CAPÍTULO 15

NUTRITIONAL SAFETY IN INSECT BY-PRODUCTS FOR PET FOOD

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ABSTRACT: The production of insects for animal feed emerges as a sustainable alternative, standing out for its efficiency in land use compared to conventional animal production. Characterized by a rapid life cycle, insects allow massive production, taking advantage of by-products from the agri-food industry as food substrate, avoiding competition with more expensive ingredients intended for human and animal food. In addition to having low greenhouse gas emissions, zootechnical entomoculture benefits economic efficiency with more sustainable production systems. In the PET FOOD industry, insects stand out for containing significant levels of protein, essential amino acids, fatty acids, macro and microminerals, vitamins, peptides with biological activity and chitin with prebiotic action. Insect farming demonstrates socioeconomic viability, providing subsistence and business opportunities on different scales. However, given the advances in the production of biomass from food insects, it is essential to understand the risks associated with consumption by dogs and cats.
KEYWORDS: Production of insects, by-products, food insects, insect farming, animal nutrition.

SEGURANÇA NUTRICIONAL EM SUBPRODUTOS DE INSETOS PARA PET FOOD

RESUMO: A produção de insetos para a alimentação animal emerge como uma alternativa sustentável, destacando-se pela eficiência no uso da terra em comparação com a produção animal convencional. Caracterizados por um ciclo vital rápido, os insetos permitem uma produção massiva, aproveitando subprodutos da indústria agroalimentar como substrato alimentar, evitando concorrência com ingredientes mais caros destinados à alimentação humana e animal. Além de apresentarem baixas emissões de gases de efeito estufa, a entomocultura zootécnica beneficia a eficiência econômica com sistemas de produção mais sustentáveis. Na indústria PET FOOD, os insetos destacam-se por conterem níveis significativos de proteína, aminoácidos essenciais, ácidos graxos, macro e microminerais, vitaminas, peptídeos com atividade biológica e quitina com ação prebiótica. A entomocultura zootécnica demonstra viabilidade socioeconômica, proporcionando oportunidades de subsistência e negócios em diferentes escalas. Contudo, diante do avanço na produção de biomassa de insetos alimentícios, é essencial compreender os riscos associados ao consumo por cães e gatos.
PALAVRAS-CHAVE: Produção de insetos, subprodutos, insetos alimentícios, entomocultura,

nutrição animal.

1 I INTRODUCTION

By 2050, the global human population is predicted to be approximately 9 to 11 billion (Legendre and Baker, 2020); therefore, the priority is food security and environmental issues related to food production and consumption. According to estimates by the World Health Organization (WHO), up to 870 million people may suffer from malnutrition during this period due to a lack of food (Baker et al., 2016). Another major global concern is the production of food intended for feeding production and companion animals, which are responsible for a large part of environmental impacts. Within this context of prospecting for new, more sustainable ingredients, the production of insects for human and animal food appears as an efficient alternative in terms of land use compared to traditional animal production (Kępińska-Pacelik and Biel, 2022).

Edible insects have a rapid life cycle and development, facilitating their mass production. Furthermore, by-products from the agri-food industry can be used as a substrate for feeding these animals, not requiring more expensive ingredients that compete with human and animal food (Makkar et al., 2014). The production of insect biomass to obtain by-products is characterized by lower greenhouse gas emissions than the farming of vertebrate animals (Halloran et al., 2014). Furthermore, the benefits of zootechnical entomoculture can increase economic efficiency through more sustainable and cost-effective production systems (Kępińska-Pacelik and Biel, 2022).

It is generally considered that insects and their by-products are interesting ingredients for the PET FOOD industry, as they have notable levels of protein, essential amino acids and fatty acids, as well as a variety of macro and microminerals, vitamins (Rumpold and Schülter, 2013), as well as bioactive compounds, such as peptides with biological activity (antioxidant, antimicrobial, anti-cancer and anti-hypertensive) and chitin (with proven prebiotic action) (Cruz-Monterrosa and Liceaga, 2022). In the socio-economic sphere, insect farming demonstrates important viability as a subsistence and business opportunity, ranging from small producers to micro-enterprises and multinationals (Pyett et al., 2023).

Among edible insect species, some have received greater attention because they are considered to have greater industrial potential for applications in the area of food and animal feed. It is interesting to mention the housefly (*Musca domestica*), black soldier fly (Hermetia illucens), mealworm or Mealworm (*Tenebrio molitor*), giant Tenebrious (*Zophobas atratus*), mealworm (*Alphitobius diaperinus*), Wax Moth (*Galleria mellonella*), Lesser Wax Moth (*Achroia grisella*), Silkworm (*Bombyx mori*), House Cricket (*Acheta domesticus*), Cinerea Cockroach (*Nauphoeta cinerea*), Cockroach de-Madagascar (*Gromphadorhina portentosa)* and Dubia Cockroach (*Blaptica dubia*) (EFSA, 2015).

In Brazil, the Ministry of Agriculture and Livestock (MAPA) issued Normative

Instruction N° 110 (IN 110/2020), which lists some species of insects that can be used as raw materials, additives, or vehicles for use in animal feed, except for ruminant animals (Costa, 2021). This IN includes dehydrated adult Cinereous Cockroach (Nauphoeta cinerea), dehydrated or non-fat chrysalis flour, dehydrated black soldier fly (*Hermetia illucens*) larvae flour, dehydrated adult black cricket (*Gryllus assimilis*) and ground dehydrated larvae or not of Mealworm (Tenebrio molitor) and giant Tenebrio (*Zophobas morio*) (Brazil, 2020).

