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NUTRITIONAL ASPECTS OF ENTOMOPHAGY AS FUTURE FOOD FOR LIVELIHOODS

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ABSTRACT: Entomophagy is the term used to describe the practise of native human populations eating insects as food. Editable insects are environmentally friendly since they can feed on recycled materials, require little food, water, and space to thrive, and grow quickly. The availability, palatability, and nutritional quality of an insect species for human consumption is determined by local customs and traditions, as well as the insect's palatability, availability, and nutritional value. Insects as food have gained a lot of attention as a result of the rising cost of animal protein, food insecurity, environmental strain, and population expansion. About 2000 insect species are reported to be used as food by humankind in 300 ethnic groups from 113 countries. Grasshoppers, caterpillars, beetles, grubs, adult winged termites, bees, wasps, ant brood, cicadas, and a variety of aquatic insects are among the most important edible insects. Insects are revolutionary food sources that seem to be exceptionally nutritious due to its higher protein content and well-balanced nutritional profile. Insects are also utilized for a variety of uses including edible, medicinal, industrial, and cultural purposes. Eating insects provides a number of advantages over traditional animal consumption, including nutritional, environmental, social, and economic benefits. The nutritional features of entomophagy as future food for livelihood are a serious problem in an ever-human population, and this review study is centred on that. With the rapid growth of the global population, the global food supply should rise at a similar, if not faster, rate. As a result, the quest for novel food sources, as well as the identification and creation of ethnically specific ones, continues.

KEY WORDS: Entomophagy, Food source, Insects, Nutrition, Protein

More than 2 billion people across the world, particularly in Africa, South America, and Asia, have traditionally practised Entomophagy. (Rumpold and Schluter, 2013). Humans are known to consume approximately 2000 species of insects as nourishment (Van Huis, 2013). Beetles contribute for 31 Per cent of the total, caterpillars for 18 Per cent, wasps, bees, and ants for 15 Per cent, crickets, grasshoppers, and locusts for 13 Per cent, true bugs for 11 Per cent, and termites, dragon flies, flies, and other insects for 12 Per cent. (Jongema, 2017). In India, entomophagy studies found that over 255 kinds of insects are used as food by tribal groups. The ingestion of coleopteran insects was the highest among all these edible bug species, amounting for around 34 Per cent of the total. Orthoptera (24 Per cent), Hemiptera (17 Per cent), Hymanoptera (10 Per cent), Odonatae (8 Per cent), Lepidoptera (4 Per cent), Isoptera (2 Per cent), and Ephimeroptera (2 Per cent) were the least popular (1 Per cent). Entomophagy is popular among ethnic communities in North East India, notably among the tribes of Arunachal Pradesh, Assam, Manipur, and Nagaland, and to a lesser extent among the tribes of Meghalaya and Mizoram. (Chakravorty J., 2014) India has a large number of edible insects' species. Arunachal Pradesh has 158 species, Nagaland and Manipur have 41, Assam has 38, Meghalaya has 16, Kerala has five, and Odisha, Tamil Nadu, Madhya Pradesh, and Karnataka each have just one. (Ronghang R., Ahmed R., 2010; Doley A. K., Kalita J., 2011)

Human preference for insect's species for food is impacted by the insect's palatability, availability, and nutrient benefits, as well as local customs and traditions. Insect consumption has a long tradition spanning back to the 19^{th} century, when British entomologist V. M. Holt encouraged his fellow Englishmen to try eating insects in his short publication "Why Not Eat Insects?" published in 1885. This was continued by other scientists like De Foliart and others (De Foliart, 1997; Ramos Elorduy, 1997). Insects are a high-fat, high-protein, high-vitamin, high-fiber, and high-mineral dietary source that compares favourably to other protein sources such as beef, fish, and chicken. (Rumpold and Schluter, 2015). For example, Van Huis *et al.*, (2013) found Mealworms' unsaturated Omega-3 and Omega-6 fatty acid composition was close to that of fish (and greater than that of cattle and pigs), and their protein and micronutrient content was comparable to that of fish and meat.

