condition score (BCS) is a subjective, semi-quantitative method for assessing the animal's body composition, particularly the percentage of body fat (% BF), and for estimating the degree of over- and underweight. Different body condition score (BCS) systems have been developed over the years. A scale of 1 to 9 has been validated for dogs and cats and showed very good repeatability and predictability *(Laflamme DP 1997a, Laflamme DP 1997b)*. The body condition of animals is a continuum, which body condition scoring attempts to partition into a number of categories *(Burkholder WJ 2000)*, therefore, values of % BF of successive BCS may overlap. Table VII 1 & 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.

### 7.1.3. Practical use and interpretation

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

**Cats** Studies have shown that neutered cats are at risk of accumulating more fat than intact cats *(Fettman MJ et al. 1997, Harper EJ et al. 2001, Kanchuk ML et al. 2002)* and normal weight inactive neutered cats could have relatively less lean body mass *(Bjornvad CR 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** A study over 14 years with Labrador dogs found that restricted feeding was associated with a longer median life span and delayed onset of chronic diseases *(Kealy RD et al. 2002)*. These dogs had a BCS of 4/9 to 5/9 with a % BF ranging from 12 to 20%, which corresponds better to the optimal BCS found by Mawby DI 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 *(Bjornvad CR et al. 2011, Laflamme DP 1997a, Mawby DI et al. 2004)*. This resulted in a bias towards higher body weights and % BF; scores at the lower end of the scale being either absent or underrepresented *(Bjornvad CR et al. 2011, Laflamme DP 1997a, Laflamme DP 1997b, Mawby DI et al. 2004)*. In addition, scores at the lower end of the BCS are confounded by muscle atrophy *(Baez J et al. 2007, Michel KE et al. 2011)*. Recently a 4-scale muscle mass scoring system has been developed for evaluating muscle mass in critically ill patients *(Baez J et al. 2007, Michel KE et al. 2011)* (Table VII-3).

## 7.1.4. Conclusion

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

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 WJ 2000, German AJ et al. 2006)*. One study showed that also owners can gain experience with a BCS system with sufficient accuracy *(German AJ et al. 2006)*.

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

| Score 9-point | Score 5-point | Location Feature | Estimated body fat (%) | % BW below or above BCS 5 |
|---|---|---|---|---|
| 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 DP et al. 1995, Laflamme DP 1997a, Laflamme DP 2006, Bjornvad CR 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 CR et al. 2011)*

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

| Score | | Location<br>Feature | Estimated body fat (%) | % BW below or above BCS 5 |
|---|---|---|---|---|
| 9-point | 5-point | | | |
| 1.<br>Emaciated | 1 | **Ribs & other bony prominences** Visible from a distance & easily palpable with no overlaying fat.<br>**Abdomen** Severe abdominal tuck when viewed from the side, exaggerated hourglass shape when viewed from above.<br>**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.<br>Very Thin | | **Ribs & other bony prominences** Visible & easily palpable with no fat layer under the skin.<br>**Abdomen** Strong abdominal tuck when viewed from the side, accentuated hourglass shape when viewed from above.<br>**Tail base** Prominent, raised bone structures with no tissue between the skin and bone. Minimal loss of muscle mass. | 4-10% | -30-40% |
| 3.<br>Thin | 2 | **Ribs & other bony prominences** Discernible & easily palpable with minimal fat cover.<br>**Abdomen** Pronounced abdominal tuck when viewed from the side, marked hourglass shape when viewed from above.<br>**Tail base** Raised bony structures with little tissue between skin and bone. | 5-15% | -20-30% |
| 4.<br>Slightly underweight | | **Ribs & other bony prominences** Easily palpable with minimal fat cover.<br>**Abdomen** Abdominal tuck when viewed from the side, slightly marked hourglass shape when viewed from above.<br>**Tail base** Raised bony structures with little subcutaneous tissue. | 10-20% | -10-15% |
| 5.<br>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.<br>**Abdomen** Abdominal tuck when viewed from the side and well proportioned lumbar waist (hourglass shape) when viewed from above.<br>**Tail base** Smooth contour or some thickening, bony structures palpable under a thin layer of subcutaneous fat. | 15-25% | 0% |
| 6.<br>Slightly overweight | | **Ribs & other bony prominences** Palpable with moderate fat cover.<br>**Abdomen** Less obvious abdominal tuck when viewed from the side, hourglass shape less pronounced when viewed from above.<br>**Tail base** Smooth contour or some thickening, bony structures remain palpable under moderate layer of subcutaneous fat. | 20-30% | +10-15% |
| 7.<br>Overweight | 4 | **Ribs & other bony prominences** Difficult to palpate, thick fat cover.<br>**Abdomen** Little abdominal tuck when viewed from the side or waist, and back slightly broadened when viewed from above.<br>**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 DP 1997b, Laflamme DP 1993, Laflamme DP 2006, Laflamme DP et al. 1994, Mawby DI et al. 2004.*

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

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

*After Baez J et al. 2007, Michel KE et al. 2011*

## 7.2. ENERGY

### 7.2.1. Introduction

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

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

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

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

### Table VII-4. Abbreviations

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

### 7.2.2. Energy density of the food

Energy is expressed either in kilocalories (kcal) or in kilojoules (kJ). **Conversions:** 1 kcal = 1000 cal = 4.184 kJ, 1 MJ = 1000 kJ = 239 kcal

### 7.2.2.1. Gross energy

The gross energy (GE) of a food is defined as the total chemical combustible energy arising from complete combustion of a food in a bomb calorimeter *(NRC 2006b)*.

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

## Table VII-5.
## Predicted gross energy values of protein, fat and carbohydrate

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

*(Kienzle E et al. 2002, NRC 2006b)*

### 7.2.2.2. Metabolisable energy

Digestible energy and metabolisable energy (ME) are a more accurate way of expressing the energy density of a food. ME reflects better the energy that is utilised by the animal, but is more difficult to determine. The ME of a pet food is measured most accurately by performing digestibility trials using one of the two methods described in Chapter 6. Since animal studies are labour intensive, predictive equations are used extensively for calculating ME concentrations of dog and cat foods. Several of these predictive equations have been developed during the years, and their accuracy and precision have been compared to those of equations developed from animal feeding studies.

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

- The equations cited by NRC provide a more accurate estimate of ME compared to the modified Atwater method in dry pet foods;
- The modified Atwater method and the NRC equations provide an equally moderate accuracy of ME estimation for wet foods for both dogs and cats.

The above-mentioned findings have been used for the development of the European Standard EN 16967 referencing the predictive equations for the calculation and declaration of the ME in pet foods.

**a) Predictive Equations *(NRC 2006a)* for ME in prepared pet 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 has to be used:

| | | |
|---|---|---|
| **1.** | **Calculate GE:** | |
| | GE (kcal) = | (5.7 x % crude protein) + (9.4 x % crude fat) + [4.1 x (% NFE + % crude fibre)] |
| | GE (kJ) = | (23.8 x % crude protein) + (39.3 x % crude fat) + [17.1 x (% NFE + % 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.** | **Calculate metabolisable energy:** | |
| **Dogs:** | kcal ME = | kcal DE – (1.04 x % crude protein) |
| | kJ ME = | kJ DE – (4.35 x % crude protein) |
| **Cats:** | kcal ME = | kcal DE – (0.77 x % crude protein) |
| | kJ ME = | kJ DE – (3.22 x % crude protein) |

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

**b) The ME in products of vegetable or animal origin, in their natural state, fresh or preserved, such as meat, offal, milk products, cooked starch sources; highly digestible special products such as milk substitutes or diets for enteral nutrition has to be predicted with the following equations.**

| **Dogs:** | |
|---|---|
| kcal ME = | (4 x % crude protein) + (9 x % crude fat) + (4 x % NFE) |
| kJ ME = | (16.7 x % crude protein) + (37.6 x % crude fat) + (16.7 x % NFE) |
| **Cats:** | |
| kcal ME = | (4 x % crude protein) + (8.5 x % crude fat) + (4 x % NFE) |
| kJ ME = | (16.7 x % crude protein) + (35.6 x % crude fat) + (16.7 x % NFE) |

**c) Determination of ME content of foods by feeding trials**

Manufacturers should be aware that feeding trials are regarded as the gold standard for determination of the energy content of any pet food. Using the trials described in Chapter 6. the digestible energy (DE) can be accurately measured. An approximate factor to convert digestible into metabolisable energy is 0.9. Alternatively, NRC 2006 recommends subtracting 1.25 kcal/g digestible crude protein (5.23 kJ/g) for dogs and 0.9 kcal/g (3.77kJ/g) for cats *(NRC 2006a)*.

FEDIAF recommends that members who wish to use feeding trials should employ the quantitative collection protocol described in Chapter 6, Section 6.2.

## 7.2.3. Literature review

While the formulae give average metabolisable energy needs, actual needs of cats and dogs may vary greatly depending on various factors *(Meyer H and Zentek J 2005, NRC 1985b, NRC 2006j)*.

Energy allowances, recommended for maintenance of adult dogs, differ widely, with figures ranging from less than 90 kcal ME/kg$^{0.75}$ (377 kJ) to approximately 200 kcal ME/kg$^{0.75}$ (810 kJ). 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 90 kg or more (St. Bernard), is the greatest diversity across mammalian species *(Lauten SD 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.

### 7.2.3.1. Maintenance Energy Requirements (MER) of adult dogs

Energy requirements of animals with widely differing body weights are not correlated with kg body weight (BW) in a linear way *(Meyer H et al. 1986, NRC 1985a)*. 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 MD 1994, Kienzle E et al. 1991, Männer K 1991)*.

The equation for MER provides 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 *(NRC 2006j)*.

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 H and Zentek J 2005, Rainbird AL et al. 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 IH 1994, Finke MD 1994, Kienzle E and Rainbird A 1991, Meyer H and Heckötter E 1986, NRC 2006j)*.

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

## 7.2.3.2. Activity

It is clear that spontaneous activity significantly influences MER; for example, standing up requires 40 per cent more energy than lying down *(Meyer H and Zentek J 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 MR 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.

## 7.2.3.3. Age

Apart from lactation and imposed activity during work or sport, age may be the single most-important factor influencing MER of most household dogs *(Finke MD 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 MD 1994, Kienzle E and Rainbird A 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 H and Zentek J 2005, Rainbird AL and Kienzle E 1989)*. Older animals need fewer calories because of decreased activity *(Finke MD 1991, Meyer H and Zentek J 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 H and Zentek J 2005)*. Dogs over seven years of age may need 10 - 15 % less energy than at three to seven years *(Finke MD 1994, Kienzle E and Rainbird A 1991)*. Therefore, practical recommendations should always be related to age *(Finke MD 1994, Gesellschaft für Ernährungsphysiologie 1989)*. 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.

## 7.2.3.4. Breed & type

It has been shown that some breeds such as Newfoundland dogs and huskies have relatively lower energy requirements, while Great Danes have a MER above the average *(Kienzle E and Rainbird A 1991, Rainbird AL and Kienzle E 1989, Zentek J et al. 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 MD 1994)*. Yet NRC reports Newfoundland dogs, Great Danes and terriers as breeds with energy requirements outlying the predictive range *(NRC 2006b)*.

## 7.2.3.5. Thermoregulation and housing

Cool environment increases animals' energy expenditure *(Blaza SE et al. 1982, Finke MD 1991, Meyer H and Zentek J 2005, NRC 1985b, Walters L et al. 1993)*. When kept outside in winter, dogs may need 10 to 90 % 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 M 1961, Männer K 1991, Meyer H and Zentek J 2005, Zentek J and Meyer H 1992)*.

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

During exposure to heat, the basal metabolic rate cannot be lowered *(Ruckebusch Y et al. 1991)*. 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 M 1961)*. Vasodilatation becomes ineffective when the environmental is equal to the rectal temperature (Kleiber M 1961). The UCT for adult dogs seems to be 30 to 35°C *(NRC 2006k)*.

Individually housed dogs, with little opportunity to move, may have daily energy requirements (DER) as low as 70 kcal 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 144 kcal ME/kg$^{0.75}$ (602.5 kJ/kg$^{0.75}$) *(NRC 2006b)*.

Diet-induced thermogenesis plays a small role; it represents about 10 % 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 2006b)*.

## 7.2.4. Practical recommendations for daily energy intake by dogs and cats in different physiological states

As mentioned before, it is impossible to have one equation which expresses the energy requirements for every individual animal. Since the energy requirement of an individual animal may differ from the average shown in the tables, these recommendations should only be used as starting points, and the owner has to adapt the amount when the animal tend to lose or gain weight.

### 7.2.4.1. Dogs

Tables VII-6 - VII-8 provide practical recommendations for maintenance energy requirements (MER) of adult dogs at different ages (Table VII-6), energy needed in relation to activity (Table VII-7) or for growth and reproduction (Table VII-8).

**a) Maintenance energy requirements**

Based on the study by *Kealy RD et al. (2002)* 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 Table VII-2.) for optimal health and longevity.

**Table VII-6** provides MER at different ages without taking into account the degree of activity. However, some young adult dogs may have a sedentary lifestyle and need fewer calories than the average shown in table VII-6, whereas older dogs (> 7 years of age) which are still playing and running will need more energy than indicated.

## Table VII-6.
## Practical recommendations for MER in dogs at different ages.

| Age (years) | kcal ME/kg$^{0.75}$ | kJ ME/kg$^{0.75}$ |
|---|---|---|
| 1 – 2 | 130 (125-140) | 550 (523-585) |
| 3 – 7 | 110 (95-130) | 460 (398-545) |
| > 7 (senior dogs) | 95 (80-120) | 398 (335-500) |

*(Männer K 1990 , Burger IH 1994, Wichert B et al. 1999, Connor MM et al. 2000, Kealy RD et al. 2002, , Patil AR et al. 2002, NRC 2006b)*

The values shown in Table VII-6 are only starting points, the amount of energy a particular dog will finally need is significantly influenced by other factors such as activity, environment, breed, temperament, insulation characteristics of skin and hair coat, body condition or disease.

