

INSECTS A NEW SOURCE OF NUTRIENTS IN DOG NUTRITION – A REVIEW

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ABSTRACT

Cynologists try to breed their dogs as best as possible within their economic and time possibilities. The dog needs regular exercise, training, treatment, proper nutrition, which will not cause damage to its health. When formulating an appropriate feeding ration, it is necessary to know the needs of the dog, which vary depending on age, breed, workload and breeding conditions. The market offers a wide range of dog food: dried feed mixture, canned food, and BARF. With complete feeds, the nutrients are balanced according to the needs of the category, size, use, or the health status of the dog. Feeds containing insects have a great potential due to the following attributes: a) insects have a high protein content, b) high levels of lipids, c) vitamins and minerals. These nutrients vary widely depending on the insect species, stage of development, sex and other factors. Insects are rich in elements such as

calcium, potassium, manganese, sodium, iron, copper, zinc and phosphorus, probably due to their food sources. Insects for dog consumption have a big potential to increase its importance as source of nutrients and as a sustainable and efficient feed source. Basically, insects are a natural food for dogs. Dogs often eat flies, bugs, wasps or even bees as part of a play or as an expression of their hunting instinct. The aim of this article was to get acquainted with possible insect sources and their nutritional composition in dog nutrition.

Keywords: dog; feed; insects; nutrients

People have fed, domesticated, and kept dogs for work and/or pleasure for thousands of years. A hundred years ago, however, dog breeders paid little attention to dog feeding because dogs' diets were very similar to their owners' diets, consisting of what owners could keep, such as bone joints, food scraps, and crusts bread. Only rich people could effort a high quality meat for dogs. Currently dogs are an integral part of our households, very often considered as a member of the family, and a lot of owners try to provide a dog nutrition in harmony with latest scientific findings and feed safety requirements.

In order to clarify the correct feeding of a dog, it is necessary to know the physiology of its digestion as well as the history, from which we learn that the dog is not purely a carnivore. The dog was domesticated more than 15,000 years ago and comes from a single ancestor - the wolf. The wolf is a typical representative of a carnivore. As a canine animal, the dog is also classified as a carnivore, but after thousands of years of domestication, we can state that the dog is a partial omnivore. Only protein in the form of meat is not enough for a dog to cover all its nutritional needs, it also needs carbohydrates, fats, minerals and

vitamins. In dogs, we observe anatomical peculiarities in the digestive system that distinguish them from other carnivores. A dog's teeth are typical of carnivore. Includes small incisors, strong canines and large molars. With the help of this tooth, the dog does not chew food, but pulls out and swallows whole pieces of food. The digestive tube is relatively short and food passes through it faster. This increases the demands on the quality and digestibility of feed. However, in the course of domestication, the digestive tube was partially lengthened and the dog was given the opportunity to digest even more solid plant food. The dog's stomach is relatively large and this allows the dog to take in a large amount of food at once. For this reason, it is sufficient to feed the dog once a day. Hydrochloric acid, which is present in the gastric juice (0.5%), destroys the bacteria found in the feed. Thus, the dog is not at risk of bacterial infection from the feed. Another peculiarity in dogs are the anal sacs located near the anus. The glands produce a smelly secretion that helps dogs identify each other. Anal sacs react sensitively to the quality of food, and in case of inappropriate feeding (too hard, salty, spicy food) these glands can become blocked and subsequently inflamed (Kváš, 1998; Laukner, 2006; Suvegová, 1994). Even dogs were fed meat, bones, or small rodents and vegetable scraps from the kitchen until industrially produced feed came onto the market. However, feeding with industrial feed meant a total transformation of the organism into a different type of food. It takes about 24 hours for pelleted food to pass through the digestive system, while it takes about 6-8 hours for pure meat to pass through. The digestive tract is constantly burdened with unnatural feed mixtures and this causes improper fermentation in the intestines (Laukner, 2006; Novosádová, 2011; Zieglerova, 2016). Insects are considered a new

source of protein in dog nutrition. Black fly larvae, mealworms and crickets are a good alternative to both protein and oil sources in feed (Wall, 2022). Lisenko et al. (2023) in research on the digestibility of insect feeds for dogs and their effect on blood parameters, faecal properties, volatile fatty acids and intestinal microflora evaluated the effects of feeding three insect feeds in the diet of dogs. Cinerea cockroach, Madagascar cockroach and superworm feed is a sufficient source of protein included in the diet of adult dogs with the potential to replace conventional feed ingredients. Among insect feeds, differences in chemical composition have led to superworm as a highly digestible ingredient for dogs with a lower negative impact on intestinal fermentation products and microbiota profile. Case (2011) reports that a lack of protein in a dog's feed leads to growth retardation, weight loss and deterioration of condition, muscle loss, reduced immunity, bristly fur, loss of appetite, swelling and, in extreme cases, death.

