Potential of Edible Insects in Indonesia as Nutritious Local Food

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ABSTRACT

Amid the expansion of the global population, the demand for sustainable, high-quality food rises. Edible insects provide an innovative and promising alternative to traditional sources of animal protein. Abundant types of insects are recognized as safe to eat worldwide and various edible insect-based food products have been widely developed globally. This research is a narrative review that identified articles using keywords in English and Bahasa. Searches were conducted on Google Scholar, Scopus, Science Direct, and MDPI. Twenty out of 106 articles were selected for the final used in the review. The review emphasizes the diverse range of edible insect species present in Indonesia and their remarkable nutritional benefits, which include energy, carbohydrate, protein, fat, and micronutrients. These insects have been integrated into local delicacies, leading to the creation of some innovative products such as pempek, cookies, sausages, and meat substitutes. However, the wider acceptance of edible insects in everyday diets is still hindered by religious, cultural, food safety, and perceptual obstacles. Further multidisciplinary research is needed to make edible insects a viable solution for a sustainable food system in the future.

Keywords: Alternative protein, insect-based, local delicacy, nutritional value

ABSTRAK

Permintaan akan bahan pangan berkelanjutan dan berkualitas tinggi akan terus meningkat seiring dengan bertambahnya populasi dunia. Serangga yang dapat dimakan memberikan alternatif yang inovatif dan menjanjikan sebagai sumber protein hewani. Spesies serangga konsumsi telah banyak diketahui dan berbagai produk makanan berbasis serangga telah dikembangkan secara luas di seluruh dunia. Penelitian ini merupakan tinjauan naratif yang mengidentifikasi artikel menggunakan kata kunci dalam bahasa Inggris dan bahasa Indonesia. Pencarian dilakukan di Google Scholar, Scopus, Science Direct, dan MDPI. Dua puluh dari 106 artikel dipilih untuk tinjauan akhir. Artikel ini memberikan informasi beragamnya spesies serangga yang dapat dimakan di Indonesia dan manfaat gizinya yang luar biasa, yang meliputi energi, karbohidrat, protein, lemak, dan zat gizi mikro. Serangga ini telah diintegrasikan ke dalam berbagai pangan lokal, yang selanjutnya mendukung terciptanya beberapa produk inovatif seperti pempek, kue, sosis, dan produk pengganti daging. Namun, penerimaan serangga yang lebih luas dalam makanan sehari-hari masih terhalang oleh beberapa faktor seperti budaya, agama, keamanan pangan, dan preferensi individu. Penelitian multidisipliner lebih lanjut dibutuhkan untuk menjadikan serangga konsumsi sebagai salah satu solusi sistem pangan berkelanjutan di masa yang akan datang.

Kata kunci: *Nilai gizi, pangan lokal, protein alternatif, serangga konsumsi, serangga pangan*

1. Introduction

As the world's population keeps rising, the necessity for sustainable resources is becoming more urgent, high-quality food sources becomes more pressing, edible insects present an innovative and promising alternative to traditional animal–source protein. Adopting this solution may help tackle food security issues while also promoting environmental sustainability (Tuhumury, 2021; van Huis, 2015). In numerous regions around the globe, particularly in Asia, Africa, and Latin America, the consumption of insects has a long history (Nasir & Świąder, 2022; Omuse et al., 2024; Raheem et al., 2019). These creatures are not only embraced in many traditional diets but also offer significant nutritional advantages. Various research studies have emphasized the promise of insects as an affordable and sustainable option for future food sources (Nasir et al., 2024; Omuse et al., 2024; van Huis, 2020). The advancement of edible insects is anticipated to tackle various concerns related to the economy, nutrition, and the environment (Adi et al., 2020; Omuse et al., 2024; Setyawati & Magfirah, 2024; Tuhumury, 2021; van Huis, 2020).

More than 2,000 insect types have been known to be safe to eat, providing a rich source of protein, essential amino acids, healthy fats, vitamins (such as B12), and minerals like iron, zinc, and calcium (van Huis 2020; Nasir and Świąder 2022; Nasir et al. 2024; Palupi et al. 2025). Aside from their nutritional value, edible insects provide notable environmental benefits. Farming insects demands considerably less land, water, and feed than raising livestock, and it contributes very little to greenhouse gas emissions (FAO, 2021). Their high feed conversion efficiency and ability to thrive on organic waste make them a highly sustainable food source (Nasir et al. 2024).

The consumption of edible insects is currently still mostly dominated in Western areas with wider and more varied food acceptance (Moruzzo et al., 2021). Meanwhile, in Asia itself, several countries have made edible insects one of the commonly consumed food ingredients, such as in Thailand, Vietnam, and Myanmar (Hanboonsong et al., 2013; Hanboonsong & Durst, 2014). Edible insects have also been widely developed globally in various forms, including protein bars, candy, ice cream, cookies, etc. (Nasir & Świąder, 2022). Grasshoppers from Yogyakarta, and sago grub from Papua have been some of the local food delicacies that have been known by society, whereas the others may not seem quite popular. In Indonesia, the information about the available species and the nutrition of edible insects in local culture is still scattered. In addition, the development of various food products based on local edible insects is also very limited. This review aimed to give an insight into the local potential of edible insects as nutritious food and their current development in Indonesian local food.

2. Methodology

This research was a narrative literature review. Articles used as references were found using several keywords related to the topic in English and Bahasa, including; “indonesian edible insects”, “indonesia edible insects”, “serangga pangan”, “serangga konsumsi”. The searching process was conducted through journal search engine sites (Google Scholar and Scopus) and journal databases (Science Direct and MDPI). The articles were selected based on the available nutrition information about edible insects from many regions of Indonesia as their origin, and a study about food development using edible insects in Indonesia. After the searching process, 20 articles were selected, with 10 articles related to edible insects' nutritional value and 10 articles related to local food development. Flow chart of the screening and selection process was shown in Figure 1.

