Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 03, Issue: 01 (JAN-FEB, 2023)
Available online at http://www.agriarticles.com

Nutrients Present in Insect and Factors Affecting their Variability

(*Amar Singh)
M. Sc. (Ag.), Entomology, Agriculture University, Jodhpur (Rajasthan)
*Corresponding Author's email: amarchahar15@gmail.com

Insects are important sources of nutrients for humans and a wide variety of other animal species. Hence studies on insect nutrient composition can be found in disciplines ranging from anthropology to zoology. Comprehensive literature reviews of insect nutrient content have been published (Bukkens, 1997; Finke, 2004; Payne et al., 2016; Raubenheimer and Rothman, 2013; Rumpold and Schluter, 2013a). While the first mention of using insects to feed production animals were in 1919 (Linder, 1919), it was not until the 1960s and 1970s that research started in earnest (Calvert et al., 1969; Hale, 1973; Teotia and Miller, 1973, 1974; Ueckert et al., 1972). The renewed interest in this area of study in the last decade yields numerous papers and comprehensive reviews regarding the safety of insects as food and feed, as well as several overviews of feeding trials for production animals (Gasco et al., 2019; Henry et al., 2015; Makkar et al., 2014; Riddick, 2014; Rumpold and Schluter, 2013b; Sanchez-Muros et al., 2014, 2016). Given the comprehensive nature of these recent reviews, this article will summaries this compositional data, focus on nutrients that have received little attention and nutrient manipulation. Data on both wild and produced insects is discussed.

Keywords: Amino acids, Fatty acids, Vitamins, Minerals, Digestibility, Nutrient manipulation

Nutrient Content of Insect

Protein and Amino acids: Nutrients present in insects and factors affecting their variability. Data on protein content and amino acid profiles of a variety of insect species are discussed and their amino acid profiles compared to nutrient requirements of growing broiler chicks, catfish, trout, swine, and human adults and young children. Both in vitro and in vivo protein digestibility data for a variety of insect species is presented and factors affecting these data are discussed. Furthermore, the fat content and fatty acid profiles of a variety of insect species is reviewed, with special attention on omega-6 and omega-3 fatty acids. Information on carbohydrates, fiber and chitin in insects is shown along with potential effects on nutrient availability. This is followed by a discussion of essential minerals in insects with an emphasis on calcium Data on insect vitamin content is shown along with a discussion of antinutritional factors such as phytate and thiaminase, which can adversely affect their nutritional value. Dietary effects on insect nutrient composition are reviewed with an emphasis on essential minerals, heavy metals, vitamin E, and carotenoids.

The protein consumption in developing countries is much less – about 56 g/person/day and a still lesser portion (only 25% of it) is animal protein. The protein content varies by species of insects, but generally is of a good quality and high digestibility. Analyses showed that in egg, larva, pupa and adult stages, the raw protein content is generally 15% – 81% on a dry basis. The protein content of some insects is also higher than that of chicken eggs, meat and fowl. The content of essential amino acids is 10% – 30% of all amino acids (35% – 50%). The protein digestibility of insect protein is reported at values of 77% – 98%, especially after removing the exoskeleton. This is only slightly lower than the values reported in other animal protein sources (egg 95%, beef 98% and casein 99%). Whole dried bees had a digestibility of 94.3% and the moth *Clanis bilineata* 95.8% compared to casein. Protein digestibility of fresh termites *Macrotermes subhylanus* was 90.5%, of the green form of grasshoppers *Ruspolia differens* 82.3% and of the brown form of grasshoppers *Ruspolia differens* 85.7%. The amino acid composition of insects ranges from approximately 40% – 95% of all nitrogenous substances.