Bosch et al. (2014) in one of the studies evaluated the quality of proteins in insect species. For research, they used: pupae of house flies, adult house crickets, larvae of mealworms - yellow, mealybug, Morio worm larvae and others. House fly, mainly pupae were high in protein, but less digestible. The protein content of crickets was high – similar to fishmeal, but in vitro digestibility was higher. Including insects in a dog's ration can have this effects: a) increases the source of proteins and oils in the feed (Wall, 2022); b) low probability of allergy to insect proteins (Böhm et al., 2018); c) higher protein and fat digestibility and lower fecal dry matter content (Abd El-Wahab et al., 2021); d) no intolerance and no physiological effects (Freel et al., 2021).

In some countries in Europe, pet products are made with insect-based ingredients. Among the most common species used in mixtures were

mealworms and black fly larvae (Wall, 2022). Regulation (EC) No. 999/2001 in order to allow processed animal proteins obtained from insects to feeding aquaculture animals is likely to open up the possibility of producing processed animal proteins obtained from insects in the Union on a larger scale. While the current microbreeding of insects intended as fodder for companion animals can be adequately regulated by existing national control systems, to ensure that the farming of insects on a larger scale in the EU is safe, appropriate provisions are necessary relating to animal health, public health, plant health or environmental risks accepted at the level of EU. As regards insect species reared in the EU, they should not be pathogenic species or such species should they not have any other adverse effects on the health of plants, animals or people; they should not be known as vectors human, animal or plant pathogens and should not be protected or defined as invasive non-native species. With regard to the mentioned national risk assessments, as well as the EFSA opinion of 8 October 2015 perhaps as those insect species which are currently kept in the EU and which meet the above safety conditions for rearing insects for use as feed, identify the following insects: black soldier fly (*Hermetia illucens*), housefly (*Musca domestica*), mealworm (*Tenebrio molitor*), barn fly (*Alphitobius diaperinus*), house cricket (*Acheta domesticus*), short-winged cricket (*Gryllodes sigillatus*) and *Gryllus assimilis* cricket (*Gryllus assimilis*). For the use of dried insects as feed for companion animals apply the provisions listed in Annex XIII to Regulation (EU) no. 142/2011. On the basis of the EU Regulation 2021/1925, eight species were added to the seven insect species, namely the silkworm (*Bombyx mori*).

Insects as a source of nutrients.

Analyzes show that eggs, larvae, pupae and adults contain 15 to 81% protein in dry matter (Xiaoming et al., 2008). The protein content ranges from 30% in worms to 81% in wasps of the genus *Polybia*. In locusts, the proportion of protein ranges from 52 to 77%. For beetles (*Coleoptera*) 36 to 71%, homoptera (*Homoptera*) 33 to 72%, butterflies (*Lepidoptera*) 34 to 71%, dragonflies (*Diptera*) 35 to 61% and in ants, bees and wasps (*Hymenoptera*) 10% to 81% (Ramos-Elorduy, 1997).

Table 1. Total crude protein content (%) (Xiaoming et al. 2008).

Order of insects	Development phase	CP
<i>Coleoptera</i>	Adults and larvae	23 – 66
<i>Lepidoptera</i>	Pupae and larvae	14 – 68
<i>Hemiptera</i>	Adults and larvae	42 – 74
<i>Homoptera</i>	Adults, larvae and eggs	45 – 74
<i>Hymenoptera</i>	Adults, pupae, larvae and eggs	13 – 77
<i>Odonata</i>	Adult dragonflies and nymphs	46 – 65
<i>Orthoptera</i>	Adult and nymphs	23 – 65

CP – crude protein

Table 2. Crude protein and fat content in selected species of invertebrates (%) according to available literature