**Table VII-7** provides examples of daily energy requirements of dogs at different activity levels, for specific breeds and for obese prone adults. It is a good alternative to table VII-6 to estimate the energy requirements of adult dogs.

## Table VII-7.
## Recommendations for DER in relation to activity

| Activity level | kcal ME/kg$^{0.75}$ | kJ ME/kg$^{0.75}$ |
|---|---|---|
| Low activity (< 1 h/day) (e.g. walking on the lead) | 95 | 398 |
| Moderate activity (1 – 3 h/day) (low impact activity) | 110 | 460 |
| Moderate activity (1 – 3 h/day) (high impact activity) | 125 | 523 |
| High activity (3 – 6 h/day) (working dogs, e.g. sheep dogs) | 150 -175 | 628 – 732 |
| High activity under extreme conditions (racing sled dogs 168 km/d in extreme cold) | 860-1240 | 3600-5190 |
| **Obese prone adults** | ≤ 90 | ≤ 377 |
| **Breed specific differences:** | | |
| Great Danes | 200 (200-250) | 837 (837-1046) |
| Newfoundlands | 105 (80-132) | 439 (335-550) |

*(Männer K 1990, Burger IH 1994, Wichert B et al. 1999, Connor MM et al. 2000, Kealy RD et al. 2002, Patil AR andBisby TM 2002, NRC 2006b, NRC 2006h)*

In addition, when dogs are housed at an ambient temperature, which is below or over their specific thermo-neutral zone, MER increases by 2-5 kcal (8-21 kJ) per kg$^{0.75}$ for every degree centigrade *(NRC 2006k).*

### b) Growth and reproduction

An accurate estimation of metabolizable energy (ME) requirement is essential to ensure optimal feeding recommendations in support of healthy growth and to prevent excessive energy supply to young dogs.

Overfeeding of puppies has been demonstrated to lead to accelerated growth, which can result in skeletal deformities especially in large and giant breeds (Dämmrich K 1991, Dobeneckeret al. 1998; Hedhammar et al. Wu, & Krook 1974, Kealy RD et al. 1992, Kealy RD et al. 2002, Meyer H et al. 1992, Richardson DC et al. 1997). However, puppies with a high energy intake do not necessarily show increased Body Condition Scores (Dobenecker B 2010). In consequence, puppies should never be fed ad libitum.

Tables VII-8a provides equations for growth curves (GfE 1989, Meyer H and Zentek J 1992), valid from weaning age (8 weeks) to 1 year.

Although it is appreciated that growth patterns show a certain individual variability, we consider the recommended growth curves to be a powerful tool to generate an estimate of the optimal actual body weight throughout the growth period. This is a critical parameter to predict the ME requirement in puppies and subsequently needed to create feeding guides. However, regular weighing of puppies, based on the veterinarian`s recommendation and individual correction for food (i.e. energy) allocation to ensure growth along the curve is recommended for puppy owners.

Tables VII-8b provides average energy requirements during growth and reproduction in dogs

Energy requirements for lactation depend on the litter size. Table VII-8b provides equations to calculate the average energy needs of lactating bitches at different stages of lactation. For some individuals the energy needs may require ad libitum feeding to avoid significant weight loss during lactation.

## Table VII-8$_a$ Equations for growth curves modified according to Gesellschaft für Ernährungsphysiologie (1989) and Meyer and Zentek (1992), valid from weaning age (8 weeks) to 1 year

| Expected mature BW (kg) | Growth curve |
|---|---|
| ≤7 | % of expected mature BW = 36.92Ln(age in weeks) − 43.57 |
| >7–15 | % of expected mature BW = 36.86Ln(age in weeks) − 48.22 |
| >15–27.5 | % of expected mature BW = 39.88Ln(age in weeks) − 60.70 |
| >27.5–47.5 | % of expected mature BW = 36.96Ln(age in weeks) − 56.18 |
| >47.5 | % of expected mature BW = 36.61Ln(age in weeks) − 62.39 |

Ln= Natural logarithm

## Table VII-8$_b$. Average energy requirements during growth and reproduction in dogs

| Puppies | Age | Energy requirement | |
|---|---|---|---|
| | | kcal | kJ |
| | Newborn puppies | 25 kcal/100 g BW | 105 kJ/100 g BW |
| | 8 weeks to 1 year* | (254.1 – 135.0 × [actual BW/expected mature BW]) × actual BW$^{0.75}$ | (1063 – 565 × [actual BW/expected mature BW]) × actual BW$^{0.75}$ |
| **Bitches** | **Reproduction phase** | **Energy requirement** | |
| | | **kcal** | **kJ** |
| **Gestation**** | first 4 weeks of gestation | 132 kcal/kg BW$^{0.75}$ | 550 kJ/kg BW$^{0.75}$ |
| | last 5 weeks of gestation | 132 kcal/kg BW$^{0.75}$ + 26 kcal/kg BW | 550 kJ/kg BW$^{0.75}$ + 110 kJ/kg BW |
| **Lactation***** | **Lactating bitch:** | **Energy requirement** | |
| | | **kcal** | **kJ** |
| | 1 to 4 puppies | 145 kcal/kg BW$^{0.75}$ + 24 n x kg BW x L | 607 kcal/kg BW$^{0.75}$ + 100 n x kg BW x L |
| | 5 to 8 puppies | 145 kcal/kg BW$^{0.75}$+ (96+12 n-4) x kg BW x L | 607 kcal/kg BW$^{0.75}$+ (400+50 n-4) x kg BW x L |

* Klein C, Thes M, Böswald LF, et al. (2019). Metabolisable energy intake and growth of privately owned growing dogs in comparison with official recommendations on the growth curve and energy supply. J Anim Physiol Anim Nutr. 103:1952–1958.
** Gesellschaft für Ernährungsphysiologie 1989
*** NRC 2006b, NRC 2006h
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

## 7.2.4.2. Cats

Owing to the small variation in adult body weights, the energy needs of cats are often expressed per kg BW instead of per kg metabolic weight. In addition, if metabolic weight is used to calculate MER, the intra-specific allometric coefficient of 0.67 proposed by Heusner in 1991 should be used *(NRC 2006b)*, which has recently been confirmed to be a more accurate than the 0.75 *(Edtstadtler-Peitsch G 2003, Nguyen P et al. 2001)*.

Although NRC specifies that 100 kcal/kg$^{0.67}$ is only valid for cats with a lean body condition, many lean cats may need less energy *(Riond JL et al. 2003, Wichert B et al. 2007)*.

FEDIAF recommendations for normal active adult cats are in accordance with NRC *(NRC 2006j)* assuming a maintenance energy requirement of 100 kcal/kg BW$^{0.67}$.

For indoor and/or neutered adult cats the average maintenance energy requirement is estimated to be 75 kcal/kg BW$^{0.67}$ *(Fettman MJ et al. 1997, Harper EJ et al. 2001)*.

Bjornvad CR et al. *(2011)* recommended that neutered cats should be fed to maintain a body condition score (BCS) of 4 on the 9-point BCS (see ANNEX 7.1.).

## Table VII-9.
## Average daily energy requirements of adult cats

| Gender - Activity | kcal ME/kg$^{0.67}$ | kcal ME/kg BW (4 kg cat) | kJ ME/kg$^{0.67}$ | kJ ME/kg BW (4 kg cat) |
|---|---|---|---|---|
| Neutered and/or indoor cats | 52-75 | 35-45 | 215-314 | 145-190 |
| Active cats | 100 | 60-65 | 418 | 250-270 |

*(Riond JL et al. 2003, NRC 2006b, NRC 2006h, Wichert B et al. 2007)*

## Table VII-10.
## Average energy requirements during growth and reproduction in cats

| Kittens | Age | Times MER | |
|---|---|---|---|
| | Up to 4 months | 2.0-2.5 | |
| | 4 to 9 months | 1.75-2.0 | |
| | 9 to 12 months | 1.5 | |
| **Queens** | **Reproduction phase** | | |
| Gestation | | 140 kcal/kg BW $^{0.67}$ | 585 kJ/kg BW $^{0.67}$ |
| Lactation | < 3 kittens | 100 kcal/kg BW $^{0.67}$ + 18 kcal x kg BW x L | 418 kJ/kg BW $^{0.67}$ + 75 kJ x kg BW x L |
| | 3-4 kittens | 100 kcal/kg BW $^{0.67}$ + 60 kcal x kg BW x L | 418 kJ/kg BW $^{0.67}$ + 250 kJ x kg BW x L |
| | > 4 kittens | 100 kcal/kg BW $^{0.67}$ + 70 kcal x kg BW x L | 418 kJ/kg BW $^{0.67}$ + 293 kJ x kg BW x L |

*(Loveridge GG 1986, Loveridge GG 1987, Kienzle E et al. 1998, Rainbird A 1988, Dobenecker B et al. 1998, Debraekeleer J et al. 2000, Nguyen P et al. 2001, NRC 2006b, NRC 2006h, )*
L = 0.9 in weeks 1-2 of lactation; 1.2 in weeks 3-4; 1.1 in week 5; 1 in week 6; and 0.8 in week 7.

# Table VII-11.
## Recommended nutrient levels for complete food for dogs and cats
## Units per kg metabolic bodyweight (dogs kg $BW^{0.75}$, cats kg $BW^{0.67}$)

| Nutrient | UNIT | Minimum Recommended Nutrient Levels per kg metabolic BW (dogs kg $BW^{0.75}$; cats kg $BW^{0.67}$) | |
|---|---|---|---|
| | | Adult Dog Maintenance | Adult Cat Maintenance |
| **Protein*** | **g** | **4.95** | **6.25** |
| Arginine* | g | 0.14 | 0.25 |
| Histidine | g | 0.06 | 0.08 |
| Isoleucine | g | 0.13 | 0.12 |
| Leucine | g | 0.23 | 0.29 |
| Lysine* | g | 0.12 | 0.09 |
| Methionine* | g | 0.11 | 0.04 |
| Methionine + Cystine* | g | 0.21 | 0.09 |
| Phenylalanine | g | 0.15 | 0.12 |
| Phenylalanine + Tyrosine* | g | 0.24 | 0.44 |
| Threonine | g | 0.14 | 0.15 |
| Tryptophan | g | 0.05 | 0.04 |
| Valine | g | 0.16 | 0.15 |
| Taurine (canned pet food)* | g | | 0.05 |
| Taurine (dry pet food)* | g | | 0.03 |
| **Fat*** | **g** | 1.51 | **2.25** |
| Linoleic acid (ω-6)* | g | 0.36 | 0.13 |
| Arachidonic acid (ω-6) | mg | - | 1.50 |
| Alpha-linolenic acid (ω-3)* | g | - | - |
| EPA + DHA (ω-3)* | g | - | - |
| **Minerals** | | | |
| Calcium | g | 0.14[a,b] | 0.10 |
| Phosphorus | g | 0.11[h] | 0.06[f,g] |
| Potassium | g | 0.14 | 0.15 |
| Sodium* | g | 0.03[c] | 0.02[e] |
| Chloride | g | 0.04[c] | 0.03 |
| Magnesium | g | 0.02 | 0.01 |
| **Trace elements*** | | | |
| Copper* | mg | 0.20 | 0.13 |
| Iodine* | mg | 0.03 | 0.03 |
| Iron* | mg | 1.00 | 2.00 |
| Manganese | mg | 0.16 | 0.13 |
| Selenium* (wet diets) | µg | 6.40[d] | 6.60[d] |
| Selenium* (dry diets) | µg | 5.20[d] | 5.30[d] |
| Zinc* | mg | 2.00 | 1.88 |
| **Vitamins** | | | |
| Vitamin A* | IU | 167.00 | 83.25 |
| Vitamin D* | IU | 15.20 | 6.25 |
| Vitamin E* | IU | 1.00 | 0.95 |
| Vitamin B1 (Thiamine)* | mg | 0.06 | 0.11 |
| Vitamin B2 (Riboflavin)* | mg | 0.17 | 0.08 |
| Vitamin B5 (Pantothenic acid)* | mg | 0.39 | 0.14 |
| Vitamin B6 (Pyridoxine)* | mg | 0.04 | 0.06 |
| Vitamin B12 (Cyanocobalamin)* | µg | 0.92 | 0.44 |
| Vitamin B3 (Niacin)* | mg | 0.45 | 0.79 |
| Vitamin B9 (Folic acid)* | µg | 7.10 | 19.00 |
| Vitamin B7 (Biotin)* | µg | - | 1.50 |
| Choline | mg | 45.00 | 60.00 |
| Vitamin K* | µg | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-$4_c$.

# Table VII-12.
# Impact of energy requirement on nutrient intake and minimum recommendations

| Example: Impact of energy requirement on dry matter and nutrient intake | | | | |
|---|---|---|---|---|
| | 4 kg cat | | 15 kg dog | |
| MER | 100 kcal/kg $BW^{0.67}$ | 75 kcal/kg $BW^{0.67}$ | 110 kcal/kg $BW^{0.75}$ | 95 kcal/kg $BW^{0.75}$ |
| Daily energy intake | 253 kcal | 189 kcal | 838 kcal | 724 kcal |
| DM intake (400 kcal/100 g DM) | 63 g | 47 g | 210 g | 181 g |
| Total daily Zn requirement | 4.75 mg | | 15 mg | |
| Adequate Zn level | 7.5 mg/100 g DM | 10.0 mg/100 g DM | 7.2 mg/100 g DM | 8.34 mg/100 g DM |

## 7.2.5. Impact of energy requirement on product formulation

Balanced nutrition ensuring adequate intakes of energy, protein, minerals and vitamins is essential for cats and dogs to ensure health and longevity. In order to achieve the recommended intake of energy and nutrients, products must be formulated to match these needs. The FEDIAF recommendations are principally based on NRC recommendations *(NRC 2006j)* as well as on other peer reviewed science as referenced in the substantiation tables. Major differences between FEDIAF and NRC recommendations for adult cats and dogs are driven by a systematic adjustment applied to all essential nutrients due to different assumptions on daily maintenance energy requirements.