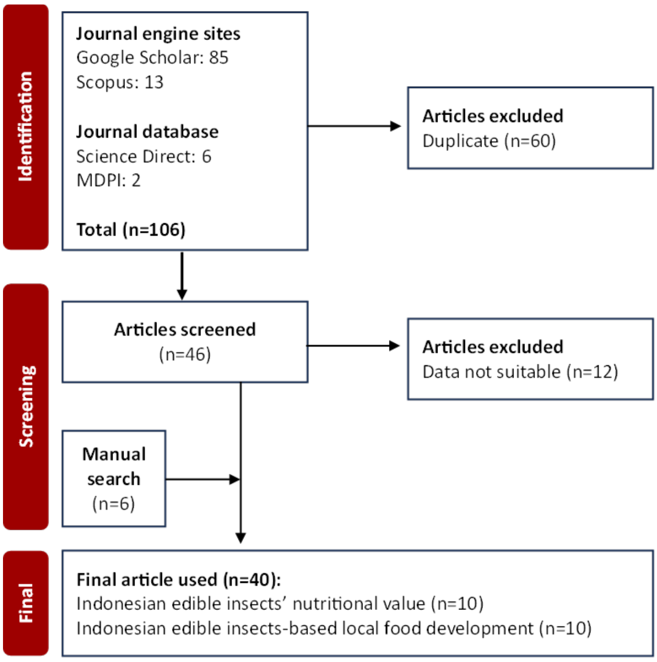

Figure 1. Flow chart of the article screening process

3. Results and Discussions

3.1. Entomophagy in Indonesia

The differences in eating habits of edible insects in various countries are largely influenced by food consumption culture, religion, and their diverse availability in various regions (Hanboonsong et al., 2013). Indonesia is home to a great diversity of insects, many of which are edible. Figure 2 shows a recent compilation that identified 133 species of edible insects in Indonesia (Aydoğan et al., 2024).

Currently, the consumption of edible insects is still uncommon due to various factors. A meta-analysis conducted by Wassmann investigated the willingness to consume insects and identified a connection between food neophobia, feelings of disgust, and the anticipated discomfort related to eating insects and the willingness to try them. To address these challenges long-term, edible insects should be promoted as a food source through community education and hands-on experiences with insect-based meals (Wassmann et al., 2021). Research by Suthar et al. (2020) also highlighted the growing potential of edible insects as a sustainable source of food and animal feed. The study outlined various scenarios for their integration into diets and agriculture, emphasizing their nutritional value and lower environmental impact compared to traditional livestock. This suggests that food products based on edible insects could play a significant role in addressing future food security challenges.

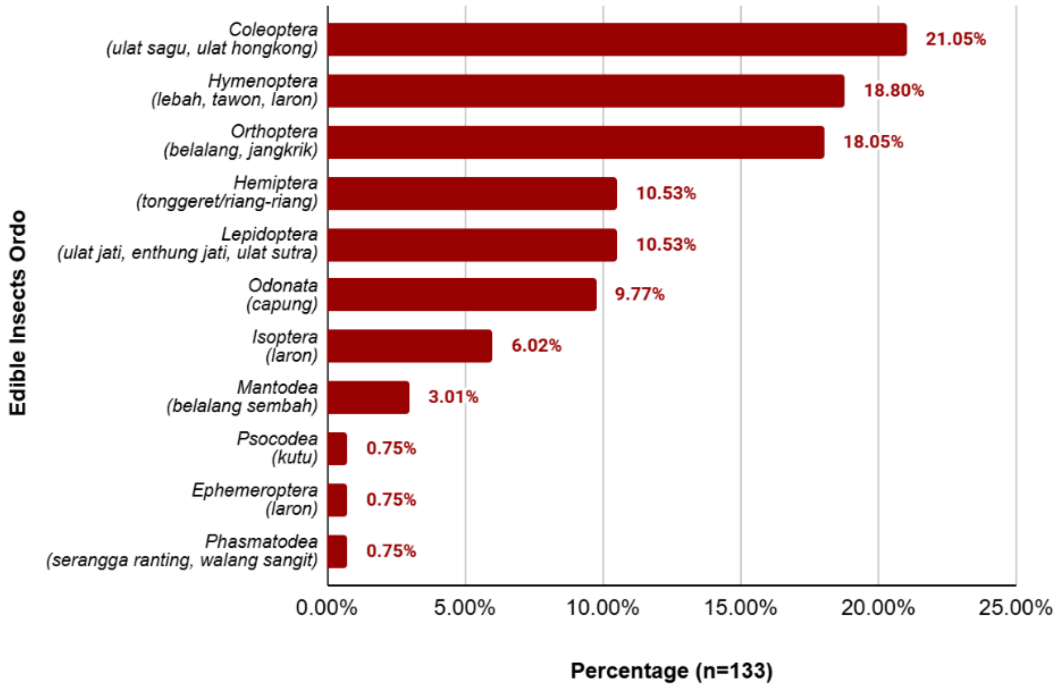

Figure 2. Percentage of most common consumed edible insects' ordo in Indonesia (re-illustrated graphic from Aydoğan et al. (2024))

In Indonesia, various local communities savor a range of insects. Table 1 shows 13 Indonesian edible insect-based local foods. Among these delicacies are creamy sago worms, a favorite in Papua, and crispy fried crickets from Ciamis, known for their savory crunch. East Java offers tender wasp larvae, rich in protein, and fried teak pupae, with a buttery flavor, along with the unique termite rempeyek, a savory fritter reflecting local traditions (Girsang, 2018). Wood/Javanese grasshopper (*Valanga nigricornis*) is one of the insects that is widely consumed as food in the Special Region of Yogyakarta (Kuntadi et al., 2018; Palupi et al., 2020). Usually, grasshoppers are processed by frying using salt as the seasoning and consumed as snacks (Palupi et al., 2024a) or served with "tiwul", a traditional food made from cassava (Palupi et al., 2020). In some regions, edible insects often served as botok, where the ingredients are blended with grated young coconut, flavored, then wrapped in banana leaves and steamed (Adi et al., 2020). Edible insects are considered a local delicacy in certain regions of Indonesia, though they are not widely consumed. They are often presented as an extreme culinary experience to attract tourists and enhance marketing efforts.