Carbohydrates: In general, carbohydrates calculated as nitrogen free extract, are present in small amounts in insects (Barker et al., 1998; Finke, 2002, 2013, Oonincx and Dierenfeld, 2011; Pennino et al., 1991). The carbohydrate content of yellow mealworm larvae can vary between one and seven percent (Ramos-Elorduy et al., 2002). Fiber and chitin Insects contain significant amounts of fiber as measured by crude fiber, acid detergent fiber, or neutral detergent fiber (Barker et al., 1998; Finke, 2002, 2007,2013; Lease and Wolf,).

Carbohydrates in insects are formed mainly by chitin. The carbohydrate content of edible insects ranged from 6.7% in sting bug to 16% in cicada. Research also showed that considerable amounts of polysaccharides might improve immune function of human body. Chitin is a macromolecular compound that has a high nutritional and health value. As a form of low-calorie food, chitin also has a medicinal value. In most cases, the hard cover polysaccharide chitin of insect's accounts for 5% – 20% of the dry weight. Chitin exists rarely in a pure form in nature but instead is usually in a complex matrix with other compounds (proteins, lipids and insignificant amounts of minerals). Insects with ''harder'' cuticles do not seem to contain significantly more chitin than softer bodied insects but rather their ADF fraction seems to contain a much higher proportion of amino acids than softer bodied insects. Although chitin presents problems of digestibility and assimilability in monogastric animals, it and its derivatives, particularly chitosan, possess properties that are of increasing interest in medicine, industry and agriculture. If the time should come when protein concentrates from insects are acceptable and produced on a large scale, the chitin byproduct could be of a significant value.

A significant contribution of chitin can be presented for example by significantly reducing serum cholesterol, acting as a hemostatic agent for tissue repair, enhancing burn and wound healing, protecting against certain pathogens in the blood and skin, serving as a non-allergenic drug carrier, providing a high tensile strength biodegradable plastic for numerous consumer goods, enhancing pollutant removal from waste-water effluent, improving washability and antistatic nature of textiles, inhibiting growth of pathogenic soil fungi and nematodes and boosting wheat, barley, oat, and % pea yield by as much as 20.

Fat: Mostly, the fat content of edible insects is between 10% – 50%. Reports and analyzed results have shown that many edible insects are rich in fat; witchetty grubs have nearly 40% of fat (a composition similar to olive oil). The fat content of insects depends on many factors such as species, reproductive stages, season, age (life stage), or sex, habitat and diet. For example, the fat content is higher in the larva and pupa stages; at the adult stage, the fat content is relatively lower. Female insects contain more fat than male insects. The content of essential fatty acids is higher as compared with animal fats. Similarly, the fatty acid composition of related species is different, as there are many factors playing a role, too. Largely it is influenced by the host plant on which they feed. For insects that feed on a single food plant, the values are probably typical for all members of the species, in contrast, the fatty acid content of generalist feeders such as the house cricket, *A. domestics*, is likely to vary widely depending on the diet being fed. Edible insects contain a good quality fatty acid especially long chain omega-3 fatty acids such as alpha-linoleic acid, eicosatetraenoic acid. The reason for insects containing long-chain PUFAs and different fatty acid compositions is linked with the diet and enzymatic activity in the insects. One of the most important PUFA is

DHA, which has been considered important for brain and eye development and also good cardiovascular health, and populations, which consume 0.5–0.7 g/day DHA have a lower incidence of heart disease. A few insect species are likely to be able to modify endogenously produced or dietary PUFAs to form the precursors to PGs (mammal prostaglandins) and related biologically active compounds.

Minerals: Minerals are classified as macro-minerals, calcium, phosphorus, magnesium, sodium, potassium and chloride) and micro or trace minerals (iron, zinc, copper, manganese, iodine and selenium). This classification is based on the amount needed to meet dietary requirements. For most species, requirements for macro-minerals are measured in g per kg and micro-mineral requirements in mg per kg. Insects are rich sources of minerals such as iron, zinc, copper, magnesium, and selenium. Analysis of mineral elements showed that edible insects are particularly rich in nutritious elements such as potassium and sodium (e.g., cricket nymph), calcium (e.g., cricket adult), copper (e.g., mealworm adult), iron (e.g., axayacatl – a mixture of several species of aquatic Hemiptera, giant mealworm), zinc (e.g., cricket nymph), manganese (e.g., cricket adult) and phosphorus (e.g., cricket adult). The mineral composition in general probably largely reflects the food sources of insects, both those which are present in the gastrointestinal tract and those which are incorporated into the insect's body as a result of the food it consumed.