The NRC adult maintenance recommendations for dogs are based on an average maintenance energy requirement of 130 kcal/kg $BW^{0.75}$/d (1000 kcal ME/d), which is the average energy intake observed in laboratory kennel dogs or active pet dogs.

FEDIAF however takes a different approach and uses an average energy requirement of 110 kcal/kg $BW^{0.75}$/d (e.g. 838 kcal/d for 15 kg dog) as basis for the adult maintenance recommendations, which is typical for dogs with 1-3 hours of low impact activity or less than 1 hour high impact activity *(Burger IH 1994, Connor MM et al. 2000, Kealy RD et al. 2002)*. Studies investigating the maintenance energy requirement of adult pet dogs in single pet households with less than 1 hour per day of low impact activity e.g. walking on the lead, showed an average energy intake ranging from 94 to 105 kcal *(Connor MM et al. 2000, Patil AR and Bisby TM 2002, Thes M et al. 2015, Wichert B et al. 1999)*. These findings have been acknowledged by FEDIAF through the introduction of separate nutrient recommendations for adult dogs with a maintenance energy requirement of 95 kcal/kg $BW^{0.75}$ (e.g. 724 kcal/d for 15 kg dog).

FEDIAF recommendations for normal active adult cats are in accordance with NRC recommendations *(NRC 2006j)* assuming a daily energy requirement of 100 kcal/kg $BW^{0.67}$/d (e.g. 253 kcal/d for 4 kg cat). For indoor and/or neutered adult cats the average maintenance energy requirement is estimated to be 75 kcal/kg $BW^{0.67}$/d (e.g. 189 kcal/d for 4 kg cat) *(Fettman MJ et al. 1997, Harper EJ et al. 2001)*. Strict indoor living in combination with neutering becomes increasingly applicable for adult pet cats in Europe. This is acknowledged in common with findings in dogs by introduction of separate nutrient recommendations for adult cats consuming 75 kcal/kg $BW^{0.67}$/d.

Are differences in energy intake affecting nutritional recommendations?

The approach to provide nutrient recommendations expressed as units/1000 kcal or MJ recognises the close relationship between energy and nutrient intake.

However the energy needs may be satisfied before the requirements of protein, minerals or vitamins are met. This leads to an increased risk of nutritional deficiencies with a consequent negative impact on health and well-being. Hence a systematic adjustment applied to all essential nutrients is needed when fed below the NRC standard assumption of 100 kcal/kg $BW^{0.67}$/d for a 4 kg cat and 130 kcal/kg $BW^{0.75}$/d for a 15 kg dog respectively.

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

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

The metabolic BW in dogs is defined as kg $BW^{0.75}$, in cats it is set at kg $BW^{0.67}$

## 7.3. TAURINE

### 7.3.1. Introduction

Taurine (2-Aminoethanesulfonic acid = NH2CH2-CH2-SO3H) is a β-aminosulfonic acid rather than an α-carboxylic amino acid *(Huxtable RJ 1992)*. It was first isolated from the bile of the ox "Bos Taurus" and was named after it *(Huxtable RJ 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.

*For more information please see also chapter 3.*

### 7.3.2. Cat

Taurine deficiency can lead to feline central retinal degeneration, dilated cardiomyopathy and reproductive failure. Taurine intake is considered to be adequate when plasma levels are greater than 50-60 µmol/L *(Douglass GM et al. 1991, Pion P et al. 1987)* or the whole blood concentration 200 µmol/L or higher *(Fox P 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 IH et al. 1982)* resulted in low plasma taurine levels in cats, and were associated with retinal degeneration and dilated cardiomyopathy *(Pion P 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 RJ 1992, Odle J et al. 1993)*. However, balance studies have indicated that taurine can be degraded by the intestinal microflora *(Morris JG et al. 1994)*. The composition of the cat food, as well as the type of production process influence this intestinal degradation *(Morris JG 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 MA et al. 1990, Hickman MA et al. 1992)*. This was the consequence of increased sensitivity of taurine to intestinal bacterial degradation owing to the heat processing *(Morris JG et al. 1994)*. For this reason the recommendation for taurine in canned cat food is higher than that for dry food or purified diets.

### 7.3.3. Dog

Healthy dogs synthesize sufficient taurine from dietary sulphur-containing amino acids such as methionine and cysteine. Nevertheless, low plasma or low whole-blood taurine levels may be seen in dogs fed non-supplemented very low protein diets, or foods that are low in sulphur-containing amino acids or with poor availability of the sulphur-containing amino acids *(Backus RC et al. 2003, Sanderson SL et al. 2001)*. 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 RC et al. 2003, Delaney SJ et al. 2003, Fascetti AJ et al. 2003, Torres CL et al. 2003)*.

In dogs, low plasma levels of taurine (< 40 µmol/L) may also predispose to dilated cardiomyopathy *(Pion PD et al. 1998)*. However, some breeds seem to be more sensitive to develop such side effects *(Pion PD et al. 1998)*, particularly Newfoundland dogs, in which the rate of taurine synthesis is decreased *(Backus RC 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 RC et al. 2003, Torres CL et al. 2003)*. In dogs, adequate levels of taurine are values greater than 40 µmol/L in plasma and greater than 200 µmol/L in whole blood *(Elliott DA et al. 2000)*.

### 7.3.4. Conclusion

The taurine values for cats, stated in the tables III-4a-c, 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 in table V.1.

## 7.4. 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 0.01 g arginine for every 1 % increase in protein (% DM) above the recommended allowance for all life stages in dogs, and an extra 0.02 g 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/100 g DM.

*For more information please see also chapter 3.*

## Table VII-13. Increases in arginine requirement with increasing protein content

| DOGS | | | | | CATS | |
|---|---|---|---|---|---|---|
| **Protein content** | **Arginine level** | | | | **All life stages** | |
| | **Adult** | **Growth** | **Early growth** | **Reproduction** | **Protein** | **Arginine** |
| % DM | g/100g DM | g/100g DM | g/100g DM | g/100g DM | % DM | g/100g DM |
| 18 | 0.52 | - | - | - | 25 | 1.00 |
| 20 | 0.54 | 0.69 | - | - | 28 | 1.06 |
| 22.5 | 0.57 | 0.72 | 0.79 | 0.79 | 30 | 1.10 |
| 25 | 0.59 | 0.74 | 0.82 | 0.82 | 35 | 1.20 |
| 30 | 0.64 | 0.79 | 0.87 | 0.87 | 40 | 1.30 |
| 35 | 0.69 | 0.84 | 0.92 | 0.92 | 45 | 1.40 |
| 40 | 0.74 | 0.89 | 0.97 | 0.97 | 50 | 1.50 |
| 45 | 0.79 | 0.94 | 1.02 | 1.02 | 55 | 1.60 |
| 50 | 0.84 | 0.99 | 1.07 | 1.07 | 60 | 1.70 |
| 55 | 0.89 | 1.04 | 1.12 | 1.12 | - | - |

## 7.5. VITAMINS

### 7.5.1. Chemical compounds

### Table VII-14. Conversion factors - Vitamin source to activity

| Vitamin | Unit declared | Vitamin source used | | Vitamin activity | |
|---|---|---|---|---|---|
| **Vitamin A** | **IU** | | | **Retinol activity** | |
| | | vitamin A alcohol (retinol) | 0.3 µg | = | 1 IU |
| | | | 1.0 mg | = | 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) | 1.0 mg | = | 833 IU |
| **Vitamin D Cholecalciferol** | **IU** | | | **Vitamin D activity** | |
| | | vitamins $D_3$ | 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) | 1 mg | = | 1 IU |
| | | Bio-equivalence of various tocopherols: | | | |
| | | d-α-tocopherol | 1 mg | = | 1.49 IU |
| | | d-α-tocopherol acetate | 1 mg | = | 1.36 IU |
| | | dl-α-tocopherol | 1 mg | = | 1.10 IU |
| | | dl-α-tocopheryl acetate | 1 mg | = | 1.00 IU |
| | | dl-β-tocopherol | 1 mg | = | 0.33 IU |
| | | dl-δ-tocopherol | 1 mg | = | 0.25 IU |
| | | dl-γ-tocopherol | 1 mg | = | 0.01 IU |
| **Vitamin B1 (Thiamine)** | **mg** | | | **Thiamine cation** | |
| | | thiamine CL | 1 mg | = | 0.88 mg |
| | | thiamine mononitrate | 1 mg | = | 0.81 mg |
| | | thiamine hydrochloride | 1 mg | = | 0.79 mg |
| **Vitamin B5 (Pantothenic acid)** | **IU** | | | **Pantothenic acid** | |
| | | calcium D-pantothenate | 1 mg | = | 0.92 mg |
| | | calcium DL-pantothenate | 1 mg | = | 0.41 - 0.52 mg |
| **Vitamin B6 (Pyridoxine)** | **mg** | | | **Pyridoxine** | |
| | | pyridoxine hydrochloride | 1 mg | = | 0.82 mg |
| **Vitamin B3 (Niacin)** | **mg** | | | **Niacin** | |
| | | nicotinic acid | 1 mg | = | 1 mg |
| | | nicotinamide | 1 mg | = | 1 mg |
| **Choline** | **mg** | | | **Choline** | |
| | | choline chloride (basis choline ion) | 1 mg | = | 0.75 mg |
| | | choline chloride (basis choline hydroxyl-analogue) | 1 mg | = | 0.87 mg |
| **Vitamin K3 (Menadione)** | **mg** | | | **Menadione** | |
| | | menadione sodium bisulphite (MSB) | 1 mg | = | 0.51 mg |
| | | menadione pyrimidinol bisulphite (MPB) | 1 mg | = | 0.45 mg |
| | | menadione nicotinamid bisulphite (MNB) | 1 mg | = | 0.46 mg |

## 7.6. ADVERSE REACTION TO FOOD

### 7.6.1. Introduction

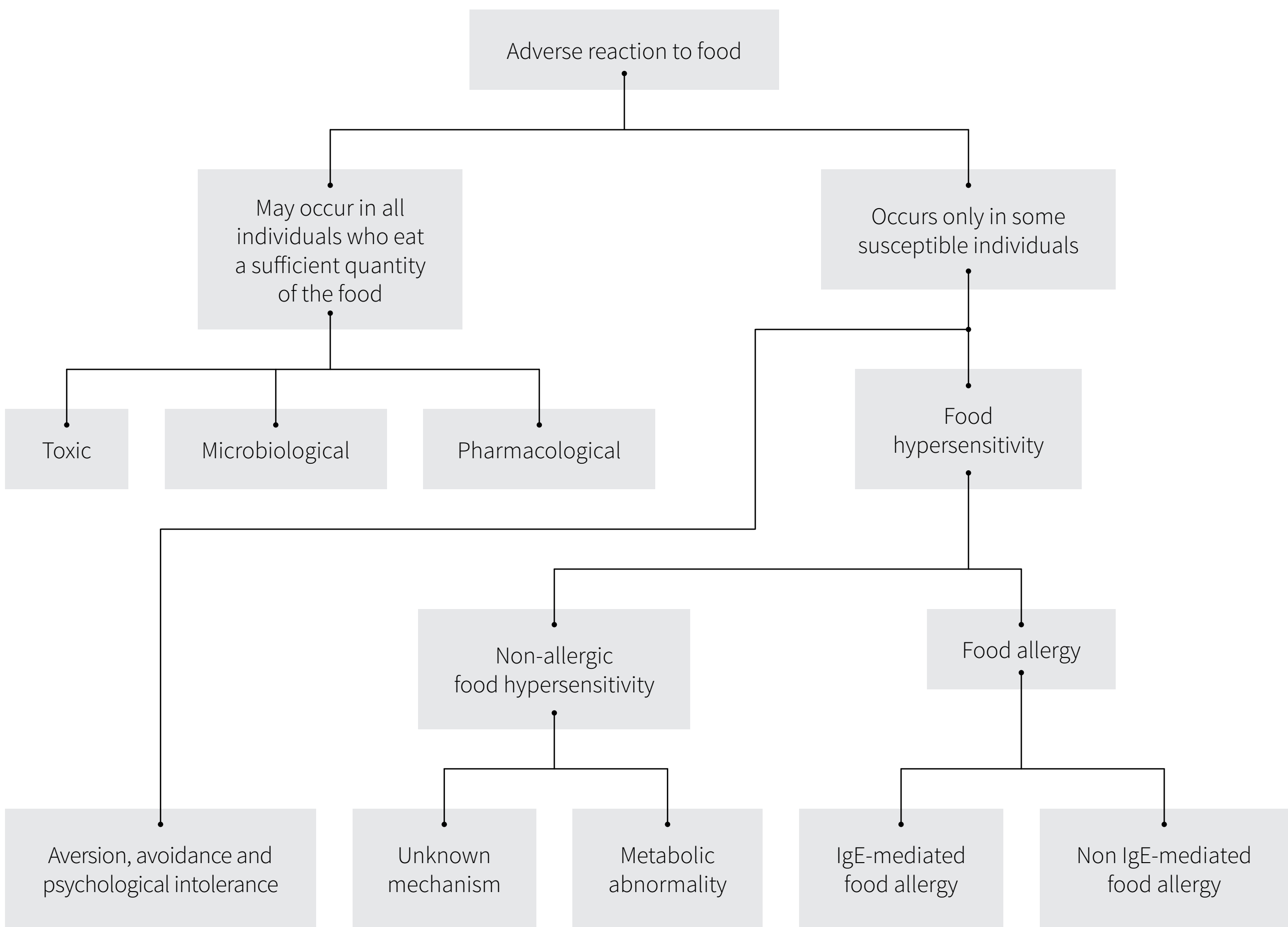
Adverse food reactions in cats and dogs are mainly expressed by pruritus and gastrointestinal signs. Acute anaphylactic reactions such as those seen in a minority of people who are allergic to nuts and some other foods have not been reported in relation to pet food.