Table 1. Indonesian Edible Insect-Based Local Foods

Edible insects	Origin/consumed region	Local food	Information
Sago Grub (*Ulat sagu*)	Papua	*Sate ulat sagu*	(Sinaga, 2024)
Cricket (*Jangkrik*)	Ciamis, West Java Madura, East Java	*Jangkrik goreng*	(Girsang, 2018)
Termites (*Laron*)	East Java	*Rempeyek*	(Girsang, 2018)
Grasshopper (*Belalang*)	Yogyakarta, Central Java	*Belalang goreng*	(Palupi et al., 2020)

Edible insects	Origin/consumed region	Local food	Information
	Madura, East Java	*Belalang goreng, belalang panggang*	(Adi et al., 2020)
Wasp (*Tawon*)	Banyuwangi, Kediri, Blitar, East Java	*Botok larva tawon*	(Khomsan, 2025)
	Wonosari, Gunung Kidul, Yogyakarta		(Hanifah, 2024)
Cicadas (*Tonggeret/Riang-Riang/Turaes*)	Wulondani, Lembata, East Nusa Tenggara	*Turaes bacem asem manis*	(Aminullah & Ika, 2020; Arif, 2024)
	Sumedang, West Java		
Catterpillar (*Ulat Bambu/Enthung Jati*)	Ndikosapu, East Nusa Tenggara	*Kering enthung*	(Arif, 2025; Lukitawati, 2010)
	Gunung Kidul, Yogyakarta		
Dung beetle larvae (*Uret*)	Java	*Larva goreng*	(Lukitawati, 2010)
Dragonfly (*Capung*)	Sijunjung, West Sumatera	*Larva Capung*	(Hanifah, 2025)
Young bee/bee larvae (*lebah*)	Madura, East Java	*Botok*	(Adi et al., 2020)
White ants (*semut putih*)	Madura, East Java	*Semut goreng, botok*	(Adi et al., 2020)
Weaver ants (the queen and egg) (*semut rangrang*)		*Botok*	(Adi et al., 2020)

Indonesia, as one of the largest Muslim societies in the world, has made halal food status a significant consideration in food preferences. Knowledge about consuming insects in Muslim countries is still limited, largely due to the potential religious implications associated with this practice. Halal food refers to items that are permissible under Islamic Shari'ah law, as outlined in the Quran, articulated by the Prophet Muhammad in the Hadith, and interpreted by religious scholars. Study from Palupi et al. 2024 investigated the halal status of six edible insects in Yogyakarta. Grasshopper was considered as halal (Palupi et al., 2024b), Locusts may be consumed without the need for slaughter, as their bodies are regarded as sacred, much like those of aquatic animals (Sabri et al., 2023). Certain edible insects, such as caterpillars, termites, and beetles, can be considered halal, provided that the consumer does not find them disgusting to eat (Palupi et al., 2024b). Honey bees are generally considered haram; however, honeycomb and bee eggs are regarded as halal (Palupi et al., 2024b). Additionally, bee larvae can be considered halal only if they cannot be separated from the hive (Palupi et al., 2024b). It is important to evaluate the nutritional quality and potential risks associated with each insect to ensure that insect-based food products can be certified as halal for worldwide consumption in the future (Tajudeen, 2020).

3.2. Nutritional Aspects of Edible Insects in Indonesia

The potential of insects as food ingredients is certainly inseparable from their nutritional content, both in terms of quantity and quality. Hanboonsong et al. (2013) stated that overall, edible insects offer a protein content of 20–70%, amino acids in the range of 30–60%, fats between 10–50%, along with important minerals and vitamins. Table 2 shows the Indonesian edible insects' diversity and their nutritional value based on 10 selected articles. This study tabulated 14 species of Indonesian edible insects' nutritional value studies in 8 Indonesian regions. This shows that edible insects' diversity was spread across all regions in Indonesia, from Sumatera, Java, Sulawesi, until Papua. Various species were also studied, although some with the same common name were actually different species.