All insects contain high levels of phosphorus, which results in a calcium: phosphorus ratio of less than one. For most monogastric animals, phosphorus from animal sources is virtually 100% available, while plant-based phytate phosphorus is approximately 30% available. Insects could provide significant proportions of daily recommendations of minerals and, in particular, be excellent sources of bioavailable iron in the diets depending on the insect species.

Vitamins: Studies dealing with the vitamin content in insects are insufficient, yet it is known that edible insects contain mainly carotene and vitamins B1, B2, B6, D, E, K and C. As far as the A vitamin (retinol) is concerned, the data differ not only in dependence on the species, but also on the origin of analyzed insects, methods used and ways of preparation. Commercially raised insects appear to contain little or no beta-carotene, most wild-caught insects contain a variety of carotenoids (astaxanthin, alpha-carotene, beta-carotene, lutein, lycopene, taraxanthin and others), which they accumulate from their food. Most species of vertebrates can convert some of these carotenoids to retinol, so insects containing high levels of carotenoids may be a significant source of vitamin A for insectivorous vertebrates. Insects appear to be a good source of most B-vitamins, but a number of insects appear to contain low levels of thiamin. These low levels are likely an effect of heat processing, although the low levels seen for house crickets and super worms are for raw, whole insects.

References

1. Abrams HL. *The preference for animal protein and fat: A cross-cultural survey*. Temple University Press; Philadelphia, PA, USA: 1987.
2. Assielou B, Due EA, Koffi MD, Dabonne S, Kouame PL. *Oryctes owariensis* larvae as good alternative protein source: Nutritional and functional properties. *Annu Res Rev Biol.* 2015; 8:1–9. doi: 10.9734/ARRB/2015/19093.
3. Awoniyi TAM, Aletor VA, Aina JM. Performance of broiler-chickens fed on maggot meal in place of fishmeal. *Int J Poult Sci.* 2003; 2:271–274. doi: 10.3923/ijps.2003.271.274.
4. Azua RV. *La domesticación animal*. Mexico City: Universidad Nacional Autónoma de Mexico/Instituto de Investigaciones Antropológicas; 2003.
5. Banjo AD, Lawal OA, Songonuga EA. The nutritional value of fourteen species of edible insects in southwestern Nigeria. *Afr J Biotechnol.* 2006; 5:298–301.

6. Belluco S, Losasso C, Maggioletti M, Alonzi CC, Paoletti MG, Ricci A. Edible insects in a food safety and nutritional perspective: A critical review. *Compr Rev Food Sci Food Saf.* 2013; 12:296–313. doi: 10.1111/1541-4337.12014.
7. Bubler S, Rumpold BA, Jander E, Rawel HM, Schluter OK. Recovery and techno-functionality of flours and proteins from two edible insect species: Meal worm (*Tenebrio molitor*) and black soldier fly (*Hermetia illucens*) larvae. *Heliyon.* 2016;2: e00218. doi: 10.1016/j.heliyon. 2016.e00218.
8. Bukkens SG. The nutritional value of edible insects. *Ecol Food Nutr.* 1997; 36:287–319. doi: 10.1080/03670244.1997.9991521.
9. Chakravorty J. Diversity of edible insects and practices of entomophagy in India: An overview. *J Biodivers Biopros Dev.* 2014; 1:124. doi: 10.4172/2376-0214.1000124.
10. Chen X, Feng Y, Chen ZY. Common edible insects and their utilization in China. *Entomol Res.* 2009; 39:299–303. doi: 10.1111/j.1748-5967.2009.00237.