### 7.6.2. Definitions

#### 7.6.2.1. Adverse reactions to food

An **adverse reaction** to a food is an abnormal or exaggerated clinical response to the ingestion of a food or food additive. It may be immune mediated (called food allergy or hypersensitivity) or not immune mediated (called food intolerance) *(Reedy LM et al. 1997)*.

### Figure VII-1. Classification of adverse reactions to food




*Source: ILSI Monograph Food Allergy 2003*

### 7.6.2.2. Food allergy

**Allergy** Immune-mediated reaction resulting in one or more of the clinical signs described under 7.6.4. Adverse reactions to food in cats and dogs.

**Anaphylaxis** Anaphylaxis is an acute life-threatening multi-system allergic reaction resulting from exposure to an offending agent. In people, foods, insect stings, and medication are the most common causes *(Oswalt M and Kemp SF 2007, Tang AW 2003, Wang J and Sampson HA 2007)*. The term has been variably employed to denote a defined IgE-mediated antigen-induced reaction or as a descriptive term delineating a severe, abrupt, untoward event of unstated immunologic significance *(Wasserman SI 1983)*.

### 7.6.2.3. Non-allergic food hypersensitivity

**Food idiosyncrasy** A non-immune mediated reaction to a food component that causes clinical signs resembling an immune-mediated reaction to food (food allergy).

**Food intolerance** Non-immunological mediated condition that may be the result of e.g. metabolic deficit.

### 7.6.2.4. All individuals susceptible if sufficient quantity eaten

**Toxic reaction** Reaction to a toxic food component (e.g. onions).

**Microbiological reaction** Reaction to a toxin released by contaminating organisms (e.g. mycotoxins).

**Pharmacologic reaction** Adverse reaction to a food as result of a naturally derived or added chemical producing a drug-like or pharmacological effect in the host such as methylxanthines in chocolate or pseudo-allergic reactions caused by high histamine levels in not well-preserved scombroid fish (e.g. tuna).

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

## 7.6.3. Food allergy in humans

Food allergies are the single most common cause of generalised anaphylaxis seen in hospital emergency departments, accounting for about one third of cases seen (twice the number of cases seen for bee stings) *(Sampson HA 1999)*. It is estimated that about 100 fatal cases of food-induced anaphylaxis occur in the US each year *(Sampson HA 1999)*. The most common allergens causing anaphylaxis in people are nuts, shellfish, milk, egg white, legumes, certain fruits, grains, chocolate, and fish *(Wasserman SI 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.

## 7.6.4. Adverse reactions to food in cats and dogs

The predominant clinical sign in dogs and cats (almost 100% of the cases) is pruritus (itching) *(Rosser EJ 1993, Scott D 2001, White S 1986, White S and Sequoia D 1989)*. 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 *(Scott D 2001, White S 1986)*. In allergic cats eosinophilic plaque, miliary dermatitis or alopecia caused by excessive grooming can be the only clinical sign present *(Scott D 2001, White S 1986)*.

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 D 2001)*. However, the GI signs can be very discrete (e.g. more frequent bowel movements) *(Scott D 2001)* and their prevalence may be underestimated *(Loeffler A et al. 2004, Loeffler A et al. 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 *(Helm RM 2002, Wills J et al. 1994)*.

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 LLM et al. 1997)*. 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 petfoods (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 JM 1997)*. There are proteins against which dogs and cats seem to react more often *(Wills J and Harvey R 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.

### 7.6.5. Conclusions

1. Most protein containing ingredients have the potential to induce allergic reactions if they are regularly fed to dogs and cats.
2. Anaphylactic reactions to food as seen in humans are not, as far as we know, reported in literature relating to cats and dogs. The hallmark of adverse reaction in dogs and cats to food is pruritus.

## 7.7. RISKS OF SOME HUMAN FOODS REGULARLY GIVEN TO PETS

ANNEX 7.7. 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.

## 7.7.1. Grape and raisin toxicity in dogs

### 7.7.1.1. Background

Since 1989 the Animal Poison Control Centre (APCC) of the American Society for the Prevention of Cruelty to Animals has recorded cases of poisoning in dogs that had eaten grapes (Vitis spp) or raisins. From April 2003 to April 2004 the APCC managed 140 cases, of which 50 dogs developed clinical signs and seven died *(ASPCA 2004)*. Cases have been reported in the USA and the UK *(Eubig PA et al. 2005, Penny D et al. 2003)*.

### 7.7.1.2. Clinical signs and pathology

Affected dogs typically suffer gastrointestinal upset followed by acute renal failure (ARF). The initial signs of grape or raisin toxicity are vomiting (100 % of reported cases) followed by lethargy, anorexia, diarrhoea, abdominal pain, ataxia, and weakness *(Eubig PA 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 PA 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 PA 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 PA 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 PA et al. 2005)*. It has to be pointed out, however, that many dogs never develop AFR after ingestion of raisins or grapes.

### 7.7.1.3. Toxic agent

The toxic agent (or agents) has so far defied detection. Analysis for a variety of substances has proved negative, including mycotoxins, heavy metals, pesticides and vitamin D3 *(AFIP 2003, Eubig PA 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 PA et al. 2005)*. Grape extract is not considered a threat; the grape or raisin itself has to be eaten for poisoning to occur *(McKnight K 2005)*. The lowest intake that has so far been reported to cause poisoning is around 2.8 g of raisins per kg bodyweight (BW) and 19.6 g of grapes per kg BW; one dog became ill after only eating 10 to 12 grapes *(Eubig PA et al. 2005)*. The severity of the illness does not seem to be dose-related *(Eubig PA et al. 2005)*. Even a large dog of 40 kg may need to eat only 120 g to be at risk and as cartons of raisins typically contain 500 g this amount could be ingested in one session. At present it appears that only dogs are affected – the susceptibility of other species is unknown.

### 7.7.1.4. Treatment

Immediate treatment consists of inducing emesis and lavage of the stomach to remove the poison, followed by decontamination using activated charcoal to inactivate the remaining poison. Aggressive fluid therapy is essential to increase the chances of survival, and should be maintained long enough (at least 48 hours). Haemodialysis and diuretics such as furosemide have been recommended to treat the ARF and oliguria *(McKnight K 2005)*, but do not seem to increase survival substantially *(Eubig PA et al. 2005)*.

## 7.7.2. Chocolate toxicity

### 7.7.2.1. Background

Cocoa poisoning was highlighted during the Second World War, when pigs, calves, dogs and horses were poisoned because by-products of cacao beans were used to supplement feeds as a result of a surplus.

Chocolate is palatable to most dogs, but it is not an innocent snack being relatively toxic. In dogs signs of toxicity may develop within hours after consumption.

In addition, chocolate cakes and other cocoa containing human foods are best avoided. It is not surprising that most accidents are reported during holiday periods such as Christmas and Easter *(Campbell A 2001)*. Chocolate treats specially developed for dogs are not toxic as they are made from ingredients that contain low or no theobromine.

No reports of chocolate poisoning in cats have been published to our knowledge, probably as a consequence of their different eating habits.

### 7.7.2.2. Toxic agent

The principle toxic components of chocolate and cocoa products are the methylxanthine alkaloids, of which theobromine is the major toxin *(Campbell A 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 *(Glauberg A et al. 1983, Hooser S et al. 1986)*. The half-life of theobromine in dogs is about 17.5 hours *(Farbman D 2001, Hooser S and Beasley V 1986)*. Theobromine undergoes enterohepatic recirculation resulting in an accumulative effect *(Campbell A 2001, Farbman D 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 E et al. 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 D 2001, Hooser S and Beasley V 1986)*.

The LD50 of theobromine has been reported to be between 250 mg and 500 mg per kg body weight (BW); lethal cases have been seen when dogs ingested amounts of chocolate that reflect an estimated theobromine intake of 90-115 mg/kg BW *(Carson TL 2006, Glauberg A and Blumenthal H 1983, Hooser S and Beasley V 1986)*.

The level of theobromine content of chocolate varies, with dark chocolate containing the highest level (Table VII-15). Unsweetened baking chocolate should definitely be kept out of reach of dogs, since it contains up to 20 mg of theobromine per gram. Dogs also voluntarily eat cocoa powder, in which the average theobromine level varies from 10 to 30 mg/g *(Sutton R 1981)*. About four grams of cocoa powder per kg BW may be sufficient to kill a dog *(Faliu L 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 S et al. 2003)*.

## Table VII-15. Theobromine content of different types of chocolate and cocoa products (mg/g)

| | | | |
|---|---|---|---|
| **White chocolate** | 0.009 - 0.035 | **Cocoa powder** | 4.5 - 30 |
| **Milk chocolate** | 1.5 - 2.0 | **Cocoa beans** | 10 - 53 |
| **Sweet to semisweet dark chocolate** | 3.6 - 8.4 | **Cocoa shell mulches** | 2 - 30 |
| **Bitter chocolate, chocolate liquor, baking chocolate** | 12 - 19.6 | **Coffee beans** | - |

*(Carson TL 2006, Farbman D 2001, Gwaltney-Brant S 2001, Hansen S et al. 2003, Shively C et al. 1984)*

## 7.7.2.3. Clinical signs

In dogs methylxanthines cause stimulation of the central nervous system with tachycardia (fast heart beating), respiratory stress and hyperactivity *(Campbell A 2001, Farbman D 2001)*. The clinical signs include vomiting, diarrhoea, agitation, muscular tremors and weakness, cardiac arrhythmias, convulsions, and, in severe cases, renal damage, coma and death *(Decker R and Meyer G 1972, Farbman D 2001, Glauberg A and Blumenthal H 1983, Hooser S and Beasley V 1986, Nicholson S 1995)*. Death may occur within six to 15 hours after intake of excessive amounts of chocolate or cocoa products *(Decker R and Meyer G 1972, Drolet R et al. 1984, Glauberg A and Blumenthal H 1983)*.

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 *(Strachan E and Bennett A 1994, Sutton R 1981)*.

## 7.7.2.4. Treatment

No specific antidote is available for theobromine, only symptomatic treatment. In order to minimise the absorption of theobromine vomiting can be induced immediately after ingestion. Subsequently lavage can be applied with warm water to keep the chocolate liquid. Repeated doses of activated charcoal can then be used to bind the remaining material and prevent further absorption and increase excretion *(Carson TL 2006, Farbman D 2001, Glauberg A and Blumenthal H 1983, Hooser S and Beasley V 1986)*.

## 7.7.3. Toxicity of onions and garlic in cats & dogs

### 7.7.3.1. Background

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

### 7.7.3.2. Clinical signs and pathology

Regenerative anaemia with marked Heinz body formation has been reported in cats and dogs after eating onions or onion containing foods *(Harvey JW et al. 1985, Kaplan A 1995, Robertson JE et al. 1998, Spice R 1976, Tvedten HW et al. 1996)*. Consumption of a sufficient amount of onions leads to oxidative injury of the lipid membrane of the erythrocytes and irreversible oxidative denaturation of haemoglobin. This results in formation of Heinz bodies, eccentrocytes (red blood cells with haemoglobin clustering at one side of the cell, which makes these cells more susceptible to lysis than normal red blood cells), haemolytic anaemia, haemoglobinuria, increased serum bilirubin and possibly methaemoglobinaemia *(Cope R 2005, Faliu L 1991, Harvey JW and Rackear D 1985, Kaplan A 1995, Lee K-W et al. 2000, Means C 2002, Robertson ID 2003)*. Relatively small amounts of fresh onions (5 to 10 g/kg BW) can already be toxic *(Cope R 2005, Faliu L 1991)*. Robertson JE 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 *(Cope R 2005, Gfeller RW et al. 1998b)*. 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 A 1995, Robertson JE 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 *(Cope R 2005, Ogawa E et al. 1986)*.

Although onion ingestion has been reported as being the most common cause of Heinz body haemolysis in dogs *(Weiser M 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 *(Cope R 2005, Weiser M 1995)*.

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 U 2005)*.

Garlic and Chinese chives have also been reported to cause the development of Heinz bodies, eccentrocytes, haemolytic anaemia and increases in methaemoglobin levels in dogs *(Lee K-W et al. 2000, Yamato O et al. 2005)*. Lee K-W et al. (2000) reported toxic effects after administration of 1.25 ml garlic extract per kg BW (equivalent to 5 g/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 antioxidants, and an increase in oxidised glutathione (GSSG) within the first few days *(Ogawa E et al. 1986, Yamato O et al. 1992)*.

Dogs with hereditary high erythrocyte concentrations of reduced glutathione and potassium appear to be more sensitive to onion and garlic poisoning *(Yamato O and Maede Y 1992)*.

Wild onions (A. validum & A. Canadense) and wild garlic (A. ursinum) have caused haemolytic anaemia in horses and ruminants *(Lee K-W et al. 2000)* and are potentially toxic for dogs and cats as well.

### 7.7.3.3. Toxic agent

Several organo-sulfoxides have been implicated in toxicity induced by onions and garlic (Table VII-16). Miyata D *(1990)* reported the extraction from onions of an unnamed phenolic compound causing similar effects on red blood cells "in vitro" *(Miyata D 1990)*. Allicin, a compound found in garlic, is similar to n-propyl disulphide found in onions *(Gfeller RW and Messonnier SP 1998b)*. These organosulfur compounds are readily absorbed in the gastrointestinal tract and metabolised to highly reactive oxidants *(Cope R 2005)*.