Insects have quite a higher fecundity and require lesser space than conventional cattle. They also produce fewer greenhouse gas emissions and ammonia than domestic pigs and cattle's have a high feed conversion efficiency (Oonincx *et al.*, 2010).

Specific greenhouse gas and ammonia emissions, land area, and water consumption from insect breeding are all far lower than those of most mammals. (Oonincx, D. G. A. B., 2012; Halloran A. *et al.*, 2017; Nadeau, L. *et al.*, 2015). Furthermore, insects are cold-blooded creatures with a high efficiency in turning food to proteins. (Oonincx, D.G.A.B., 2012; Halloran A. *et al.*, 2017; Govorushko, S., 2019; Mlcek J. *et al.*,2014). In animal husbandry, 1 kilogramme of animal protein requires 2.5, 5, or 10 kg per feed for chicken, pork, and beef, respectively. (Pimentel D.; Pimentel, M., 2003; Collavo, A. *et al.*, 2005). Acheta domesticus requires just 1.7 kg of feed, despite the fact that demand for insects has decreased dramatically since the creation of 1 kilogramme live weight of ordinary crickets. (Collavo, A. *et al.*, 2005), Animal feed can be made from materials that are not appropriate for human consumption. Nutrient deficiencies produce a significant worldwide burden of the disease, amounting approximately 2 Per cent of all survival lost in 2019. Insect harvesting and rearing involve modest technological and capital investment choices, even for the weakest sections of society, which makes insect farming more appealing than animal husbandry from an economic and social standpoint. Insect cultivation provides employment possibilities for both urban and rural residents. Insects have short life cycles, high economic rewards, and quick returns on investment. (Konstantina P. *et al.*, 2022).

When compared to animals, insects have a superior feed conversion efficiency. (Dickie F, *et al.*, 2019) and because the major input to the ecological footprint of industrial insect production is feeding rather than the rearing facility itself, raising insects uses substantially less water. (Miglietta P. P., *et al.*, 2015), land (Alexander P, *et al.*, 2017), and energy than conventional livestock systems (Govorushko S., 2019; Smetana S. *et al.*, 2015; Halloran A *et al.*, 2017; Oonincx D. G. A. B. and Boer-De I. J. M., 2012; Stull V. and Patz J., 2020).

Wild gathering (92 Per cent), semi-domestication (6 Per cent), and agricultural are the three methods for obtaining edible insects (2 Per cent) (Yen A. L., 2015). Because the diversity and number of insects are generally higher in the subtropical and tropical parts of the planet, the majority of people who eat insects live there. (Van Huis, A. *et al.*, 2013). Terrestrial insects account for 88 Per cent of edible insects, whereas aquatic insects account for 12 Per cent. (Yen A. L., 2015). Traditional preparation methods for insects include steaming, boiling, baking, frying, washing, smoking, and chutney processing. (Van Huis, A.; Oonincx, D. G. A. B., 2017; Rumpold, B. A. and Schluter, O., 2015). Insect farming is a very new and uncommon way of growing edible insects. Insects are kept in captivity, separated from their natural populations, and their living circumstances, diets, and food quality are all carefully controlled. In tropical and temperate areas, insects have been cultivated for human diet. (Thailand, Netherlands, France) (Preteseille, N. *et al.*, 2018; Derrien, C., Boccuni, A., 2018; Hanboonsong, Y.; Jamjanya, T., 2013).

Insects reproduce rapidly at a young age, resulting in higher yields of essential protein than typical meat and dairy farms. All of these factors make insect farming more successful. (Oonincx, D. A. B. and Boer-De I. J. M., 2012). Insects are commonly eaten whole (raw, boiled, or dried in a number of ways) and are also processed into powders or flours and incorporated into other dishes in various situations. Insects are a versatile ingredient that may be easily included into a variety of cuisines, including baked products, pastas, children's cereals, snacks, and sauces, to mention a few. (Matthew R. S. *et al.*, 2021)

Many insect cookbooks have already been published (Baker, M. A. *et al.*, 2019; Menzel, P., D'Aluisio, F. 1998; Gordon, D. G., 2013; Van Huis, A. *et al.*, 2014). In nations where people are not accustomed to consuming entire insects, granular and paste processing is most commonly utilised. Europe, for example, creates traditional meals from homogenised insects (patties, pasta, and bread). Grinding and milling are common procedures for processing large quantities of materials, and they are frequently utilised in the reprocessing of insects. (Van Huis A., 2013).