Table 2. Indonesian Edible Insects' Diversity and Nutritional Value

Edible insects			**Origin**	**Developmental Stage**	**Nutritional Value (% dm)**				**References**
Common name	**Indonesian name**	**Latin name**			**Energy (kcal)**	**Carb**	**Protein**	**Fat**	
Black Soldier Fly (BSF)	*Lalat/Maggot*	*Hermetia illucens*	NS	Larvae	-	2.95	20.26	25.30	(Syabana et al., 2025)
Catterpillar	*Entung/Ngengat Jati*	*Hyblaea puera*	Gunung Kidul, Yogyakarta	-	-	7.22	70.32	11.97	(Palupi et al., 2020)
Cricket	*Jangkrik*	*Acheta domesticus*	Surakarta, Central Java	Imago	-	60.63	22.46	7.84	(Porusia et al., 2020)
		Brachytrupes portentosus L.	NS	-	491.95	5.15	59.00	26.15	(Paulin et al., 2020)
		Gryllus sp.	Bogor, West Java	Imago	515.84	30.76	32.59	29.16	(Kuntadi et al., 2018)
		Gryllus assimilis	Sumatera	Nymph	-	-	56.00	32.00	(Adámková et al., 2017)
Javanese Grasshopper	*Belalang*	*Valanga nigricornis*	Surakarta, Central Java	Imago	-	39.04	39.08	9.78	(Porusia et al., 2020)
			NS	-	406.89	7.96	72.50	9.45	(Paulin et al., 2020)
			Gunung Kidul, Yogyakarta	-	-	12.11	73.47	11.42	(Palupi et al., 2020)
			Gunung Kidul, Yogyakarta	Imago	407.34	9.62	76.69	6.90	(Kuntadi et al., 2018)
Migratory Locust	*Belalang*	*Locusta migratoria*	East Sumba, East Nusa Tenggara	Nymph (5th)	380.94	13.74	64.21	7.68	(Kleden et al., 2023)
			East Sumba, East Nusa Tenggara	Imago	385.65	6.72	75.26	6.41	(Kleden et al., 2023)

Edible insects			Origin	Developmental Stage	Nutritional Value (% dm)				References
Common name	Indonesian name	Latin name			Energy (kcal)	Carb	Protein	Fat	
Paddy Locust	*Belalang*	*Nomadacris succincta L.*	Gunung Kidul, Yogyakarta	Imago	421.79	15.48	65.42	10.91	(Kuntadi et al., 2018)
Mealworm	*Ulat hongkong*	*Tenebrio molitor*	NS	-	-	42.26	21.78	16.29	(Syabana et al., 2025)
			NS	-	470.57	15.58	53.08	21.77	(Paulin et al., 2020)
			Sumatera	Larvae	-	-	52.00	31.00	(Adámková et al., 2017)
			Bogor, West Java	Larvae	498.68	26.25	38.30	26.72	(Kuntadi et al., 2018)
Sago grub/red palm weevil	*Ulat sagu*	*Rhynchophorus ferrugineus*	Ambon, Maluku	Larvae	616.40	0.64	27.97	59.71	(Leatemia et al., 2021)
			Southeast Sulawesi	-	-	4.30	9.70	21.50	(Nirmala et al., 2017)
		Rhynchophorus bilineatus	Sentani, Jayapura, Papua	Larvae	-	-	24.16	17.17	(Köhler et al., 2020)
Silkworm	*Ulat sutra*	*Bombyx mori L.*	Bogor, West Java	Pupae	509.03	0.92	60.03	29.47	(Kuntadi et al., 2018)
Superworm	*Ulat jerman*	*Zophobas morio*	Sumatera	Larvae	-	-	46.00	35.00	(Adámková et al., 2017)
			NS	-	-	19.17	37.92	18.40	(Syabana et al., 2025)
			Bogor, West Java	Larvae	517.5	14.21	49.96	28.98	(Kuntadi et al., 2018)

NS: not specified; dm: dry matter; carb: carbohydrate.

Energy content in Indonesian edible insects ranged from 380.94 to 616.40 kcal (Table 2). This is higher than that of meat, largely due to the significant levels of protein and fat they contain (Rumpold & Schlüter, 2013). Edible insects are often associated with their high protein content, so they are suggested as an alternative protein for the future and a solution to malnutrition and food security problems in various countries (Adi et al., 2020; Akhtar & Isman, 2017; Girsang, 2018; Glover & Sexton, 2015; Tao & Li, 2018). Carbohydrate content varying from 0.64–60.63%. Edible insects contain carbohydrates that are frequently seen as indigestible because they include chitin, a long-chain polymer composed of N-acetylglucosamine, which is a primary component of the insects' exoskeletons. Therefore, a high concentration of chitin can diminish their nutritional value. However, when chitin is present in low to moderate levels, it can function as a beneficial prebiotic for gut bacteria (Ferri et al., 2025; Selenius et al., 2018).

Table 2 shows that the protein content of various edible insects in Indonesia varies, ranging from 9.70% to 76.69%. The Javanese grasshopper (*Valanga nigricornis*) has the highest protein content at 76.69%, while the red palm weevil/sago grub (*Rhynchophorus ferrugineus*) has the lowest at 9.70%. A meta-analysis conducted by Nasir et al. (2024) revealed significant differences in the protein content of ten species of edible insects, which ranged from 59.90% to 75.15%. In addition to the crude protein content, the quality of the protein can also be evaluated based on the composition of the amino acids present. While edible insects typically have a lower crude protein content compared to meat, the amino acid profiles in seven out of the ten types of edible insects are still superior to those found in beef (Nasir et al., 2024). High variations of limiting amino acids present in edible insects based on their species can help identify complementary food options, supporting a high-quality protein intake (Nasir et al., 2024).

Fat is the second most abundant nutrient found in edible insects (Van Huis et al., 2021). The fat content in Indonesian edible insects varied from 6.41–59.71% (Table 2). The highest fat content was found in sago grub/red palm weevil (*Rhynchophorus ferrugineus*), while the lowest was found in the migratory locust (*Locusta migratoria*). A meta-analysis showed that edible insects have a significantly higher fat content than beef (Nasir et al., 2024). It is important to consider the fatty acid composition in daily dietary practices, as it plays a significant role in overall health outcomes (Djuricic & Calder, 2021; Kapoor et al., 2021). Understanding these effects can lead to more informed and beneficial nutritional choices. Having a proper balance of fatty acids in your diet is important for overall health and for reducing the risk of disease (Djuricic & Calder, 2021). Certain edible insects, particularly those belonging to the mealworm and weevil categories, have been identified as having a favorable fatty acid profile characterized by significant levels of polyunsaturated fatty acids (PUFA) and omega-3 (Palupi et al., 2025). This composition makes them a valuable nutritional source. Additionally, the advantageous ratio of fatty acids found in edible insects promotes a balanced diet and could decrease the likelihood of developing chronic conditions such as heart disease and obesity (Palupi et al., 2025). Including edible insects in the diet can boost overall health by offering essential fatty acids that are commonly lacking in regular diets (Amoah et al., 2023). In terms of the proportion of macronutrient composition, insects offer nutrients that are comparable not just to meat, but also to other food sources like shellfish, nuts, vegetables, and even fruits (Van Huis et al., 2021).