## Table VII-16.
## Compounds isolated from onions and garlic and reported to oxidise canine erythrocytes

| Onions | Garlic |
|---|---|
| n-propyl disulfide | sodium 2-propenyl thiosulfate |
| n-propyl | bis-2-propenyl trisulfide |
| 3 different sodium alk(en)yl thiosulfates | bis-2-propenyl tetrasulfide |
| e.g. sodium n-propyl thiosulfate | bis-2-propenyl pentasulfide |
| trans-1-propenyl thiosulfate | bis-2-propenyl thiosulfonate |
| cis-1-propenyl thiosulfate | several sulphur containing esters |

*(Chang HS et al. 2004, Fenwick G 1984, Hu Q et al. 2002, Yamato O et al. 1998, Yamato O et al. 2005)*

### 7.7.3.4. Treatment

No specific antidote exists, and the treatment is supportive and is intended to reduce the oxidative effects and to prevent renal damage caused by haemoglobinuria. Oxygen therapy, fluid therapy (particularly crystalloids) and blood transfusion have been recommended *(Gfeller RW et al. 1998a)*. Induction of vomiting can be useful within the first hour after ingestion of onions if the patient does not yet show clinical signs *(Gfeller RW and Messonnier SP 1998b)*. Antioxidant vitamins such as vitamins E and C may have subclinical beneficial effects that help in milder cases, but a study in cats did not show a significant effect on the formation of Heinz bodies *(Hill AS et al. 2001)*.

## 7.8. RECOMMENDED NUTRIENT LEVELS FOR COMPLETE DOG AND CAT FOOD BY LIFESTAGE AND MAINTENANCE ENERGY REQUIREMENT

### Tables VII-17$_{a-d}$. Recommended nutrient levels for complete dog food by lifestage and Maintenance Energy Requirement

| | |
|---|---|
| **$17_a$** | Recommended nutrient levels for complete dog food - early growth (< 14 weeks) & reproduction |
| **$17_b$** | Recommended nutrient levels for complete dog food - late growth (≥ 14 weeks) |
| **$17_c$** | Recommended nutrient levels for complete diet for adult dogs based on a MER of 110 kcal/kgBW$^{0.75}$ |
| **$17_d$** | Recommended nutrient levels for complete diet for adult dogs based on a MER of 95 kcal/kgBW$^{0.75}$ |

### Tables VII-18$_{a-c}$. Recommended nutrient levels for complete cat food by lifestage and Maintenance Energy Requirement

| | |
|---|---|
| **$18_a$** | Recommended nutrient levels for complete cat food – growth & reproduction |
| **$18_b$** | Recommended nutrient levels for complete food for adult cats based on a MER of 100 kcal/kgBW$^{0.67}$ |
| **$18_c$** | Recommended nutrient levels for complete food for adult cats based on a MER of 75 kcal/kgBW$^{0.67}$ |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-g are summarised below Table III-4$_c$.

# Table VII-17$_a$
# Recommended nutrient levels for complete dog food - early growth (< 14 weeks) & reproduction

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **62.50** | **-** | **14.94** | - | **25.00** | - |
| Arginine* | g | 2.04 | - | 0.49 | - | 0.82 | - |
| Histidine | g | 0.98 | - | 0.23 | - | 0.39 | - |
| Isoleucine | g | 1.63 | - | 0.39 | - | 0.65 | - |
| Leucine | g | 3.23 | - | 0.77 | - | 1.29 | - |
| Lysine* | g | 2.20 | 7.00 (N) | 0.53 | 1.67 (N) | 0.88 | 2.80 (N) |
| Methionine* | g | 0.88 | - | 0.21 | - | 0.35 | - |
| Methionine + Cystine* | g | 1.75 | - | 0.42 | - | 0.70 | - |
| Phenylalanine | g | 1.63 | - | 0.39 | - | 0.65 | - |
| Phenylalanine + Tyrosine* | g | 3.25 | - | 0.78 | - | 1.30 | - |
| Threonine | g | 2.03 | - | 0.48 | - | 0.81 | - |
| Tryptophan | g | 0.58 | - | 0.14 | - | 0.23 | - |
| Valine | g | 1.70 | - | 0.41 | - | 0.68 | - |
| **Fat*** | **g** | **21.25** | **-** | **5.08** | **-** | **8.50** | **-** |
| Linoleic acid (ω-6)* | g | 3.25 | 16.25 (N) | 0.78 | 3.88 (N) | 1.30 | 6.50 (N) |
| Arachidonic acid (ω-6)* | mg | 75.00 | - | 17.90 | - | 30.00 | - |
| Alpha-linolenic acid (ω-3)* | g | 0.20 | - | 0.05 | - | 0.08 | - |
| EPA + DHA (ω-3)* | g | 0.13 | - | 0.03 | - | 0.05 | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 2.50 | 4.00 (N) | 0.60 | 0.96 (N) | 1.00 | 1.60 (N) |
| Phosphorus | g | 2.25 | [h] | 0.54 | [h] | 0.90 | [h] |
| Ca / P ratio | | 1/1 | 1.6/1(N) | 1/1 | 1.6/1(N) | 1/1 | 1.6/1 (N) |
| Potassium | g | 1.10 | - | 0.26 | - | 0.44 | - |
| Sodium* | g | 0.55 | c | 0.13 | c | 0.22 | c |
| Chloride | g | 0.83 | c | 0.20 | c | 0.33 | c |
| Magnesium | g | 0.10 | - | 0.02 | - | 0.04 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 2.75 | (L) | 0.66 | (L) | 1.10 | 2.80 (L) |
| Iodine* | mg | 0.38 | (L) | 0.09 | (L) | 0.15 | 1.10 (L) |
| Iron* | mg | 22.00 | (L) | 5.26 | (L) | 8.80 | 68.18 (L) |
| Manganese | mg | 1.40 | (L) | 0.33 | (L) | 0.56 | 17.00 (L) |
| Selenium* | μg | 100.00 | (L) | 23.90 | (L) | 40.00 | 56.80 (L)[d] |
| Zinc* | mg | 25.00 | (L) | 5.98 | (L) | 10.00 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 1 250 | 100 000(N) | 299.00 | 23 900 (N) | 500.00 | 40 000 (N) |
| Vitamin D* | IU | 138.00 | (L)<br>800.00 (N) | 33.00 | (L)<br>191.00 (N) | 55.20 | 227.00 (L)<br>320.00 (N) |
| Vitamin E* | IU | 12.50 | - | 3.00 | - | 5.00 | - |
| Vitamin B1 (Thiamine)* | mg | 0.45 | - | 0.11 | - | 0.18 | - |
| Vitamin B2 (Riboflavin)* | mg | 1.05 | - | 0.25 | - | 0.42 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 3.00 | - | 0.72 | - | 1.20 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.30 | - | 0.07 | - | 0.12 | - |
| Vitamin B12 (Cyanocobalamin)* | μg | 7.00 | - | 1.67 | - | 2.80 | - |
| Vitamin B3 (Niacin)* | mg | 3.40 | - | 0.81 | - | 1.36 | - |
| Vitamin B9 (Folic acid)* | μg | 54.00 | - | 12.90 | - | 21.60 | - |
| Vitamin B7 (Biotin)* | μg | - | - | - | - | - | - |
| Choline* | mg | 425.00 | - | 102.00 | - | 170.00 | - |
| Vitamin K* | μg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-g are summarised below Table III-4$_c$.

# Table VII-17$_b$
# Recommended nutrient levels for complete dog foos - late growth (≥ 14 weeks)

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **50.00** | **-** | **11.95** | - | **20.00** | - |
| Arginine* | g | 1.84 | - | 0.44 | - | 0.74 | - |
| Histidine | g | 0.63 | - | 0.15 | - | 0.25 | - |
| Isoleucine | g | 1.25 | - | 0.30 | - | 0.50 | - |
| Leucine | g | 2.00 | - | 0.48 | - | 0.80 | - |
| Lysine* | g | 1.75 | 7.00 (N) | 0.42 | 1.67 (N) | 0.70 | 2.80 (N) |
| Methionine* | g | 0.65 | - | 0.16 | - | 0.26 | - |
| Methionine + Cystine* | g | 1.33 | - | 0.32 | - | 0.53 | - |
| Phenylalanine | g | 1.25 | - | 0.30 | - | 0.50 | - |
| Phenylalanine + T yrosine* | g | 2.50 | - | 0.60 | - | 1.00 | - |
| Threonine | g | 1.60 | - | 0.38 | - | 0.64 | - |
| Tryptophan | g | 0.53 | - | 0.13 | - | 0.21 | - |
| Valine | g | 1.40 | - | 0.33 | - | 0.56 | - |
| **Fat*** | **g** | **21.25** | **-** | **5.08** | **-** | **8.50** | **-** |
| Linoleic acid (ω-6)* | g | 3.25 | - | 0.78 | - | 1.30 | - |
| Arachidonic acid (ω-6)* | mg | 75.00 | - | 17.90 | - | 30.00 | - |
| Alpha-linolenic acid (ω-3)* | g | 0.20 | - | 0.05 | - | 0.08 | - |
| EPA + DHA (ω-3)* | g | 0.13 | - | 0.03 | - | 0.05 | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 2.00[a] - 2.50[b] | 4.50 (N) | 0.48[a] - 0.60[b] | 1.08 (N) | 0.80[a] - 1.00[b] | 1.80 (N) |
| Phosphorus | g | 1.75 | [h] | 0.42 | [h] | 0.70 | [h] |
| Ca / P ratio | | 1/1 | 1.6/1[b] or 1.8/1[a] (N) | 1/1 | 1.6/1[b] or 1.8/1[a] (N) | 1/1 | 1.6/1[b] or 1.8/1[a] (N) |
| Potassium | g | 1.10 | - | 0.26 | - | 0.44 | - |
| Sodium* | g | 0.55 | c | 0.13 | c | 0.22 | c |
| Chloride | g | 0.83 | c | 0.20 | c | 0.33 | c |
| Magnesium | g | 0.10 | - | 0.02 | - | 0.04 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 2.75 | (L) | 0.66 | (L) | 1.10 | 2.80 (L) |
| Iodine* | mg | 0.38 | (L) | 0.09 | (L) | 0.15 | 1.10 (L) |
| Iron* | mg | 22.00 | (L) | 5.26 | (L) | 8.80 | 68.18 (L) |
| Manganese | mg | 1.40 | (L) | 0.33 | (L) | 0.56 | 17.00 (L) |
| Selenium* | µg | 100.00 | (L) | 23.90 | (L) | 40.00 | 56.80 (L)[d] |
| Zinc* | mg | 25.00 | (L) | 5.98 | (L) | 10.00 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 1 250 | 100 000 (N) | 299.00 | 23 900 (N) | 500.00 | 40 000 (N) |
| Vitamin D* | IU | 125.00 | (L) 800.00 (N) | 29.90 | (L) 191.00 (N) | 50.00 | 227.00 (L) 320.00 (N) |
| Vitamin E* | IU | 12.50 | - | 3.00 | - | 5.00 | - |
| Vitamin B1 (Thiamine)* | mg | 0.45 | - | 0.11 | - | 0.18 | - |
| Vitamin B2 (Riboflavin)* | mg | 1.05 | - | 0.25 | - | 0.42 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 3.00 | - | 0.72 | - | 1.20 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.30 | - | 0.07 | - | 0.12 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 7.00 | - | 1.67 | - | 2.80 | - |
| Vitamin B3 (Niacin)* | mg | 3.40 | - | 0.81 | - | 1.36 | - |
| Vitamin B9 (Folic acid)* | µg | 54.00 | - | 12.90 | - | 21.60 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - | - |
| Choline | mg | 425.00 | - | 102.00 | - | 170.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2*. Footnotes a-g are summarised below Table III-4$_c$.

# Table VII-17$_{c}$
# Recommended nutrient levels for complete food for adult dogs based on a MER of 110 kcal ME/$kg^{0.75}$