Edible insect seasonal availability: Although edible insects are accessible all year, their numbers and diversity are influenced by their feeding plants as well as seasonal conditions. Observations of the seasonal availability of edible insects showed that the most palatable Coleopterans were available from June to September (pre-monsoon and monsoon) and subsequently declined over the winter and early spring.

(Chakravorty J., 2011). Seasonal tendencies were also found in several Odonata and Orthopterans, which were most prevalent in September and October (late summer). Insects of the Hemiptera and Hymenoptera families were found to be confined to the months of Several scientists have published studies on the nutritional value of several edible insects' species. Protein and fat are the primary ingredients, followed by fibre and nitrogen-free extract (carbohydrates) and ash (Rumpold and Schluter, 2013; FAO, 2012; Elemo *et al.,* 2011; Shantibala *et al.,* 2014; Ogbuagu *et al.,* 2014). Aside from the fact that insects are a delicious food source, their nutritional profile has

November and February (winter). Some edible insects, such as bugs and ants, were discovered to be available (and utilised) all year.

The nutritional value of edible insects

attracted the interest of health professionals such as nutritionists and physicians. (FAO, 2010). (Rumpold and Schluter, 2013). 236 edible insects' nutritional contents, as documented in the literature (based on dry matter).

Protein and amino acids of edible insects

Proteins comprise the majority of the nutritional content of edible insects. On a dry basis, the protein composition of edible insects ranges from 35.3 Per cent for termites (Isoptera) to 61.32 Per cent for crickets, grasshoppers, and locusts (Orthoptera) (Rumpold and Schluter, 2013). In general, edible insect species belonging to the Orthoptera order (grasshoppers, crickets, and locusts) are good source of protein. Grasshoppers are said to contain a protein composition of around 77 Per cent dry weight. (Ramos-Elorduy,1997; Ramos-Elorduy *et al.,* 2007). The amount of protein in edible insects varies depending on the species, style of cooking, diet, and metamorphosis stage. (FAO)

Table-1: Amino acid content of common edible insects (Per cent in crude protein of dry weight)

Name	Crude protein (Per cent)	Essential								Semi-essential			
		Ile	Leu	Lys	Met	Phe	Thr	Trp	Val	Arg	His	Cys	Tyr
Blattodea	68.33	4.57	7.77	7.80	3.13	4.60	4.93	0.97	7.70	7.43	3.13	1.23	8.93
Coleoptera	41.75	5.58	8.13	5.53	1.38	3.68	3.25	0.78	5.90	5.10	2.60	1.13	4.50
Diptera	48.80	3.74	6.48	5.74	2.00	4.76	3.98	1.43	5.12	5.05	2.38	0.83	5.52
Hemiptera	48.83	3.93	6.45	3.93	2.78	5.93	3.90	0.78	5.38	3.76	2.50	1.80	5.62
Hymenoptera	51.43	5.20	8.27	6.27	1.85	2.60	4.70	0.39	6.10	5.03	2.61	1.60	4.87
Isoptera	33.00	5.10	7.80	5.40	8.80	4.40	2.80	1.40	7.30	6.90	5.10	1.90	3.00
Lepidoptera	65.25	4.58	6.45	6.33	1.38	5.10	3.75	1.00	7.45	4.17	1.50	1.23	-
Orthoptera	59.17	3.98	7.40	5.12	1.45	4.37	3.53	0.65	5.12	5.35	1.99	1.30	-
Beef		5.10	8.40	8.40	2.30	4.00	4.00	-	5.70	6.60	2.90	1.40	3.20
Pork		4.90	7.50	7.90	2.50	4.10	5.10	-	5.00	6.40	3.20	1.30	3.00
Chicken		4.20	6.90	7.80	2.10	2.50	3.70	-	4.60	6.40	4.40	-	3.50
Amino acid requirement in human nutrition (mg)		30.0	59.0	45.0	16.0	-	23.0	6.0	39.0	-	15.0	16.0	-

Ile-Isoleucine, Leu-Leucine, Lys-Lysine, Met-Methionine, Cys-Cysteine, Phe-Phenylalanine, Tyr-Tyrosine, Thr-Threonine, Trp-Tryptophan, Val-Valine, Arg-Arginine, His-Histidine.