Edible insects also provide important minerals like copper, iron, magnesium, manganese, phosphorus, selenium, and zinc. Study from Aydoğan et al. (Aydoğan et al., 2024) highlighted Indonesian insect species to be considered as a uniform source of Ca, K, Zn, Cu, and Fe. In comparison to beef, edible insects have much greater amounts of calcium, iron, and zinc (Nasir et al., 2024). They are also rich in various vitamins, including riboflavin, pantothenic acid, biotin, and folic acid, as well as other beneficial bioactive compounds (Oonincx & Finke, 2023; Sánchez-Estrada et al., 2024; Serrato-Salas & Gendrin, 2023). Insect phenolic compounds have mainly been studied for their antioxidant properties; however, they also demonstrate a variety of other effects, such as anti-inflammatory and anticancer actions, anti-tyrosinase activity, protection against genetic damage, and the inhibition of pancreatic lipase (Aiello et al., 2023). Edible insects contain anti-nutrient compounds such as phytic acid, saponins, oxalates, cyanogenic glycosides (Sánchez-Estrada et al., 2024). These substances can chelate minerals and proteins, reducing their absorption and availability.

The nutritional content of edible insects will be influenced by several factors, such as insect's sex or gender (Garofalo et al., 2019; Kulma et al., 2019; Ojha et al., 2021), developmental stage (Kulma et al., 2020), and their species and processing (Van Huis et al., 2021). Some external factors could also affect their nutritional value, such as weather, food, and habitat of the edible insects (Hanboonsong & Durst, 2014). Additional studies are essential to explore the long-term health effects and determine the recommended consumption levels for edible insects.

3.3. Existing Edible Insects-Based Local Food Development

The existence of edible insects is also in line with the continuous innovation in insect-based food development to meet the market and society's acceptance of edible insects. Previous studies also highlighted the need to explore local edible insects to provide adequate nutrition, especially in terms of protein content (Nasir et al., 2024) as well as to combat nutritional problems and food security (Tuhumury, 2021; van Huis, 2015). Table 3 shows 10 selected articles that studied 10 food developments of edible insects-based local food for a specific target. These included Pempek (traditional fish food products from Palembang, South Sumatera, often enjoyed as a snack or as a main dish accompanied by cuko sauce), cookies, snack, dimsum, sausages, nugget, meatball, meat analog, and cream soup.

Table 3 Edible Insects-Based Local Food Development

Food development	**Edible insects used**	**Consumer target**	**Reference**
Pempek	Javanese grasshopper	Pregnant women	(Lirizka, 2021)
Cookies	Cricket	Female adolescence	(Ayustaningwarno et al., 2024)
		NS	(Tedjakusuma et al., 2022)
Snack	Javanese grasshopper	Toddlers	(Suprayogi, 2019)
Dimsum	Javanese grasshopper	Pre-school children	(Syauqiyyah, 2023)
Sausages	Javanese grasshopper	NS	(Iwansyah et al., 2024)
Nugget	Javanese grasshopper	NS	(Santi et al., 2025)
Meatball	Javanese grasshopper	Toddlers	(Setiawan, 2019)
Meat analog	Javanese grasshopper	NS	(Priyatnasari et al., 2024)
Cream soup	Javanese grasshopper	Elderly	(Mulyasari, 2021)

NS: not specified

Four studies focused on product development, so they did not mention the specific targeted consumers; cookies, sausages, nuggets, and meat analog (Iwansyah et al., 2024; Priyatnasari et al., 2024; Santi et al., 2025; Tedjakusuma et al., 2022). Two studies focused on food development to combat specific nutritional problems; wasting in toddlers (Setiawan, 2019) as well as anemia and chronic energy malnutrition in female adolescents (Ayustaningwarno et al., 2024). Four studies focused on food development for specific nutritional needs based on age; toddlers (Setiawan, 2019; Suprayogi, 2019), pre-school children (Syauqiyyah, 2023), and the elderly (Mulyasari, 2021). The food developments were still dominated by Javanese grasshoppers (8 out of 10), maybe due to the available raw materials as well as the most common edible insects known to society. All the studies utilize edible insects as a substitute for the existing ingredients, such as flour in cookies, fish in pempek, chicken in sausage and nuggets, or beef in meatballs. The substitution also varies, with the highest ratio of substitution in the selected final formulation being in Pempek, with a ratio of 1:1 grasshopper with tapioca flour (Lirizka, 2021). Although the ratio of the substitution was highly based on the product characteristics and consumer acceptance, further research on edible insects-based food development still needs to be conducted, especially on how to integrate them into Indonesian local food and culture.