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **45.00** | **-** | **10.80** | **-** | **18.00** | **-** |
| Arginine* | g | 1.30 | - | 0.31 | - | 0.52 | - |
| Histidine | g | 0.58 | - | 0.14 | - | 0.23 | - |
| Isoleucine | g | 1.15 | - | 0.27 | - | 0.46 | - |
| Leucine | g | 2.05 | - | 0.49 | - | 0.82 | - |
| Lysine* | g | 1.05 | - | 0.25 | - | 0.42 | - |
| Methionine* | g | 1.00 | - | 0.24 | - | 0.40 | - |
| Methionine + Cystine* | g | 1.91 | - | 0.46 | - | 0.76 | - |
| Phenylalanine | g | 1.35 | - | 0.32 | - | 0.54 | - |
| Phenylalanine + Tyrosine* | g | 2.23 | - | 0.53 | - | 0.89 | - |
| Threonine | g | 1.30 | - | 0.31 | - | 0.52 | - |
| Tryptophan | g | 0.43 | - | 0.10 | - | 0.17 | - |
| Valine | g | 1.48 | - | 0.35 | - | 0.59 | - |
| **Fat*** | **g** | **13.75** | **-** | **3.29** | **-** | **5.50** | **-** |
| Linoleic acid (ω-6)* | g | 3.27 | - | 0.79 | - | 1.32 | - |
| Arachidonic acid (ω-6)* | mg | - | - | - | - | - | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | - | - | - | - |
| EPA + DHA (ω-3)* | g | - | - | - | - | - | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 1.25 | 6.25 (N) | 0.30 | 1.49 (N) | 0.50 | 2.50 (N) |
| Phosphorus | g | 1.00 | 4.00 (N)[h] | 0.24 | 0.96 (N)[h] | 0.40 | 1.60 (N)[h] |
| Ca / P ratio | | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) |
| Potassium | g | 1.25 | - | 0.30 | - | 0.50 | - |
| Sodium* | g | 0.25 | [c] | 0.06 | [c] | 0.10 | [c] |
| Chloride | g | 0.38 | [c] | 0.09 | [c] | 0.15 | [c] |
| Magnesium | g | 0.18 | - | 0.04 | - | 0.07 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 1.80 | (L) | 0.43 | (L) | 0.72 | 2.80 (L) |
| Iodine* | mg | 0.26 | (L) | 0.06 | (L) | 0.11 | 1.10 (L) |
| Iron* | mg | 9.00 | (L) | 2.15 | (L) | 3.60 | 68.18 (L) |
| Manganese | mg | 1.44 | (L) | 0.34 | (L) | 0.58 | 17.00 (L) |
| Selenium* (wet diets) | µg | 57.50 | (L) | 13.70 | (L) | 23.00 | 56.80 (L)[d] |
| Selenium* (dry diets) | µg | 45.00 | (L) | 10.80 | (L) | 18.00 | 56.80 (L)[d] |
| Zinc* | mg | 18.00 | (L) | 4.30 | (L) | 7.20 | 22.70 (L) |
| **Vitamins** | | - | | - | | - | |
| Vitamin A* | IU | 1 515 | 100 000 (N) | 362.00 | 23 900 (N) | 606.00 | 40 000 (N) |
| Vitamin D* | IU | 138.00 | (L)<br>800.00 (N) | 33.00 | (L)<br>191.00 (N) | 55.20 | 227.00 (L)<br>320.00 (N) |
| Vitamin E* | IU | 9.00 | - | 2.20 | - | 3.60 | - |
| Vitamin B1 (Thiamine)* | mg | 0.54 | - | 0.13 | - | 0.21 | - |
| Vitamin B2 (Riboflavin)* | mg | 1.50 | - | 0.36 | - | 0.60 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 3.55 | - | 0.85 | - | 1.42 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.36 | - | 0.09 | - | 0.15 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 8.36 | - | 2.00 | - | 3.35 | - |
| Vitamin B3 (Niacin)* | mg | 4.09 | - | 0.98 | - | 1.64 | - |
| Vitamin B9 (Folic acid)* | µg | 64.50 | - | 15.40 | - | 25.80 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - | - |
| Choline | mg | 409.00 | - | 97.80 | - | 164.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-g are summarised below Table III-4$_{c}$.

# Table VII-17$_d$
# Recommended nutrient levels for complete food for adult dogs based on a MER of 95 kcal ME/kg$^{0.75}$

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **52.10** | **-** | **12.50** | **-** | **21.00** | **-** |
| Arginine* | g | 1.51 | - | 0.36 | - | 0.60 | - |
| Histidine | g | 0.67 | - | 0.16 | - | 0.27 | - |
| Isoleucine | g | 1.33 | - | 0.32 | - | 0.53 | - |
| Leucine | g | 2.37 | - | 0.57 | - | 0.95 | - |
| Lysine* | g | 1.22 | - | 0.29 | - | 0.46 | - |
| Methionine* | g | 1.16 | - | 0.28 | - | 0.46 | - |
| Methionine + Cystine* | g | 2.21 | - | 0.53 | - | 0.88 | - |
| Phenylalanine | g | 1.56 | - | 0.37 | - | 0.63 | - |
| Phenylalanine + Tyrosine* | g | 2.58 | - | 0.62 | - | 1.03 | - |
| Threonine | g | 1.51 | - | 0.36 | - | 0.60 | - |
| Tryptophan | g | 0.49 | - | 0.12 | - | 0.20 | - |
| Valine | g | 1.71 | - | 0.41 | - | 0.68 | - |
| **Fat*** | **g** | **13.75** | **-** | **3.29** | **-** | **5.50** | **-** |
| Linoleic acid (ω-6)* | g | 3.82 | - | 0.91 | - | 1.53 | - |
| Arachidonic acid (ω-6)* | mg | - | - | - | - | - | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | - | - | - | - |
| EPA + DHA (ω-3)* | g | - | - | - | - | - | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 1.45 | 6.25 (N) | 0.35 | 1.49 (N) | 0.58 | 2.50 (N) |
| Phosphorus | g | 1.16 | 4.00 (N)[h] | 0.28 | 0.96 (N)[h] | 0.46 | 1.60 (N)[h] |
| Ca / P ratio | | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) |
| Potassium | g | 1.45 | - | 0.35 | - | 0.58 | - |
| Sodium* | g | 0.29 | [c] | 0.07 | [c] | 0.12 | [c] |
| Chloride* | g | 0.43 | [c] | 0.10 | [c] | 0.17 | [c] |
| Magnesium | g | 0.20 | - | 0.05 | - | 0.08 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 2.08 | (L) | 0.50 | (L) | 0.83 | 2.80 (L) |
| Iodine* | mg | 0.30 | (L) | 0.07 | (L) | 0.12 | 1.10 (L) |
| Iron* | mg | 10.40 | (L) | 2.49 | (L) | 4.17 | 68.18 (L) |
| Manganese | mg | 1.67 | (L) | 0.40 | (L) | 0.67 | 17.00 (L) |
| Selenium* (wet diets) | µg | 67.50 | (L) | 16.10 | (L) | 27.00 | 56.80 (L)[d] |
| Selenium* (dry diets) | µg | 55.00 | (L) | 13.10 | (L) | 22.00 | 56.80 (L)[d] |
| Zinc* | mg | 20.80 | (L) | 4.98 | (L) | 8.34 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 1 754 | 100 000 (N) | 419.00 | 23 900 (N) | 702.00 | 40 000 (N) |
| Vitamin D* | IU | 159.00 | (L)<br>800.00 (N) | 38.20 | (L)<br>191.00 (N) | 63.90 | 227.00 (L)<br>320.00 (N) |
| Vitamin E* | IU | 10.40 | - | 2.49 | - | 4.17 | - |
| Vitamin B1 (Thiamine)* | mg | 0.62 | - | 0.15 | - | 0.25 | - |
| Vitamin B2 (Riboflavin)* | mg | 1.74 | - | 0.42 | - | 0.69 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 4.11 | - | 0.98 | - | 1.64 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.42 | - | 0.10 | - | 0.17 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 9.68 | - | 2.31 | - | 3.87 | - |
| Vitamin B3 (Niacin)* | mg | 4.74 | - | 1.13 | - | 1.89 | - |
| Vitamin B9 (Folic acid)* | µg | 74.70 | - | 17.90 | - | 29.90 | - |
| Vitamin B7 (Biotin)* | µg | - | - | - | - | - | - |
| Choline | mg | 474.00 | - | 113.00 | - | 189.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# Table VII-18$_a$
# Recommended nutrient levels for complete cat food – growth & reproduction

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **Growth 70<br>Reproduction 75** | **-** | **16.73/17.93** | **-** | **28.00/30.00** | **-** |
| Arginine* | g | Growth 7.68<br>Reproduction 2.78 | 8.75 (N) | 0.64/1.00 | 2.09 (N) | 1.07/1.11 | 3.50 (N) |
| Histidine | g | 0.83 | - | 0.20 | - | 0.33 | - |
| Isoleucine | g | 1.35 | - | 0.32 | - | 0.54 | - |
| Leucine | g | 3.20 | - | 0.76 | - | 1.28 | - |
| Lysine* | g | 2.13 | - | 0.51 | - | 0.85 | - |
| Methionine* | g | 1.10 | 3.25 (N) | 0.26 | 0.78 (N) | 0.44 | 1.30 (N) |
| Methionine + Cystine* | g | 2.20 | - | 0.53 | - | 0.88 | - |
| Phenylalanine | g | 1.25 | - | 0.30 | - | 0.50 | - |
| Phenylalanine + Tyrosine* | g | 4.78 | - | 1.14 | - | 1.91 | - |
| Threonine | g | 1.63 | - | 0.39 | - | 0.65 | - |
| Tryptophan* | g | 0.40 | 4.25 (N) | 0.10 | 1.02 (N) | 0.16 | 1.70 (N) |
| Valine | g | 1.60 | - | 0.38 | - | 0.64 | - |
| Taurine (canned pet food)* | g | 0.63 | - | 0.15 | - | 0.25 | - |
| Taurine (dry pet food)* | g | 0.25 | - | 0.06 | - | 0.10 | - |
| **Fat*** | **g** | **22.50** | **-** | **5.38** | **-** | **9.00** | **-** |
| Linoleic acid (ω-6) | g | 1.38 | - | 0.33 | - | 0.55 | - |
| Arachidonic acid (ω-6) | mg | 50.00 | - | 11.95 | - | 20.00 | - |
| Alpha-linolenic acid (ω-3)* | g | 0.05 | - | 0.01 | - | 0.02 | - |
| EPA + DHA (ω-3)* | g | 0.03 | - | 0.01 | - | 0.01 | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 2.50[g] | - | 0.60[g] | - | 1.00[g] | - |
| Phosphorus* | g | 2.10[g] | [f] | 0.50[g] | [f] | 0.84[g] | [f] |
| Ca / P ratio | | 1/1 | 1.5/1 (N) | 1/1 | 1.5/1 (N) | 1/1 | 1.5/1 (N) |
| Potassium | g | 1.50 | - | 0.36 | - | 0.60 | - |
| Sodium* | g | 0.40 | [e] | 0.10 | [e] | 0.16 | [e] |
| Chloride | g | 0.60 | - | 0.14 | - | 0.24 | - |
| Magnesium | g | 0.13 | - | 0.03 | - | 0.05 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 2.50 | (L) | 0.60 | (L) | 1.00 | 2.80 (L) |
| Iodine* | mg | 0.45 | (L) | 0.11 | (L) | 0.18 | 1.10 (L) |
| Iron* | mg | 20.00 | (L) | 4.78 | (L) | 8.00 | 68.18 (L) |
| Manganese | mg | 2.50 | (L) | 0.60 | (L) | 1.00 | 17.00 (L) |
| Selenium | µg | 75.00 | (L) | 17.90 | (L) | 30.00 | 56.80 (L)[f] |
| Zinc | mg | 18.80 | (L) | 4.48 | (L) | 7.50 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 2 250 | Growth<br>100 000 (N)<br>Reproduction<br>83 325 (N) | 538.00 | Growth<br>23 901 (N)<br>Reproduction<br>19 917 (N) | 900.00 | Growth<br>40 000 (N)<br>Reproduction<br>33 333 (N) |
| Vitamin D* | IU | 70.00 | (L)<br>7 500 (N) | 16.70 | (L)<br>1 793 (N) | 28.00 | 227.00 (L)<br>3 000 (N) |
| Vitamin E* | IU | 9.50 | - | 2.30 | - | 3.80 | - |
| Vitamin B1 (Thiamine)* | mg | 1.40 | - | 0.33 | - | 0.55 | - |
| Vitamin B2 (Riboflavin) | mg | 0.80 | - | 0.19 | - | 0.32 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 1.43 | - | 0.34 | - | 0.57 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.63 | - | 0.15 | - | 0.25 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 4.50 | - | 1.08 | - | 1.80 | - |
| Vitamin B3 (Niacin)* | mg | 8.00 | - | 1.91 | - | 3.20 | - |
| Vitamin B9 (Folic acid)* | µg | 188.00 | - | 44.90 | - | 75.00 | - |
| Vitamin B7 (Biotin)* | µg | 17.50 | - | 4.18 | - | 7.00 | - |
| Choline | mg | 600.00 | - | 143.00 | - | 240.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2*. Footnotes a-g are summarised below Table III-4$_c$.

# Table VII-18$_b$
# Recommended nutrient levels for complete food for adult cats based on a MER of 100 kcal ME/kg$^{0.67}$

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **62.50** | **-** | **14.94** | **-** | **25.00** | **-** |
| Arginine* | g | 2.50 | - | 0.60 | - | 1.00 | - |
| Histidine | g | 0.65 | - | 0.16 | - | 0.26 | - |
| Isoleucine | g | 1.08 | - | 0.26 | - | 0.43 | - |
| Leucine | g | 2.55 | - | 0.61 | - | 1.02 | - |
| Lysine* | g | 0.85 | - | 0.20 | - | 0.34 | - |
| Methionine* | g | 0.43 | - | 0.10 | - | 0.17 | - |
| Methionine + Cystine* | g | 0.85 | - | 0.20 | - | 0.34 | - |
| Phenylalanine | g | 1.00 | - | 0.24 | - | 0.40 | - |
| Phenylalanine + Tyrosine* | g | 3.83 | - | 0.92 | - | 1.53 | - |
| Threonine | g | 1.30 | - | 0.31 | - | 0.52 | - |
| Tryptophan* | g | 0.33 | - | 0.08 | - | 0.13 | - |
| Valine | g | 1.28 | - | 0.31 | - | 0.51 | - |
| Taurine (canned pet food)* | g | 0.50 | - | 0.12 | - | 0.20 | - |
| Taurine (dry pet food)* | g | 0.25 | - | 0.06 | - | 0.10 | - |
| **Fat*** | **g** | **22.50** | **-** | **5.38** | **-** | **9.00** | **-** |
| Linoleic acid (ω-6) | g | 1.25 | - | 0.30 | - | 0.50 | - |
| Arachidonic acid (ω-6) | mg | 15.00 | - | 3.59 | - | 6.00 | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | - | - | - | - |
| EPA + DHA (ω-3)* | g | - | - | - | - | - | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 1.00[g] | - | 0.24[g] | - | 0.40[g] | - |
| Phosphorus* | g | 0.64[g] | [f] | 0.15[g] | [f] | 0.26[g] | [f] |
| Ca / P ratio | | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) |
| Potassium | g | 1.50 | - | 0.36 | - | 0.60 | - |
| Sodium* | g | 0.19 | [e] | 0.05 | [e] | 0.08 | [e] |
| Chloride | g | 0.29 | - | 0.07 | - | 0.11 | - |
| Magnesium* | g | 0.10 | - | 0.02 | - | 0.04 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 1.25 | (L) | 0.30 | (L) | 0.50 | 2.80 (L) |
| Iodine* | mg | 0.33 | (L) | 0.08 | (L) | 0.13 | 1.10 (L) |
| Iron* | mg | 20.00 | (L) | 4.78 | (L) | 8.00 | 68.18 (L) |
| Manganese | mg | 1.25 | (L) | 0.30 | (L) | 0.50 | 17.00(L) |
| Selenium (wet diets) | µg | 65.00 | (L) | 15.50 | (L) | 26.00 | 56.80 (L)[f] |
| Selenium (dry diets) | µg | 52.50 | (L) | 12.50 | (L) | 21.00 | 56.80 (L)[f] |
| Zinc | mg | 18.80 | (L) | 4.48 | (L) | 7.50 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 833.00 | 100 000 (N) | 199.00 | 23 901 (N) | 333.00 | 40 000 (N) |
| Vitamin D* | IU | 62.50 | (L)<br>7 500 (N) | 14.90 | (L)<br>1 793 (N) | 25.00 | 227.00 (L)<br>3 000 (N) |
| Vitamin E* | IU | 9.50 | - | 2.30 | | 3.80 | - |
| Vitamin B1 (Thiamine)* | mg | 1.10 | - | 0.26 | - | 0.44 | - |
| Vitamin B2 (Riboflavin) | mg | 0.80 | - | 0.19 | - | 0.32 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 1.44 | - | 0.34 | - | 0.58 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.63 | - | 0.15 | - | 0.25 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 4.40 | - | 1.05 | - | 1.76 | - |
| Vitamin B3 (Niacin)* | mg | 8.00 | - | 1.91 | - | 3.20 | - |
| Vitamin B9 (Folic acid)* | µg | 188.00 | - | 44.90 | - | 75.00 | - |
| Vitamin B7 (Biotin)* | µg | 15.00 | - | 3.59 | - | 6.00 | - |
| Choline | mg | 600.00 | - | 143.00 | - | 240.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-h are summarised below Table III-4$_c$.