Fats in edible insects

Fat is the other primary dietary component of edible insects, in addition to proteins. (Womeni *et al.,* 2009) The quantity and composition of oils derived from a variety of insects were examined. Polyunsaturated fatty acids were bundant in the oils, he discovered. The average fat content of edible insects ranges from 13.4 Per cent for grasshoppers, crickets, and locusts (Orthoptera) to 33.4 Per cent for beetles and their larvae on a dry matter basis

(Coleoptera). The fatty acid profile of edible insects obtained largely in the wild, according to (Rumpold *et al.*, 2013) Saturated fatty acids (SFA) in bees, wasps, and ants (Hymenoptera) range from 31.8 Per cent to 42.0 Per cent in termites (Isoptera). Monounsaturated fatty acids (MUFA) vary from 22.0 Per cent in termites (Isoptera) to 48.6 Per cent in bees, wasps, and ants (Hymenoptera), whereas polyunsaturated fatty acids (PUFA) range from 16.0 Per cent in flies (Diptera) to 39.8 Per cent in caterpillars of butterflies and moths (Hymenoptera) (Lepidoptera). As with traditional cattle, (St-Hilaire *et al.*, 2007) The fatty acid content of edible insects is said to be dependent on the meal they eat .

Table-2: Fat content (Per cent) of common edible insects (Per cent in crude fat of dry weight)

Name	Crude fat (%)	Saturated fatty acids				Monounsaturated fatty acids			Polyunsaturated fatty acids (EFA)		
		Total SF	C14:0	C16:0	C18:0	Total MUFA	C16:1 n7	C18:1 n9	Total PUFA	C18:2 n6	C18:3 n3
Blattodea	25.05	37.18	1.22	23.13	11.41	45.02	2.23	41.88	17.85	16.43	0.75
Coleoptera	35.81	37.68	1.62	29.77	5.40	53.12	7.32	44.91	13.01	11.61	0.99
Diptera	21.94	45.74	6.63	22.53	2.18	34.65	16.87	17.63	16.04	15.08	0.88
Hemiptera	32.25	45.44	1.17	11.42	32.33	21.75	5.45	17.91	34.17	4.90	0.45
Hymenoptera	18.71	34.58	1.54	23.83	8.46	50.97	2.57	43.99	4.07	3.39	0.60
Isoptera	36.80	48.98	2.17	42.45	2.86	17.94	2.10	15.84	33.08	24.24	3.30
Lepidoptera	37.95	36.42	0.36	26.92	9.11	22.60	1.37	21.23	40.57	6.51	33.94
Orthoptera	19.92	37.17	13.86	20.65	0.67	18.81	1.56	17.25	46.14	32.20	1.70
Beef		32.25	0.77	16.74	9.53	18.83	-	10.52	45.08	36.10	6.16
Pork		41.04	3.43	21.68	21.71	43.04	2.93	39.39	16.00	7.29	1.71
Chicken		33.33	1.33	22.67	8.00	46.67	0.27	41.33	20.00	14.00	0.67
Fatty acid req. in human nutrition (g)		26.90	-	-	-	30.85	-	-	16.90	14.95	1.50

SFA-Saturated fatty acids: C14:0, myristic acid; C16:0, palmitic acid; C18:0, stearic acid. MUFA: C16:1 n7 – palmitoleic acid; C18:1 n9 – oleic acid. PUFA: C18:2 n6 – linoleic acid; C18:3 n3 – α-linolenic acid.