Currently, the global outlook on edible insects is increasingly positive as they emerge as a sustainable and nutritious alternative to traditional animal-based protein (Adi et al., 2020; Leatemia et al., 2021; Moruzzo et al., 2021; Tuhumury, 2021). Edible insects provide an effective solution due to their high protein content, efficient feed conversion, low environmental impact, and minimal greenhouse gas emissions (FAO, 2021; Nasir et al., 2024). Countries across Asia, Africa, and Latin America have long included insects in their traditional diets (Nasir & Świąder, 2022), and now Western nations are beginning to recognize their potential (Gambelli et al., 2024; Veldkamp et al., 2024). Regulatory frameworks (Lähteenmäki-Uutela et al., 2021), research investments (CSIRO, 2021), and market innovations are continually advancing (Lalander et al., 2025; Nasir & Świąder, 2022), making edible insects more accessible in different forms including protein powders, snack bars, and meat alternatives (Nasir & Świąder, 2022). Although there is significant potential for future development in the use of edible insects, it's important to address several associated risks (Nasir et al., 2024). These include concerns about food safety as well as the presence of allergens and antinutrients (FAO, 2021). As environmental and food security concerns grow, edible insects are positioned to play a vital role in shaping the future of sustainable global food systems.

4. Conclusion

Edible insects present a sustainable substitute for conventional animal-derived proteins, with significant potential to enhance food and nutrition security in Indonesia. Despite their inclusion in traditional diets for many years, they are still underutilized and often regarded as exotic rather than mainstream food sources. This review highlights the rich diversity of edible insect species in Indonesia, their impressive nutritional value—including protein, fat, and essential micronutrients—and their incorporation into local cuisines. While innovative products such as pempek, cookies, sausages, and meat analogs are available, the integration of edible insects into broader dietary practices is still limited due to religious, cultural, and perceptual barriers. To address these challenges, further interdisciplinary research is essential. Therefore, further interdisciplinary research is essential, not only to explore their long-term health impacts but also to develop culturally appropriate, appealing, and nutritionally beneficial insect-based food products that align with local culinary traditions.

With the right approach, edible insects could play a crucial role in fostering sustainable food systems in Indonesia.

References

Adámková, A., Mlček, J., Kouřimská, L., Borkovcová, M., Bušina, T., Adámek, M., Bednářová, M., & Krajsa, J. (2017). Nutritional potential of selected insect species reared on the island of Sumatra. *International Journal of Environmental Research and Public Health*, *14*(5). https://doi.org/10.3390/ijerph14050521

Adi, A. C., Andrias, D. R., & Rachmah, Q. (2020). The potential of using wild edible animals as alternative food sources among food-insecure areas in Indonesia. *Journal of Health Research*, *34*(3), 247–257. https://doi.org/10.1108/JHR-07-2019-0156

Aiello, D., Barbera, M., Bongiorno, D., Cammarata, M., Censi, V., Indelicato, S., Mazzotti, F., Napoli, A., Piazzese, D., & Saiano, F. (2023). Edible Insects an Alternative Nutritional Source of Bioactive Compounds: A Review. In *Molecules* (Vol. 28, Issue 2). MDPI. https://doi.org/10.3390/molecules28020699

Akhtar, Y., & Isman, M. B. (2017). Insects as an Alternative Protein Source. In *Proteins in Food Processing, Second Edition* (pp. 263–288). Elsevier. https://doi.org/10.1016/B978-0-08-100722-8.00011-5

Aminullah, A., & Ika, A. (2020, April 20). *Turaes, Kuliner Ekstrem Khas Sumedang, Mendadak Viral Saat Pandemi Corona*. Kompas.Com. https://regional.kompas.com/read/2020/04/20/06000071/turaes-kuliner-ekstrem-khas-sumedang-mendadak-viral-saat-pandemi-corona?page=all

Amoah, I., Cobbinah, J. C., Yeboah, J. A., Essiam, F. A., Lim, J. J., Tandoh, M. A., & Rush, E. (2023). Edible insect powder for enrichment of bakery products– A review of nutritional, physical characteristics and acceptability of bakery products to consumers. *Future Foods*, *8*, 100251. https://doi.org/10.1016/J.FUFO.2023.100251

Arif, A. (2024, March 22). *Tonggeret/Riang – Riang | Nusantara Food Biodiversity*. Nusantara Food Biodiversity. https://nusantarafoodbiodiversity.org/data/kotok-7e95cemoqb0jgw8

Arif, A. (2025, May 3). *Ulat bambu | Nusantara Food Biodiversity*. Nusantara Food Biodiversity. https://nusantarafoodbiodiversity.org/data/katu-peri-592mtzq7714n365

Aydoğan, Z., Taşer, A., İncekara, Ü., & Prastiwi, A. (2024). *Mineral Composition Of Four Wild Harvested Edible Insects Consumed By The Indonesian People With An Updated List Of Edible Insects In Indonesia*. https://doi.org/10.21203/rs.3.rs-4815162/v1

Ayustaningwarno, F., Ayu, A. M., Syiffah, L., Muthia, H., Amalina, F. A., Afifah, D. N., Nindita, Y., Maharani, N., Widyastuti, N., Anjani, G., Kurniawati, D. M. ah, Rustanti, N., Susilo, M. T., Noer, E. R., & Rizqiawan, A. (2024). Physicochemical and sensory properties of cookies with cricket powder as an alternative snack to prevents iron deficiency anemia and chronic energy deficiency. *Applied Food Research*, *4*(2). https://doi.org/10.1016/j.afres.2024.100485

CSIRO. (2021). *Edible insects A roadmap for the strategic growth of an emerging Australian industry*.