# Table VII-18$_c$
# Recommended nutrient levels for complete food for adult cats based on a MER of 75 kcal ME/kg$^{0.67}$

**Maximum levels are expressed as either EU legal limit (L) – given only on DM basis, or nutritional (N) levels**

| Nutrient | UNIT | Per 1000 kcal ME | | Per MJ ME | | Per 100 g DM | |
|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max |
| **Protein*** | **g** | **83.30** | **-** | **19.92** | **-** | **33.30** | **-** |
| Arginine* | g | 3.30 | - | 0.80 | - | 1.30 | - |
| Histidine | g | 0.87 | - | 0.21 | - | 0.35 | - |
| Isoleucine | g | 1.44 | - | 0.35 | - | 0.57 | - |
| Leucine | g | 3.40 | - | 0.81 | - | 1.36 | - |
| Lysine* | g | 1.13 | - | 0.27 | - | 0.45 | - |
| Methionine* | g | 0.57 | - | 0.14 | - | 0.23 | - |
| Methionine + Cystine* | g | 1.13 | - | 0.27 | - | 0.45 | - |
| Phenylalanine | g | 1.33 | - | 0.32 | - | 0.53 | - |
| Phenylalanine +Tyrosine* | g | 5.11 | - | 1.23 | - | 2.04 | - |
| Threonine | g | 1.73 | - | 0.41 | - | 0.69 | - |
| Tryptophan* | g | 0.44 | - | 0.11 | - | 0.17 | - |
| Valine | g | 1.70 | - | 0.41 | - | 0.68 | - |
| Taurine (canned pet food)* | g | 0.67 | - | 0.16 | - | 0.27 | - |
| Taurine (dry pet food)* | g | 0.33 | - | 0.08 | - | 0.13 | - |
| **Fat*** | **g** | **22.50** | **-** | **5.38** | **-** | **9.00** | **-** |
| Linoleic acid (ω-6) | g | 1.67 | - | 0.40 | - | 0.67 | - |
| Arachidonic acid (ω-6) | mg | 20.00 | - | 4.78 | - | 8.00 | - |
| Alpha-linolenic acid (ω-3)* | g | - | - | - | - | - | - |
| EPA + DHA (ω-3)* | g | - | - | - | - | - | - |
| **Minerals** | | | | | | | |
| Calcium* | g | 1.33[g] | - | 0.32[g] | - | 0.53[g] | - |
| Phosphorus* | g | 0.85[g] | [f] | 0.20[g] | [f] | 0.35[g] | [f] |
| Ca / P ratio | | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) | 1/1 | 2/1 (N) |
| Potassium | g | 2.00 | - | 0.48 | - | 0.80 | - |
| Sodium* | g | 0.25 | [e] | 0.06 | [e] | 0.10 | [e] |
| Chloride | g | 0.39 | - | 0.09 | - | 0.15 | - |
| Magnesium* | g | 0.13 | - | 0.03 | - | 0.05 | - |
| **Trace elements*** | | | | | | | |
| Copper* | mg | 1.67 | (L) | 0.40 | (L) | 0.67 | 2.80 (L) |
| Iodine* | mg | 0.43 | (L) | 0.10 | (L) | 0.17 | 1.10 (L) |
| Iron* | mg | 26.70 | (L) | 6.37 | (L) | 10.70 | 68.18 (L) |
| Manganese | mg | 1.67 | (L) | 0.40 | (L) | 0.67 | 17.00 (L) |
| Selenium (wet diets) | µg | 87.50 | (L) | 20.90 | (L) | 35.00 | 56.80 (L)[f] |
| Selenium (dry diets) | µg | 70.00 | (L) | 16.70 | (L) | 28.00 | 56.80 (L)[f] |
| Zinc | mg | 25.00 | (L) | 5.98 | (L) | 10.00 | 22.70 (L) |
| **Vitamins** | | | | | | | |
| Vitamin A* | IU | 1 110 | 100 000 (N) | 265.00 | 23 901 (N) | 444.00 | 40 000 (N) |
| Vitamin D* | IU | 83.30 | (L)<br>7 500 (N) | 19.90 | (L)<br>1 793 (N) | 33.30 | 227.00 (L)<br>3 000 (N) |
| Vitamin E* | IU | 12.70 | - | 3.03 | - | 5.07 | - |
| Vitamin B1 (Thiamine)* | mg | 1.47 | - | 0.35 | - | 0.59 | - |
| Vitamin B2 (Riboflavin) | mg | 1.05 | - | 0.25 | - | 0.42 | - |
| Vitamin B5 (Pantothenic acid)* | mg | 1.92 | - | 0.46 | - | 0.77 | - |
| Vitamin B6 (Pyridoxine)* | mg | 0.83 | - | 0.20 | - | 0.33 | - |
| Vitamin B12 (Cyanocobalamin)* | µg | 5.87 | - | 1.40 | - | 2.35 | - |
| Vitamin B3 (Niacin)* | mg | 10.50 | - | 2.52 | - | 4.21 | - |
| Vitamin B9 (Folic acid)* | µg | 253.00 | - | 60.50 | - | 101.00 | - |
| Vitamin B7 (Biotin)* | µg | 20.00 | - | 4.78 | - | 8.00 | - |
| Choline | mg | 800.00 | - | 191.00 | - | 320.00 | - |
| Vitamin K* | µg | - | - | - | - | - | - |

*When a nutrient has an asterisk (*), additional information and substantiation references are available in Chapter 3.3.1. and 3.3.2.* Footnotes a-g are summarised below Table III-4$_c$.

# 8. 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:

  o N = nutritional maximum

  o 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 III-$3_a$ to III-$3_c$ Dogs

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

Tables III-$4_a$ to III-$4_c$ Cats

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

d. Substantiation tables

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

e. Complementary pet foods

- Improved definitions

## 2. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2012 VS. THE NUTRITIONAL GUIDELINES 2011

a. Recommendation tables

- Maximum ratios moved to the right column where all nutritional maximums are listed

Tables III-$3_a$ to III-$3_c$ Dogs

- The footnotes about the minimum calcium levels for puppies were adapted to reflect the new recommendations by the research subgroup on calcium

- Corrections of recommended vitamin levels

Tables III-$4_a$ to III-$4_c$ Cats

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

- The minimum iodine recommendation for adult cats was adapted after re-evaluation of the literature

- Nutritional maximum for sodium has been deleted and replaced by a footnote

b. Substantiation tables

- Updated references for vitamin A in growing dogs

- Deleted references for calcium-phosphorus ratio for cats

- Adapted the substantiation and references for iodine recommendation for adult cats

c. Vitamin conversion tables

- Thiamine = thiamine Cl was added

## 3. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2013 VS. THE NUTRITIONAL GUIDELINES 2012

a. Recommendation tables

Tables III-$3_a$ to III-$3_c$ Dogs

- Deletion of nutritional max. for zinc

Tables III-$4_a$ to III-$4_c$ Cats

- Deletion of nutritional max. for zinc

b. Substantiation tables

- Updated references for selenium in growing dogs

c. New ANNEX 1: Body condition scores

d. ANNEX 2: Energy

- Adapted to the new recommendations for energy requirements of household dogs and cats in order to lower the risk of obesity

- Added paragraph 2.5 with a rationale for adapting nutrient levels at differing daily energy requirements

## 4. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2014 VS. THE NUTRITIONAL GUIDELINES 2013

a. Throughout the document

- Numbering of sections and tables

b. Recommendation tables

Tables III-$3_a$ to III-$3_c$ Dogs

- Inclusion of recommendations for dogs with a MER of 95 kcal/$kg^{0.75}$

- Legal max values only displayed on dry matter basis to comply with EU legislation

- Met/Cys values increased to comply with NRC recommendations plus correction for energy intake

- Change of B-Vitamin recommendations with reference to NRC AI (where available)

Tables III-$4_a$ to III-$4_c$ Cats

- Inclusion of recommendations for cats with a MER of 75 kcal/$kg^{0.67}$
- Legal max values only displayed on dry matter basis to comply with EU legislation
- Change of B-Vitamin recommendations with reference to NRC AI (where available)
- Removal of Vitamin K recommendation
- Correction of Nutritional maximum value for Vitamin D

c. Substantiation tables

- Updated substantiation for total protein, total fat, B Vitamins and Vitamin K (cats)

d. ANNEX 2: Energy

- Updated paragraph 2.4.2 (cats)
- Updated table VII-9
- Updated paragraph 2.5
- New table VII-11 with recommended nutrient levels per kg metabolic bodyweight

e. New ANNEX 9: Recommended Nutrient Levels by Life stage and Maintenance Energy Requirement

## 5. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2016 VS. THE NUTRITIONAL GUIDELINES 2014

a. Glossary

- References for the definition of GE, DE and ME updated
- Reference for the definition of daily ration updated to Reg (EU) 1831/2003

b. Sodium and chloride recommendations for dogs

- Nutritional maxima removed from Tables III-$3_{a-c}$ & VII-$17_{c-d}$
- Footnote added with regard to know safe levels

c. Selenium legal limit dogs & cats

- Additional footnote added to Tables III-$3_{a-c}$, III-$4_{a-c}$, VII-$17_{a-d}$, VII-$18_{a-c}$

d. Vitamin D nutritional minimum for growth & reproduction in cats

- Value changed from 75 IU/100 g DM to 28 IU/100 g DM in Table III-$4_a$
- Value changed from 188 IU/1000 kcal to 70 IU/1000 kcal in Table III-$4_b$
- Value changed from 44.8 IU/MJ to 16.7 IU/MJ in Table III-$4_c$
- Values changed as per previous in Table VII-$18_a$

e. Potassium recommendations for late growth dogs

- Value per 1000 kcal corrected to 1.10 g/1000 kcal in Tables III-$3_b$ & VII-$17_b$

f. Cysteine/Cystine

- References to cysteine are replaced by cystine in Tables III-$3_{a-c}$, VII-11 and on pages 71 & 72.

g. Energy requirements during lactation

- Factors in equation to estimate energy requirements during lactation in Table VII-8 corrected, i.e. for kcal factor 132 changed to 145, for MJ factor 550 changed to 607

# 6. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2017 VS. THE NUTRITIONAL GUIDELINES 2016

a. Acknowledgement – Scientific Advisory Board

- Prof. Ahlstrøm, Øystein removed
- Dr. Marge Chandler & Dr. Marta Hervera added

b. Legal maximum for Zinc

- Value changed from 28.40 mg/100 g DM to 22.70 mg/100 g DM in Table III-3$_a$, Table III-4$_a$, Tables VII-17 $_{a-d}$, Tables VII-18 $_{a-c}$

c. Cystine

- Explanation and reference to cystine added in chapter 3.3.1. and 3.3.2.

d. Sodium

- Adult dogs – reference to personal communication removed (page 27)
- Adult cats – reference to internal SAB report replaced by reference to publication from P Nguyen et al. (page 34)

e. Metabolisable Energy

- Section 2.2.2 updated to reflect latest findings for the calculation of energy in foods for cats and dogs

# 7. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2018 VS. THE NUTRITIONAL GUIDELINES 2017

a. All references were summarised at the end of the document

b. References were revised and referencing style was harmonised

c. Notation of Units was harmonised xx Unit/xxx Unit

d. Numbering of chapters was changed (Annex is chapter 7) – several references in the text were adapted accordingly

e. American spelling was replaced by British spelling – harmonisation (e.g. metabolisable energy)

f. **1. Glossary** New reference for the definition of dry, semi-moist and wet food

- Dry pet food. Pet food with a moisture content of 14 % or less (Longstanding industry definition).
- Semi-moist pet food. Pet food with a moisture content of 14 % or more or less than 60 % (Longstanding industry definition).
- Wet pet food. Pet food with a moisture content of 60 % or more (Longstanding industry definition).

g. **3.1.1.** "The Fediaf guide is based on published scientific studies (including NRC 2006) and unpublished data from experts in the field" was deleted.