Species	CP	Fa	Source
<i>Hermetia illucens</i>	35-57	35	Veldkamp et al., 2012
<i>Tenebrio molitor</i>	44-69	23-47	Veldkamp et al., 2012
<i>Tenebrio molitor</i>	50.7	n.d.	Bednářová, 2013
<i>Tenebrio molitor</i>	62.6	16.7	Adámková a Kouřimská, 2016
<i>Alphitobius diaperinus</i>	59.8	28.8	Adámková a Kouřimská, 2016
<i>Musca domestica</i>	43-68	4-32	Veldkamp et al., 2012
<i>Locusta migratoria</i>	62.2	n.d.	Bednářová, 2013

CP – crude protein; Fa – fat; n.d. – not defined

From the point of view of the development stage, larvae and pupae contain the largest amount of fat, in adults individuals, the fat

content is lower (Xiaoming et al., 2008; Chen et al., 2009). In general, the large amount of fat contains the larvae of beetles, caterpillars and termites (Bukkens, 1997). The average crude protein and fat concentration of the selected insects are shown in Table 2.

The caloric value of insects varies between 1225 and 3185 kJ/100g (Ramos-Elorduy et al., 1997). The amount of metabolizable energy depends on the fat content, so larval stages are usually more energy-rich. On the contrary, they have rather proteinaceous species lower energy content (Finke, 2002).

The content of minerals such as calcium, iron and zinc is also interesting, which is higher than in beef, chicken and pork. Likewise, the calcium content of some types of insects is up to 26 times higher than in chicken, pork or beef (Pavelková et al. 2019).

International Platform of Insects for Food and Feed - IPIFF (2022) provides a list of insects approved for the production of processed animal protein intended as feed for farm animals (other than fur animals) within the framework of EU regulation no. 142/2011. In Table 3 are listed the most common insects that were used in the researches mentioned above. However, not all of the cited articles reported the nutritional composition of all insect species, such as for *Musca domestica*. Table 3 shows a large variation in nutritional values not only between insect species, but also between developmental stages within a species.

Table 3. The nutritional composition of different species of edible crickets (Magara et al., 2024; EFSA, 2021a, 2021b, 2021c; EFSA 2022; Tyshko et al., 2021; Payne et al., 2016)

Species	Stage	CP	Fa	Fi	Ash	C	GE
<i>Acheta domestica</i>	Nymph	62-71	10-23	10	5-9	n.d.	1904
	Adult	n.d.	19-30	n.d.	n.d.	n.d.	n.d.
	Frozen	15	n.d.	n.d.	n.d.	n.d.	477
	DP	60	n.d.	n.d.	n.d.	n.d.	2230
<i>Tenebrio molitor</i>	LL	n.d.	22		2		n.d.
	GL	42	42	n.d.	4	n.d.	n.d.
	Frozen	15	n.d.	n.d.	n.d.	n.d.	619
	DP	56	n.d.		n.d.		2151
<i>Gryllus assimilis</i>	Adult	56	22	8	6	12	1661
	Nymph	56	12	8	n.d.	8	n.d.
<i>Gryllus sigillatus</i>	Nymph	56	n.d.	n.d.	n.d.	n.d.	n.d.
<i>Locusta migratoria</i>	Frozen	14	n.d.	n.d.	n.d.	n.d.	690
	DP	55	n.d.	n.d.	n.d.	n.d.	2343
<i>Alphitobius diaperinus</i>	Frozen	189	n.d.	n.d.	n.d.	n.d.	669
	DP	61					2084
<i>Hermetia illucens</i>	FF	28	52	n.d.	7	n.d.	n.d.
	DF	55	10	7	8	n.d.	n.d.
<i>Bombyx mori</i>		18	10	n.d.	n.d.	n.d.	536
<i>Musca domestica</i>		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

CP – crude protein (g/100g dry matter); Fa – fat (g/100g dry matter); Fi – fibre (g/100g dry matter); Ash (g/100g dry matter); C – Carbohydrates (g/100g dry matter); GE – gross energy (kJ/100g dry matter); LL – live larvae; GL – ground larvae; DP – dried powder; FF – full fat flour; DF defated flour; n.d. – not defined-1⁻¹

The mineral concentrations of the insects are given in Table 4. In the articles cited, the mineral content was given for only 3 insect species. Either way, both the mineral content and the overall nutritional value of the insects is substantially influenced by the substrate on which the

insects have been reared. The amino acids concentration is shown in the Table 5.

Table 4. Concentration of minerals of the insects in mg/100g (Udomisil et al., 2019; AJAI et al., 2013).