Micronutrients in edible insects

Micronutrients are essential for food nutritional value as well as human health. Micronutrient deficiencies can have serious health consequences, causing problems with growth, immunological function, mental and physical development, and reproductive results that aren't always reversible. (FAO,2011c). Edible insects can supply significant amounts of minerals including copper, iron, magnesium, manganese, phosphorus, selenium, and zinc when digested. (Sirimung kararat *et al.*, 2010) Insects carry more iron and zinc than beef, pork, and chicken, according to research. Similarly, (Paoletti *et al.*,2003) The calcium content of earthworms was discovered to be equivalent to that of fresh cheese and greater than that of regular meat.

The World Health Organisation (WHO) has studied insects as a viable source of protein for malnourished people, particularly HIV-positive people who require higher-quality diet to combat immunological damage. (World Health Organization and Food and Agriculture Organization of the United Nations, 2002). The nutritive value of insects may be ascribed to new-borns' increased nutritional status (weight, length, and iron status) in the research included in this review. (Bauserman *et. al.*, 2015; Omolo, 2014; Konyole *et. al.*, 2012)

DISCUSSIONS

Insects and insect products such as honey have been used by humans for thousands of years, in some situations as emergency food, in others as a mainstay, and in yet others as delicacies, snacks, and additives. Regional and sub-regional organisations have acclaimed edible insects as a high-protein, vital fatty acid, fibre, mineral, and vitamin source. Simultaneously, various concerns about safety, processing effects, and nutritional bioavailability have been raised.

The purpose of this systematic review was to summarise known evidence on the influence of entomophagy on people's wellbeing. This review found that eating insects might cause negative health effects or allergic reactions; that eating insects can cause weight and length increase in new-born's; and those cereals fortified with termites and caterpillars but not spiders can enhance children's iron status.

Table-3:Micronutrient composition of some edible insects (per 100 g edible portion on fresh weight).

Name	Coleoptera	Lepidoptera	Hymenoptera	Orthoptera	Hemiptera	Isoptera
Energy (kcal)	78–155	358–361	79–184	89–227	63–165	93–535
CHO (g)	1–3	12–18	5–6	1–5	3–8	20–21
Fiber (g)	5–7	4–15	1–3	2–10	4–5	5–6
Fe(mg)	0.3–24	0.03–109	3–103	0.1–42	0.4–29	0.1–31
Zn (mg)	5–6	2–11	4–15	4–13	4–46	3–8
Vit A (IU)	8–27	4.3–4.4	-	21–25	21–150	03–0.7
Vit E (IU)	0.7–1.2	8.3–8.6	-	1.0–2.3	1.4–13	0.8–1.0
Thiamine (mg)	0.2–0.3	-	0.2–0.3	0–0.4	0–0.6	-
Riboflavin (mg)	1.1–3.5	-	0.2–0.9	0.4–3.4	0.9–1.5	1.5–4.2
Vit.B12 (mcg)	-	-	-	5–9	-	-

From: FAO/INFOODS (Charrondiere, U. R., 2013)

CONCLUSIONS

In conclusion, insects provide a readily available source of protein, lipids, carbs, dietary fibre, some vitamins, and minerals in the majority of situations. Insects include polyunsaturated and monounsaturated fatty acids, which are necessary for the prevention of various cardiovascular disorders. The majority of the research included in this review imply that eating edible insects promotes positive health outcomes, however caution is warranted to avoid allergic responses in sensitive persons. Despite the limited number of studies found, additional study is needed to evaluate whether equivalent results will be obtained for other insects and to confirm that eating insects' benefits health.

Though still in its infancy, large-scale insect cultivation and broader consuming, particularly in areas where eating insects is already common, offers a promising pathway toward increasing global nutrition while protecting our planet's natural systems. As we face rising pressure from two opposing forces—rapidly expanding food demands and a global environmental system with diminishing natural resources to supply them—our capacity to discover new, sustainable, and inventive solutions to meet future food and nutritional needs is critical. In this article, we investigate the ramifications of one such approach and discover that it has tremendous potential to decrease malnutrition. Documenting the importance of food insects becomes the most important requirement in establishing a link between people's livelihoods and determining their long-term viability. Thus, future research on insects as food should consider key factors such as ecology, management and conservation implications, industrialization, and marketing of edible insects to promote their long-term development. We can discover our path to food and nutritional security while reducing environmental impact via ingenuity and the development of various solutions of this type.

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