With the increasing advancement in the production and commercialization of food insect biomass, it is necessary to have a greater understanding of the risks associated with the consumption of insect products and by-products by dogs and cats.

2 I CHEMICAL RISK

Several chemical risks inherent to the consumption of insect by-products for dogs and cats have been reported in the scientific literature. Worryingly, insects can be vectors for antimicrobial resistance genes, according to Channaiah et al. (2010). It is mentioned in the literature that symbiotic fungi (including Aspergillus spp.) are present in the intestine of *Acheta domesticus* and are capable of producing or modifying toxins, which is why studies have emerged investigating the detection and quantification of mycotoxins in insect by-products and their effects on the metabolism of dogs and cats (Fernandez-Cassi et al., 2019).

Bednarska et al. (2015) proved the possibility of bioaccumulation of heavy metals in insects. In these studies, *Gryllus assimilis* were exposed to diets enriched with zinc or cadmium. It was concluded that zinc accumulation occurred at the highest level of exposure, while tissue bioaccumulation occurred for cadmium at a lower level of exposure.

In the case of the black soldier fly larva (*H. illucens*), it was demonstrated that the absorption of heavy metals can influence its growth rate, but the effect of heavy metals on the intestinal microbiota of the live larva is largely unknown and requires further studies. In studies by Wu et al. (2020), the effect of copper and cadmium on the growth and intestinal microma of black soldier fly larvae was analyzed, as well as the distribution of heavy metals accumulated in the larvae and their excreta. The experiments by Proc et al. 2020 demonstrated the ability of *H. illucens* to bioaccumulate Cu, Fe, Hg, Mg, Mo, Se, and Zn, and this accumulation occurred at all stages of insect development. From the point of view of dog and cat food production, it is obvious that the content of toxic heavy metals must be monitored, and their effects must be further studied.

3 I MICROBIOLOGICAL RISK

Biological contaminants refer to species of pathogenic microorganisms, such as bacteria and fungi, and the toxic metabolites they produce, in addition to viruses and parasites (Vandeweyer et al., 2021). When analyzing the microbiological aspects of edible insect species, it is essential to consider that they naturally harbor microorganisms, which are essential for their metabolic functions (Jordan and Tomberlin, 2021). The composition of the microbiome is associated with factors such as vertical transmission as well as production and processing conditions (Garofalo et al., 2019). However, the possible presence of biological contaminants is one of the main risks associated with entomoculture (Garofalo et al., 2019), considering that these agents affect the safety of insects as food, with adverse implications for animal health and impacting product quality (Kooh et al., 2019).

It is important to highlight that food insects are recognized as safe as long as prophylactic measures are implemented during breeding and slaughter using correct and efficient techniques, which promote a reduction in the microbial load (Wade and Hoelle, 2020). However, for a product to be considered microbiologically safe, it is necessary that, in a pre-determined quantity for analysis, certain contaminants are below a defined level or are not detected (Brasil, 2022). Values are expressed in Colony Forming Units per gram or milliliter (CFU/g or CFU/mL) or based on the logarithm of this result (log CFU/g or log CFU/mL) (Messina et al., 2019).

4 | ALLERGENIC RISK

Despite the numerous advantages of using insects to feed canines and felines, it is necessary to analyze the risk of adverse food reactions, including allergic reactions (Broekman et al., 2017). Allergy is a hypersensitivity reaction initiated by specific immunological mechanisms. The clinical signs of food allergy can affect a variety of organs and systems in dogs and cats, including the skin, intestine, and respiratory, circulatory, and nervous systems. They can range from mild symptoms of hypersensitivity, such as itching in the mouth, to severe, systemic, and often fatal reactions, such as anaphylactic shock (De Martinis et al., 2020). Food allergies are a common cause of skin diseases in dogs and cats, where skin symptoms in food-allergic dogs can include itching and erythematous dermatitis of the face and ear canals (Kim and Kim, 2020).

Research indicates that insects can also be a trigger for food allergies. An allergy related to insect consumption can be caused by a primary sensitization or by a cross-reaction with another allergen (de Gier and Verhoeckx, 2018). In a study carried out by Kim and Kim (2020) with the aim of investigating the interaction between T. molitor proteins and the immune system of dogs with clinical signs of allergy and dust mite allergy, compared to a control group of clinically healthy dogs, no evident correlation was found between dust mite allergy and the clinical condition of dogs. In this study, the binding of canine serum IgE to mealworm proteins was confirmed, but the differences between healthy and allergic dogs were nonsignificant. The results of these studies suggest that dogs allergic to dust mites may also exhibit clinical cross-reactivity with tenebrious mealworm proteins.

Therefore, caution should be exercised when using mealworms as an alternative source of dietary protein.

5 I CONCLUSION

Insects can be used in the dog and cat food industry, a fact that is supported by evolution in the adaptation of their wild ancestors to entomophagy in the natural environment. The chemical composition of insects also corresponds to the nutritional needs of dogs and cats, as insect by-products are characterized by a very good nutritional value (high protein content, high content of essential amino acids and fatty acids, including lauric acid) and good acceptability. However, diets containing insect proteins and their effects on animals require careful analysis, especially in terms of the risk of adverse reactions to foods, including allergic reactions that can be caused by consuming insects. Other hazards are related to microbiological or chemical contamination. There must be quality control to prevent them from being contaminated with anthropogenic factors during creation, packaging, cooking, or eating. These contaminants include the presence of bacteria, fungi, mycotoxins, and heavy metals, metals, among others. More studies are needed to look at the use of insects and their products in the diet of dogs and cats, associating the levels of inclusion in the diet with microbiological, chemical, and allergenic risks in the short to long term.

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