Species	Stage	Ca	P	K	Mg	Na
<i>Tenebrio molitor</i>	LL	17	319	373	88	40
	DP	32	700	727	145	81
<i>Acheta domesticus</i>	n.d.	150	899	390	137	101
<i>Locusta migratoria</i>	n.d.	n.d.	n.d.	48	148	29
<i>Tenebrio molitor</i>	LL	0.4	4.2	3.8	0.8	n.d.
	DP	0.8	8.2	4.1	1.2	
<i>Acheta domesticus</i>	n.d.	4.4	20	8.8	4.9	n.d.
<i>Locusta migratoria</i>	n.d.	n.d.	16	57	9.9	0.9

LL – live larvae; DP – dried powder; n.d. – not defined

Gryllodes sigillatus

Order: *Orthoptera*; Family: *Gryllidae*

Tropical house cricket, Indian house cricket or banded cricket, native to Southwest Asia, widespread in tropical regions around the world. Due to its high thermal optimum, this species is considered non-invasive in temperate zones. Adults grow up to 20-22 mm, both male and female have reduced wings, in females only a small scale is visible behind the thorax. Tropical house crickets are light yellow in colour and can be easily distinguished from house crickets by two thick, black bands on the thorax and upper abdomen. *Gryllodes sigillatus* is extremely resistant to environmental conditions, and is very productive in mass culture, tolerating the high population density, as well as is immune to

the cricket paralysis virus. Protein content in larvae and imago varies from 60 to 70% (d.m.), with fat content of 20-25% (d.m.) and generally lower chitin content than average crickets. Incubation period (days from egg-laying to hatching) 12, and time to maturity (days from hatch to max body weight) 33-40 (IPIFF, 2024).

Table 5. Amino acid content in different types of insects g/100g (Bednářová et al., 2013)

Species	Ala	Arg	Asp	Cys	Phe	Glu	Gly	His	Ile
<i>Acheta domesticus</i>	3.0	3.5	5.4	0.5	3.8	7.2	2.9	1.8	2.2
<i>Tenebrio molitor</i>	3.2	4.6	4.0	2.9	2.9	6.9	1.5	2.5	3.2
<i>Gryllus assimilis</i>	4.0	8.6	3.0	0.7	0.7	3.6	2.4	1.3	2.1
<i>Locusta migratoria</i>	3.3	2.9	4.1	1.9	5.6	6.2	3.0	1.7	2.5
<i>Bombyx mori</i>	4.8	3.9	6.5	0.9	2.1	3.6	6.6	1.4	2.1
<i>Acheta domesticus</i>	3.6	3.2	1.4	4.1	2.5	2.4	0.4	2.2	3.2
<i>Tenebrio molitor</i>	6.1	3.6	1.9	0.9	1.3	0.3	0.3	0.9	0.7
<i>Gryllus assimilis</i>	5.0	7.9	0.6	1.3	0.6	3.6	1.0	5.4	4.6
<i>Locusta migratoria</i>	5.0	2.9	2.2	3.2	3.9	2.9	1.8	1.7	3.9
<i>Bombyx mori</i>	2.8	3.9	1.9	2.1	2.2	1.3	0.5	1.5	2.4

Ala – alanine, *Arg*- arginine, *Asp* – aspartate, *Cys* – cysteine, *Phe* – phenylalanine, *Glu* – glutamate, *Gly* – glycine, *His* – histidine, *Ile* – isoleucine, *Leu* – leucine, *Lys* – lysine, *Met* – methionine, *Pro* – proline, *Ser* – serine, *Thr* – threonine, *Trp* – tryptophan, *Tyr* – tyrosine, *Val* – valine

Gryllus assimilis

Order: *Orthoptera*; Family: *Gryllidae*

Jamaican field cricket, tropical species of cricket native to West Indies and Southern part of North America. Due to its high thermal optimum, this species is considered non-invasive in temperate zones. Adults grow up to 25-28 mm, both sexes are fully winged. Adult females are slightly bigger with prominent ovipositor protruding from the abdomen. Crickets are greyish yellow in colour, more robust than house crickets. *Gryllus assimilis* is relatively resistant to environmental conditions, and is productive in mass culture, however under high population density it shows a tendency towards cannibalism. Protein content in larvae and imagines varies from 50 to 65 % (d.m.), with a fat content of 25-30 % (d.m.). Contains a high level of chitin. Incubation period (days from egg-laying to hatching) 12. Time to maturity (days from hatch to max body weight) 42-49 (IPIFF, 2024).

