

# Edible Insects-the Future of a Healthy Diet?

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## Abstract

The global population is increasing, it is estimated that in 2050 the human population will reach 9 billion. Generally, insect represents a valuable alternative source of proteins with nutritional benefits that cannot be neglected. Entomophagy, the eating of insects, can be promoted for different reasons:

- Insects are rich in nutrients (proteins, fat, fibre, vitamins and minerals)
- They are the most species-rich resources
- Their farming can be a more sustainable practice than beef rearing
- They can be eaten a variety of ways
- They taste great.

**Keywords:** Edible insects; Nutrition; Sensory analysis

## Introduction

Insects have always been a part of human nutrition. However, in most countries, people still associate eating insects with primitive behavior [1]. It is estimated that more than 2100 species of insects are consumed in about 113 countries across Asia, Africa and Latin America [1-3]. The most frequently consumed insects are beetles (Coleoptera-659 species), caterpillars (Lepidoptera-362 species), bees, wasps and ants (Hymenoptera-321 species), followed by grasshoppers, locusts and crickets (Orthoptera-278 species) [1,4,5]. Edible insects are usually divided into 3 groups: food insects, drug/medicinal insects and drug dual-use insects. Besides serving as a food, insects offer a variety of other valuable products such as honey, silk and/or medicinal applications (e.g. maggot therapy) [1]. Common insect's products and services are listed in Table 1.

**Table 1:** List of common insects' products and services.

Insects	Products
Scale insects	Cochineal (carminic acid) [18]
Bees	Honey, propolis (natural medicine), royal jelly (beauty products), beeswax (cosmetics and candles) [19]
Human flea	Resilin protein (for artery repair) [20]
Silkworms	Silk [21]
Termites	Termite hills (architectural models) [22]
Various insects	Pollination [23]

## Nutritional value

It has been proven that insects have high nutritional value, although it is highly variable [2,3,6]. Significant variations were found in nutritional values of different species. Besides species variations, factors such as metamorphic stage of insect, their habit and diet, preparation and processing methods (e.g. boiling, drying, frying) may influence nutritional composition [1,2,5]. The main components of insect body are proteins, fats, fibre, nitrogen-free extract (NFE-carbohydrates other than fibre) and ash [7].

Proteins are the most significant components of insect body, comprising between 13% and 77% of total dry matter, reflecting high variability of analyzed species [8]. Protein quality is determined by amino acid composition and the digestibility of the protein fraction [9].

Elorduy et al. [10] estimated digestibility of insect proteins to be between 77% and 98% [11]. Previous studies showed that insect's essential amino acid profile score ranges from 46% to 96% of total amino acids [11,12]. Generally, phenylalanine tyrosine, leucine and valine are dominant amino acids, while methionine, cysteine and tryptophan represent minor ones [7,11,13].

Fat represents the second largest portion of the nutrient composition of insects. The average fat contents range from 10% to 60% of dry matter, with larval stages having a higher fat content than adults [5,7,11], although these values depend on insect diet and insect species. For instance, caterpillars and termites have the highest levels of fat (from 8.6 to 15.2g/100g of insects), while grasshoppers and crickets are at the lower end (3.8 to 5.3g/100g of insects) [9,14]. The lipid fraction of edible insects is rich in mono- (MUFA) and polyunsaturated fatty acids (PUFA), with a high  $\omega$ -3 (omega 3):  $\omega$ -6 (omega 6) ratios [3]. The major MUFA of edible insects include palmitoleic (C16:1) and oleic acid (C18:1n9), while the two main components of PUFA are linoleic (C18:2n6) and  $\alpha$ -linolenic acid (C18:3n3). Palmitic acid (saturated fatty acid - SFA) content is also relatively high [1,5,7].

Insects contain significant amount of fibre (crude fibre, acid detergent fibre and neutral detergent fibre). Chitin, an insoluble fibre derived from the exoskeleton, is the most common form of fibre in insects. Finke (2007) estimated that chitin content ranges from 2.7mg to 49.8mg per kg (fresh), and from 11.6mg to 137.2mg per kg (dry matter) [15]. In addition to proteins, fats and fibre, edible insects are a valuable source of minerals such as iron, copper, zinc, potassium, sodium, calcium, phosphorous, magnesium and manganese [1]. Edible insects can be rich also in vitamins such as thiamine (B1), riboflavin (B2), pantothenic acid (B5), vitamin E and retinol. Again, a large variation in mineral and vitamin contents is often seen between individual species due to environmental factors and contaminants, particularly metal, acquired during processing [1,5,7,9].

### Sensory quality

Although nutritional values are important, for steady intake a food has to be acceptable from a sensory point of view. In many countries' insects are consumed alive and/or processed by various methods such as steaming, roasting, frying, curing or smoking. On the other hand, various techniques of insect processing have been developed in order to increase consumer's interest in the Western countries. These techniques which include drying (e.g. sun-drying, freeze-drying, oven-drying, microwave-drying), ultrasound-assisted extraction, cold atmospheric pressure plasma or dry fractionation, are aimed primarily at using insects as ingredients in a non-recognizable form, such as powders or flours [5,16,17]. All the above-mentioned techniques may influence sensory properties of edible insects. Flavor and taste are very diverse (Table 2). Elorduy et al. [10] concluded that flavor and taste are mainly affected by pheromones occurring at the surface of the insect's body, by the environment, feed and/or processing methods. For instance, scalded insects are practically tasteless, because pheromones are washed off by rising [18-23]. Moreover, during cooking insects take the flavor of added ingredients [5,10]. Texture is influenced

primarily by exoskeleton of insects. Most insect's adults are crunchy, while pupae, larvae and nymphs are not so crispy due to a minimal amount of chitin. Processing techniques also influence insect's texture. Fried, roasted or dried insects are crunchier/crispier than boiled ones [17]. Insects color is strongly affected by the processing methods and by the technological conditions applied. During cooking (boiling), the insects turn a reddish color [17]. On the other hand, insects that contain significant amount of oxidized fat or are inappropriately dried, may be black [5,10]. Smoked, properly dried or fried insects are golden or brown [17].

**Table 2:** Flavor and taste of selected edible insect species.

Insect	Sensory Description
Ants, termites	Sweet; nutty; fatty; crunchy; notes of cereal and wood
Grasshopper	Aroma of cereal, wood and nuttiness; flavour of umami and vegetable; crusty; hard
Cricket	Popcorn; chicken; creamy; aroma of broth, nuttiness and cereal; flavour of umami and vegetable
Mealworm ( <i>Tenebrio molitor</i> )	Nutty, umami, intense aroma of cereal, nuttiness and wood; flavour of nut, cereal and umami; brittle texture

Source: Elhassan et al. [16] and Elorduy et al. [10]

### Conclusion

Edible insects represent valuable source of nutrients and may be included among the common diet of consumers in the future. They could be used for direct consumption and/or as a nutritional ingredients and supplements for special diets. Insects can be regarded as safe, if properly managed and consumed. In addition, standardized conditions of their rearing and monitoring their composition are necessary to include potential suitable species of insects into the normal human diet.

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