h. **Table III-3$_a$.** and **Table VII-17$_a$.** Choline value for early growth and reproduction was changed from 209 to 170 mg/100 g DM

i. **3.3.** Header changed from *"Complete pet food (cont´d) Substantiation of nutrient recommendations´ table" to "Substantiation of nutrient recommendations´ table"*

j. **3.3.** *"These recommendations are based on scientific publications, NRC 2006 and unpublished data from experts in the field" changed* into: *"These recommendations are based on scientific publications and NRC 2006."*

k. **3.3.2.** The header "total protein" was replaced by *"Amino acids"* and *"Glutamate"*

l. **Table VI-1**. Title was changed to *"Abbreviations"*

m. **6.1.1. and 6.2.1.** In the introduction "nutrient digestibility" was added

n. **6.1.2.4.** Food allowances were modified: *"about"* was inserted

o. **6.1.2.9.** *"since controlled sample digestion"* was changed into: *"Since controlled sample acid digestion"*

p. **6.2.2.4.** Food allowances were harmonised with **6.1.2.4.**

q. **6.2.2.7.** Header was changed from *"Faeces collection"* into *"Collection"*

r. **6.2.2.9.** Analytical determination table V-1 was referenced, not the page anymore

s. **6.2.2.10.** The word "crude" has been added: *"Digestible* **crude** *fat,* **crude** *ash and dry matter can be calculated in the same way as digestible protein."*

t. **Table VII-4.** Abbreviations REE, RER and ECF were deleted

u. **7.2.2.2.** Metabolisable energy tables, the word "crude" was added in the tables

v. **7.7.2.2.** Table 1 was changed into Table VII-15., **7.7.3.3.** table 2 was changed into VII-16.

w. **Table VII-8.** "kcal" was added to gestation energy formula (dog), lactation energy formula (cat)

x. **Table VII-11.** Unit for Taurine (g) was added

y. **Table VII-14.** Niamin was changed into Niacin

z. Table numbering was changed: VII-18$_{a-d}$. into VII-17$_{a-d}$. and VII-19$_{a-c}$. into VII-18$_{a-c}$.

aa. **Table VII-5.** *"Crude"* was added to *"Fat"*

bb. **References:** *"Dobenecker B. (2015) Metabolisable energy in pet food - a comparison between the accuracy of predictive equations versus experimental determination. In. FEDIAF internal report"* was deleted and replaced by: *"EN 16967:2017 Animal feeding stuffs: Methods of sampling and analysis. Predictive equations for metabolizable energy in feed materials and compound feed (pet food) for cats and dogs including dietetic food"*

cc. **7.2.3.1.** *"What such an equation tells you is the expected mean value for a "typical dog of the given size"* was changed into: *"The equation for MER provides the expected mean value for a typical dog of the given size"*.

*"It is widely accepted and easy to calculate by cubing BW and then taking its square root twice (Lewis et al. 1987a)" was deleted.*

dd. **7.6.2.3.** *"Food allergy* **Metabolic reaction** *Food intolerance. An adverse reaction caused by a metabolic defect (e.g. lactose intolerance)"* was replaced by *"Food intolerance Non-immunological mediated condition that may be the result of a metabolic deficit, for example."*

ee. Annex 8. Product families was deleted

ff. **3.1.** *"Each family of products (ANNEX 8) should be validated by chemical analysis of the finished product"* was changed into *"Each product should be validated by chemical analysis of the finished product."*

gg. **3.1.5.** *"and/or truly satisfies its claim of belonging to a family" was deleted*

hh. **Table III-4a.** Nutritional maximum for Chloride was deleted

ii. **3.3.2.** "**Chloride** *Value based on the assumption that chloride is provided as NaCl"* was deleted

jj. **Table VII-17$_{a,\ b}$ and Table VII-18$_{a,\ b,\ c}$** *"Reg organic selenium"* was changed into *"For organic selenium a maximum supplementation level of 22.73 µg organic Se/100 g DM (0.20 mg organic Se/kg complete feed with a moisture content of 12 %) applies."*

kk. **Table VII-17$_{c,\ d}$** *"cf. footnote c to Tables III-3$_{a\text{-}c}$"* was replaced by *"a. Scientific data show that sodium levels up to 1.5 % DM and chloride levels up to 2.35 % DM are safe for healthy dogs. Higher levels may still be safe, but no scientific data are available." "For organic selenium a maximum supplementation level of 22.73 µg organic Se/100 g DM (0.20 mg organic Se/kg complete feed with a moisture content of 12 %) applies" was added as b.*

ll. **Table III-4$_{a,b,c}$** Footnote g was added: High intake of inorganic Phosphorus compounds may affect indicators of renal function in cats (*Dobenecker B et al* (2018): Effect of a high phosphorus diet on indicators of renal health in cats. J Feline Med Surg.; 20(4):339-343). More research is needed to clarify potential risk.

mm. The following reference was added to the reference list: *Dobenecker B et al* (2018): Effect of a high phosphorus diet on indicators of renal health in cats. J Feline Med Surg.; 20(4):339-343).

nn. Footnotes a-g are summarised below Table III-4$_c$.

oo. **Table VII-17$_b$** the Calcium value for MJ ME and per 100g DM was changed.

# 8. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2018 DECEMBER VS. THE NUTRITIONAL GUIDELINES 2018 AUGUST

a. Footnote g was replaced by: High intake of inorganic phosphorus compounds (such as $NaH_2PO_4$) may affect indicators of renal function in cats (Alexander et al. 2018, Dobenecker et al. 2018a, Dobenecker et al. 2018b). More research is needed to clarify potential risk.

b. **3.3.2.** New paragraph was added under header "MINERALS": Phosphorus

Studies suggest intake of some sodium containing inorganic phosphorus compounds may dose dependently and differentially influence post-prandial blood phosphorus and phosphorus regulating hormones as compared to diets in which phosphorus is provided by cereals and bone meal *(Coltherd et al. 2018).*

c. The following references were added to the reference list:

Alexander J, Stockman J, Atwal J, et al. (2019) Effects of the long-term feeding of diets enriched with inorganic phosphorus on the adult feline kidney and phosphorus metabolism. Br J Nutr. 121(3):249-269.

Coltherd JC, Staunton R, Colyer A, et al. (2019) Not all forms of dietary phosphorus are equal: an evaluation of postprandial phosphorus concentrations in the plasma of the cat. Br J Nutr. 121:270-284.

Dobenecker B, Hertel-Böhnke P, Webel A, et al. (2018a) Renal phosphorus excretion in adult healthy cats after the intake of high phosphorus diets with either calcium monophosphate or sodium monophosphate. J Anim Physiol Anim Nutr (Berl). 102(6):1759-1765.

# 9. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2019 VS. THE NUTRITIONAL GUIDELINES 2018

a. **Table III-3a, III-4a, VII-17a-d and Table VII-18a-c.** Legal maximum for iron was changed from 142.00 mg to 68.18 mg per 100 g dry matter (DM)

b. **3.3.1.** Following sentence was added under header "iron": In addition, the amount of inert iron is not to be taken into consideration for the calculation of the total iron content of the feed for EU legal maximum.

c. **3.3.2.** Following sentence was added under header "iron": In addition, the amount of inert iron is not to be taken into consideration for the calculation of the total iron content of the feed for EU legal maximum.

# 10. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2020 VS. THE NUTRITIONAL GUIDELINES 2019

a. Preface - Revision by Dr Marge Chandler, Chair of the SAB
b. Acknowledgement - Scientific Advissory Board Prof. Charlotte Reinhard Bjørnvad and Dr Ana Luísa Lourenço added
c. Nutritional minimum for Calcium value for cats changed
d. Nutritional minimum for Phosphorus value for cats changed
e. Nutritional minimum for Selenium value changed
f. Footnote g was added: The bioavailability of minerals should be carefully considered in diet formulas where the concentration of these nutrients is close to the recommended amounts. For example, in high fiber diets and in formulas where plant based raw materials rich in phytate are used as the main source of phosphorus.
g. The following reference was added to chapter 3.3.1. heading Omega-3 and 6 fatty acids and to the reference list: Hadley, KB., Bauer, J., Milgram, NW. (2017). The oil-rich alga Schizochytrium sp. as a dietary source of docosahexaenoic acid improves shape discrimination

learning associated with visual processing in a canine model of senescence. Prostaglandins Leukot. Essent. Fatty Acids, 118, 10-18.

h. Table VII-14 Thiamine calculations are based on thiamine cation and values recalculated for Thiamine Cl, Thiamine mononitrate and Thiamine hydrochloride

i. Table VII-14 Pyridoxine calculation was corrected. Value changed from 0.89 to 0.82 mg.

j. Numerous editorial corrections were made without changing context.

# 11. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2021 VS. THE NUTRITIONAL GUIDELINES 2020

a. Titles of tables and substantiation of "nutrient recommendations for dogs and cats" were changed into "nutrient recommendations for complete dog and cat food" throughout the document (3.1.1., 3.1.3., 3.2., 3.2.2., 3.2.3., 3.3.1., 3.3.2., 7.8)

b. 1.1. A, 9. –Allowance: deleted citation Food and Nutrition Board 1994

c. 1.1. M – Minimum recommended level – definition added

d. 1.1. R – Recommended allowance – definition and citation added

e. 3.2.1. "The nutrient levels in the tables are minimum recommended allowances for commercial pet food, not minimum requirements or optimal intake levels" changed into "The nutrient levels in the tables are minimum recommended nutrient levels for commercial pet food, not minimum requirements or optimal intake levels"

f. Table III-3a, III-4a, VII-17a-d and Table VII-18a-c "minimum recommended" change into "minimum recommended level"

g. Footnote f was updated: High intake of inorganic phosphorus compounds (such as $NaH_2PO_4$) affect indicators of kidney function in cats (Alexander J et al. 2019, Dobenecker B et al. 2018a, Dobenecker B et al. 2018b). More research is needed to understand the impact of different sources and nutrient interactions. For $Na_5P_3O_{10}$ a recent feeding study with healthy adult cats (Coltherd JC et al. 2021) observed no adverse effects on kidney or bone (skeletal) function and general health when feeding complete and balanced diets containing 1 g/1000 kcal inorganic phosphorus coming from $Na_5P_3O_{10}$ and total phosphorus level of 4.0g/1000kcal (Ca:P ratio of 1.0) or 5g/1000kcal (Ca:P ratio of 1.3) for 30 weeks.

h. Footnote h was added (Tables III-3a-c and VII-17a-d): High intake of inorganic phosphorus compounds affects the calcium and phosphorus homeostasis in dogs (Siedler S 2018, Dobenecker B et al. 2021). More research is warranted to further define the impact of different phosphorus sources and nutrient interactions as well as the role in renal, skeletal and cardiovascular health.

i. 3.3.1. New paragraph was added under header "MINERALS": Phosphorus: AAFCO introduced a nutritional maximum for both Ca (6.25 g/1000 kcal) and P (4 g/1000 kcal) in 1992 out of concern for the risk of nutrient excess (Dzanis DA, 1994). FEDIAF adopted the same nutritional maximums for both Ca and P. P excess, especially in case of an inverse Ca / P ratio (Ca:P ≤0.4:1) was demonstrated to cause adverse effects in adult dogs in the work of LaFlamme GH and Jowsey J (1972) and Schneider P et al. (1980). While the current SUL of Ca and P for adult dogs is extrapolated from puppies, the work of Stockman J et al. (2017) demonstrated these values being appropriate. In this study a diet providing 7.1 g/1000 kcal of total Ca and 4.5 g/1000 kcal of total P (Ca:P 1.6:1), was well tolerated over a period of 40 weeks, with no adverse effects noted (Stockman et al., 2017).

j. 7.2.4.1.b - Practical recommendations for daily energy intake by dogs for growth and reproduction – text of whole chapter, including insert of table VII-8a and update of energy equation in table VII-8b

k. The following references were added to the reference list:

Coltherd JC, Alexander JE, Pink C et al. (2021) Towards establishing no observed adverse effect levels (NOAEL) for different sources of dietary phosphorus in feline adult diets: results from a 7-month feeding study. Br J Nutr. 1-16.

Dobenecker B (2010) Effect of energy supply on the growth rate of foxhound crossbreds. ESVCN.

Dobenecker B, Reese S, Herbst S (2021) Effects of dietary phosphates from organic and inorganic sources on parameters of phosphorus homeostasis in healthy adult dogs. PLoS One 16, e0246950.

Dobenecker BK, E.; Köstlin, R.; Matis, U. (1998) Mal and overnutrition in puppies with or without clinical disorders of skeletal development. J Anim Physiol Anim Nutr. 80(1-5): 76-81.

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## 12. ADAPTATIONS IN THE NUTRITIONAL GUIDELINES 2024 VS. THE NUTRITIONAL GUIDELINES 2021

a. Acknowledgement – Scientific Advisory Board - Prof. Iben, Christine retired
b. Introduction: - Introduction was updated to reflect current membership
c. Table VII-8b: Added n-4 to equation
d. Section 7.2.2.2
   - GE (k/J) Rounded to one decimal point following consultation of EN 16967
   - kept all reference to kJ consistent
e. **Glossary: Recommended allowance pg 8 correction of typo in Recommended allowance**
f. **3.3.1. Substantiation of nutrient recommendations for complete dog food'** - 'Change in substantiation of Total Fat referencing NRC 2006(j)
g. Footnotes: Updated footnote (f)
h. 9. References addition
   Reynolds BS, Chetboul V, Elliott J, Laxalde J, Nguyen P, Testault I, Dorso L, Abadie J, Lefebvre HP, Biourge V. Long-term safety of dietary salt: A 5-year Prospective randomized blinded and controlled study in healthy aged cats (PEANUT study). J Vet Intern Med. 2024 Jan-Feb;38(1):285-299. doi: 10.1111/jvim.16952
i. Updated the FEDIAF address last page

# 9. References


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