Acheta domesticus

Order: *Orthoptera*, Family: *Gryllidae*

House cricket, native to Southwest Asia, widespread in tropical and temperate zones. Species are native to most of the European countries. Adults grow up to 20-22 mm, both sexes are fully winged. Adult females are slightly bigger with prominent ovipositor protruding from the abdomen. Crickets are greyish yellow in colour. *Acheta domesticus* is resistant to environmental conditions, and is very productive in mass culture, tolerating high population densities. The species is however very susceptible to the Cricket Paralysis Virus. Protein content in larvae and images varies from 60 to 70% (d.m.), with a fat content of 20-25% (d.m.). Incubation period (days from egg – laying to hatching) 11. Time

to maturity (days from hatch to max. body weight) 32-49 (IPIFF, 2024).

Tenebrio Molitor

Order: *Coleoptera*, Family: *Tenebrionidae*

Known as mealworm, species of the darkling beetles. It has a cosmopolitan distribution, being common in Europe, as a pest of the grain storages. The adult beetles are up to 15-18 mm long. It is shiny black or brown with reddish brown elytra. The eggs are oval, whitish, 1.5 mm long. The larvae resemble larvae of other mealworms, at the final stage measuring is up to 25 mm in length. *Tenebrio Molitor* is resistant to environmental conditions, and is very productive in mass culture, tolerating high population densities. Protein content in larvae varies from 50-65% (d.m.), with a fat content of 30-40% (d.m.) highly depending on the feed and rearing conditions. Incubation period (days from egg – laying to hatching) 10-12. Time to maturity (days from hatch to max. body weight) 280-400 (IPIFF, 2024).

Alphitobius diaperinus

Order: *Coleoptera*; Family: *Tenebrionidae*

Known as lesser mealworm or litter beetle, species of the darkling beetles. It has a cosmopolitan distribution, being common in Europe, as a pest of the grain storages and poultry farms. The adult beetles are 6 mm long, oval in shape. It is shiny black or brown with reddish brown elytra. Colour is variable among individuals and subpopulations and changing with age. The antennae are paler at the tips and are covered in tiny, yellowish hairs. The elytra have shallow longitudinal grooves. The eggs are narrow, whitish, about 1.5 mm long. The larvae resemble larvae of other mealworms, at the final stage measuring up to 11 mm in length. *Alphitobius diaperinus* is resistant to environmental conditions

and is very productive in mass culture. Protein content in larvae varies from 50 to 65% (d.m.), with fat content of 30-40 % (d.m.) highly depending on the feed and rearing conditions. Incubation period (days from egg-laying to hatching) 10-12. Time to maturity (days from hatch to adult) 280-400 (IPIFF, 2024).

Hermetia illucens

Order: *Diptera*; Family: *Stratiomyidae*

Black soldier fly, composting fly belonging to the soldier fly family. It is supposedly native to South America but is currently widespread in tropic and temporal zones worldwide. As it requires a high level of UV irradiation and temperatures above 24 °C to mate it must be considered as non invasive species in colder zones. The adult flies reach up to 15-18 mm in length. Adults are black, showing mimicry to wasps. The eggs are round, yellow and about 0.5 mm in diameter. The whitish larvae grow up to 25 mm in length, going through six instars to reach the brown prepupa stage. Prepupae leave the moist compost environment to seek for a dry place to pupate, that enables efficient separation of the larvae from the substrate. Larvae of the black soldier fly are very efficient composters, being able to digest a whole variety of organic products. *Hermetia illucens* grows in a wide range of environmental conditions, and is very efficient in mass culture, tolerating high population densities and being able to complete the life-cycle within 3 weeks. Protein content in larvae varies from 40 to 50% (d.m.), with a fat content of 35-45 % (d.m.) with high lauric acid content. Black soldier fly worms are an important source of animal protein. The dry matter content is 30% of their total original larval weight, of which 54% is crude protein (Hwangbo et. al., 2009). Exact composition highly depends on the feed and rearing conditions (IPIFF,

2024). Live pupae consists of 44% dry matter and can be easily store for longer period (Hale, 1973). Incubation period (days from egg-laying to hatching) 4. Time to maturity (days from hatch to max body weight) 12-60 (IPIFF, 2024).