Djuricic, I., & Calder, P. C. (2021). Beneficial outcomes of omega-6 and omega-3 polyunsaturated fatty acids on human health: An update for 2021. In *Nutrients* (Vol. 13, Issue 7). MDPI AG. https://doi.org/10.3390/nu13072421

FAO. (2021). Looking at edible insects from a food safety perspective. In *Looking at edible insects from a food safety perspective*. FAO. https://doi.org/10.4060/cb4094en

Ferri, I., Canala, B., & Rossi, L. (2025). Unravelling the Role of Chitin and Chitosan in Prebiotic Activity and Correlation With Cancer: A Narrative Review. *Nutrition Reviews*, *83*(7), e2015–e2024. https://doi.org/10.1093/nutrit/nuae168

Gambelli, D., Vairo, D., Zanoli, R., & Alleweldt, F. (2024). Future scenarios of the sector of insect as food and feed in Europe. *Journal of Insects as Food and Feed*. https://doi.org/10.1163/23524588-00001108

Garofalo, C., Milanović, V., Cardinali, F., Aquilanti, L., Clementi, F., & Osimani, A. (2019). Current knowledge on the microbiota of edible insects intended for human consumption: A state-of-the-art review. In *Food Research International* (Vol. 125). Elsevier Ltd. https://doi.org/10.1016/j.foodres.2019.108527

Girsang, P. (2018). Serangga, Solusi Pangan Masa Depan. *Jurnal Pembangunan Perkotaan*, *6*(2), 69–76. http://ejpp.balitbang.pemkomedan.go.id/index.php/JPP

Glover, D., & Sexton, A. (2015). *Edible insects and the future of food : a Foresight scenario exercise on entomophagy and global food security*. http://eprints.whiterose.ac.uk/170473/

Hanboonsong, Y., & Durst, P. B. (2014). *Edible insects in Lao PDR: building on tradition to enhance food security*. FAO. www.fao.org/publications

Hanboonsong, Y., Jamjanya, T., & Durst, P. B. (2013). *Six-legged livestock: edible insect farming, collection and marketing in Thailand*. FAO.

Hanifah, A. Y. (2024, October 16). *Botok Larva Tawon | Nusantara Food Biodiversity*. Nusantara Food Biodiversity. https://nusantarafoodbiodiversity.org/data/botok-tawon-lwgk8l2xb67fapi

Hanifah, A. Y. (2025, June 13). *Larva capung | Nusantara Food Biodiversity*. Nusantara Food Biodiversity. https://nusantarafoodbiodiversity.org/data/pasin-8p6f1lau3l1x5dr

Iwansyah, A. C., Kristanti, D., Andriansyah, R. C. E., Pramareti, G. M. J., Aditya, I. G. M. R. A., Azzahra, F. L., & Na Bakar, S. (2024). Effect of javanese grasshopper (Valanga nigricornis Burm.) flour on chicken sausage physical properties and its microstructure. *IOP Conference Series: Earth and Environmental Science*, *1377*(1). https://doi.org/10.1088/1755-1315/1377/1/012032

Kapoor, B., Kapoor, D., Gautam, S., Singh, R., & Bhardwaj, S. (2021). Dietary Polyunsaturated Fatty Acids (PUFAs): Uses and Potential Health Benefits. *Current Nutrition Reports*, *10*(3), 232–242. https://doi.org/10.1007/S13668-021-00363-3/FIGURES/3

Khomsan, A. (2025, February 18). *Pangan Lokal, Serangga, dan Makan Bergizi Gratis*. Detik News. https://news.detik.com/kolom/d-7782510/pangan-lokal-serangga-dan-makan-bergizi-gratis

Kleden, Y. L., Mukkun, L., Ndapamuri, M. H., & Pramatana, F. (2023). The migratory locust (Locusta migratoria) as a potential source of protein and biopolymer compounds in the future. *Biodiversitas*, *24*(11), 5979–5987. https://doi.org/10.13057/biodiv/d241117

Köhler, R., Irias-Mata, A., Ramandey, E., Purwestri, R., & Biesalski, H. K. (2020). Nutrient composition of the Indonesian sago grub (Rhynchophorus bilineatus). *Journal of Tropical Insect Science*, *40*, 677–686. https://doi.org/10.1007/s42690-020-00120-z/Published

Kulma, M., Kouřimská, L., Homolková, D., Božik, M., Plachý, V., & Vrabec, V. (2020). Effect of developmental stage on the nutritional value of edible insects. A case study with Blaberus craniifer and Zophobas morio. *Journal of Food Composition and Analysis*, *92*. https://doi.org/10.1016/j.jfca.2020.103570

Kulma, M., Kouřimská, L., Plachý, V., Božik, M., Adámková, A., & Vrabec, V. (2019). Effect of sex on the nutritional value of house cricket, Acheta domestica L. *Food Chemistry*, *272*, 267–272. https://doi.org/10.1016/j.foodchem.2018.08.049

Kuntadi, K., Adalina, Y., & Maharani, K. E. (2018). Nutritional Compositions of Six Edible Insects in Java. *Indonesian Journal of Forestry Research*, *5*(1), 57–68. https://doi.org/10.20886/ijfr.2018.5.1.57-68

Lähteenmäki-Uutela, A., Marimuthu, S. B., & Meijer, N. (2021). Regulations on insects as food and feed: a global comparison. *Journal of Insects as Food and Feed*, *7*(5), 849–856. https://doi.org/10.3920/JIFF2020.0066

Lalander, C., Barrett, M., Gasco, L., Lopes, I. G., Picard, C. J., Tomberlin, J. K., & Van Huis, A. (2025). Working out the bugs: navigating challenges and unlocking opportunities in the insect industry. In *Journal of Insects as Food and Feed* (pp. 1–15). Brill Wageningen Academic. https://doi.org/10.1163/23524588-20250001

Leatemia, J. A., Patty, J. A., Masauna, E. D., Noya, S. H., & Hasinu, J. V. (2021). Utilization of sago grub (Rhynchophorus ferrugineus Olivier) (Coleoptera: Curculionidae) as an alternative source of protein. *IOP Conference Series: Earth and Environmental Science*, *800*(1). https://doi.org/10.1088/1755-1315/800/1/012028

Lirizka, S. P. (2021). *Pengembangan Produk Pempek Belalang Kayu (Valanga nigricornis) sebagai Pangan Selingan Ibu Hamil*. IPB University.