Musca domestica

Order: *Diptera*; Family: *Muscidae*

House fly, most common fly species, with a cosmopolitan distribution, therefore it is a native species in Europe. The adult flies reach up to 10-12 mm in length. Adults are grey to black with four longitudinal dark lines on the back, and the body covered with hair-like protrusions. Eggs are usually laid on decaying organic matter, yellow in colour and about 0.5 mm in diameter. After few days of incubation, they hatch into legless white maggots which after two to five days of development transform into reddish brown pupae of ca. 8 mm in length. *Musca domestica* resistant to a wide range of environmental conditions, and is very efficient in mass culture, tolerating high population densities. Protein content in larvae varies from 40 to 65 % (d.m.), with a fat content of 20-45 % (d.m.). The amino acid profile composition highly depends on the feed and rearing conditions. Incubation period (days from egg-laying to hatching) 1. Time to maturity (days from hatch to max larval body weight) 2-30 (IPIFF, 2024).

Bombyx mori

Order: *Lepidoptera*; Family: *Bombycidae*

Domestic silk moth (*Bombyx mori*) is the lepidopteran whose caterpillar has been used in silk production for thousands of years. Its closest relative is the wild silk moth (*Bombyx mandarina*). Although native to China, the silkworm has been introduced throughout the world and has undergone complete domestication. An adult silkworm has a

cream-coloured body with dark veined wings of 40 to 50 mm span. The female silkworm lays about 300 to 500 eggs, which their hatching period fluctuates based on the environmental conditions. The voracious larvae are monophagous, exclusively feed on mulberry (*Morus spp.*) leaves, and may grow up to 75 mm in length. Pupation occurs within a cocoon composed of two proteins: soluble sericin and insoluble fibroin. Fibroin is the component of silk fiber and is present in single strands of 900-1000 meters long. After 10-14 days of developing, the silkworm moth will emerge. It lives a very brief life of 5-10 days. The silkworm pupae is the remaining after reeling of silk and can serve as feed material. The dry pupae contain 50–82% (d.m.) crude protein and 23–34% (d.m.) crude lipid. It has a rich and balanced content of essential amino acids such as valine, methionine and phenylalanine and is considered a good dietary source of protein for animal feed (poultry, cattle and all types of fish). The silkworm cocoon is made of fibroin (≈75%) and sericin (≈25%), two nutritive proteins that are a source of essential amino acids. Incubation period (days from egg-laying to hatching) 7-14 days at the temperature 23-29 °C and relative humidity 80%. Time to maturity (days from hatch to max body weight) 24-33 days (IPIFF, 2024).

Locusta Migratoria

Order: *Diptera*, Family: *Stratiomyidae*

The common name is migratory locust and it is considered as a pest in many regions of the world. Through history, large swarms of migratory locusts have caused reductions in crop and vegetation. Migratory locust (*Locusta Migratoria*) is the most abundant between the locust species and occur throughout Africa, Asia, Australia, New Zealand, and seldom in Europe. Their size ranges between 32 to 80 mm and the

development from egg deposit to adult is approximately 3 months depending on the environmental conditions. Currently the migratory locust can be mass produced in colonies and the adults can be harvested and consumed as human food (IPIFF, 2024).

The results of research by Bajuk et al. (2021) suggest that dogs allergic to mites can also clinically show cross-reactivity with mealworm proteins. Other hazards associated with the contamination of insects can be the result of flawed processing procedures related to anthropogenic factors during breeding, packaging, cooking or feeding. Contaminants include the presence of bacteria, mold fungi, mycotoxins and heavy metals, among others. Importantly also, as an undesirable consequence of insects' readily incorporating nutrients from their diet into their body composition, we must be aware of heavy metal accumulation such as copper, cadmium and lead.

CONCLUSION

From the above cited researches and studies, we can conclude that insects are rich in nutrients. Some insects are richer in live form, some in dried form. Their incubation period and the achievement of the imago is incomparably shorter compared to livestock serving as pet food and they can cover the nutritional needs of pets. Therefore, insects seem to be a good option as a substitute for some types of feed. Dogs allergic to mites can also clinically show cross-reactivity with mealworm proteins. Other hazards associated with the contamination of insects can be the result of flawed processing procedures related to anthropogenic factors during breeding, packaging, cooking or feeding. Contaminants include the presence of bacteria, mold fungi, mycotoxins and heavy metals, among others. Importantly also, as an undesirable

consequence of insects' readily incorporating nutrients from their diet into their body composition, we must be aware of heavy metal accumulation such as copper, cadmium and lead.

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