Lukitawati, D. R. (2010). Teak caterpillars and other edible insects in Java. In P. B. Durst, D. V. Johnson, R. N. Leslie, & K. Shono (Eds.), *Forest insects as food: humans bite back* (pp. 99–103). FAO.

Moruzzo, R., Mancini, S., & Guidi, A. (2021). Edible insects and sustainable development goals. In *Insects* (Vol. 12, Issue 6). MDPI AG. https://doi.org/10.3390/insects12060557

Mulyasari, A. (2021). *Formulasi dan Nilai Gizi Sup Krim Berbahan Tepung Belalang (Valanga Nigricornis) sebagai Makanan Alternatif untuk Lansia* [Undergraduate Thesis]. IPB University.

Nasir, S. Q., Palupi, E., Nasution, Z., Ploeger, A., Susanto, I., Setiawan, B., Rimbawan, R., & Jayanegara, A. (2024). Edible insects as a sustainable protein source: A meta-analysis. *Journal of Insects as Food and Feed*. https://doi.org/10.1163/23524588-20230108

Nasir, S. Q., & Świąder, K. (2022). Insects as Food – Opportunities and Constrains. *Technological Progress in Food Processing*, *2*, 137–154. www.kaweczynska.pl/wydawnictwo/czasopisma

Nirmala, I. R., Trees, Suwarni, & Pramono, M. S. (2017). Sago worms as a nutritious traditional and alternative food for rural children in Southeast Sulawesi, Indonesia. *Asia Pacific Journal of Clinical Nutrition*, *26*, S40–S49. https://doi.org/10.6133/apjcn.062017.s4

Ojha, S., Bekhit, A. E. D., Grune, T., & Schlüter, O. K. (2021). Bioavailability of nutrients from edible insects. In *Current Opinion in Food Science* (Vol. 41, pp. 240–248). Elsevier Ltd. https://doi.org/10.1016/j.cofs.2021.08.003

Omuse, E. R., Tonnang, H. E. Z., Yusuf, A. A., Machekano, H., Egonyu, J. P., Kimathi, E., Mohamed, S. F., Kassie, M., Subramanian, S., Onditi, J., Mwangi, S., Ekesi, S., & Niassy, S. (2024). The global atlas of edible insects: analysis of diversity and commonality contributing to food systems and sustainability. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-55603-7

Oonincx, D. G. A. B., & Finke, M. D. (2023). Insects as a complete nutritional source. In *Journal of Insects as Food and Feed* (Vol. 9, Issue 5, pp. 541–543). Wageningen Academic Publishers. https://doi.org/10.3920/JIFF2023.x002

Palupi, E., Anwar, F., Tanziha, I., Gunawan, M. A., & Khomsan, A. (2024a). The Contribution of Forgotten Foods for Supporting Food Security in Gunungkidul, Yogyakarta – Indonesia. *Journal of Nutrition and Food Security*, *9*(3), 539–550. https://doi.org/10.18502/jnfs.v9i3.16163

Palupi, E., Anwar, F., Tanziha, I., Gunawan, M. A., Khomsan, A., Kurniawati, F., & Muslich, M. (2020). Protein sources diversity from Gunungkidul District, Yogyakarta Province, Indonesia. *Biodiversitas*, *21*(2), 799–813. https://doi.org/10.13057/biodiv/d210228

Palupi, E., Nasir, S. Q., Jayanegara, A., Susanto, I., Ismail, A., Iwansyah, A. C., Setiawan, B., Sulaeman, A., Damanik, M. R. M., & Filianty, F. (2025). Meta-analysis on the fatty acid composition of edible insects as a sustainable food and feed. *Future Foods*, *11*. https://doi.org/10.1016/j.fufo.2024.100529

Palupi, E., Uswah, F., Tanziha, I., Khomsan, A., Setiawan, B., Sulaeman, A., Iwansyah, A. C., Filianty, F., & Muslich, M. (2024b). Halal status and society acceptance of edible insects. *Halal Studies and Society*, *1*(2), 24–29. https://doi.org/10.29244/hass.1.2.24-29

Paulin, I. G., Goretti, M., & Purwanto, M. (2020). Nutritional Characteristics of Teak Grasshopper (Valanga nigricornis Burmeister), Cricket (Brachytrupes portentosus L.), and Mealworm (Tenebrio molitor) as Alternative Food Sources in Indonesia. In *Indonesian Journal of Biotechnology and Biodiversity* (Vol. 4, Issue 1).

Porusia, M., Rauf, R., & Haryani, F. (2020). Nutritional value of grasshopper and cricket cooked with different methods. In *EurAsian Journal of BioSciences Eurasia J Biosci* (Vol. 14).

Priyatnasari, N. S., Palupi, E., Kamila, F., Ardhiani, K. R., Khalisah, Prilyadi, G. T., & Iwansyah, A. C. (2024). Meat-analog made from Javanese Grasshopper, kidney beans, and elephant foot yam as a high-protein and low-cholesterol product. *Journal of Agriculture and Food Research*, *16*. https://doi.org/10.1016/j.jafr.2024.101071

Raheem, D., Carrascosa, C., Oluwole, O. B., Nieuwland, M., Saraiva, A., Millán, R., & Raposo, A. (2019). Traditional consumption of and rearing edible insects in Africa, Asia and Europe. In *Critical Reviews in Food Science and Nutrition* (Vol. 59, Issue 14, pp. 2169–2188). Taylor and Francis Inc. https://doi.org/10.1080/10408398.2018.1440191

Rumpold, B. A., & Schlüter, O. K. (2013). Potential and challenges of insects as an innovative source for food and feed production. In *Innovative Food Science and Emerging Technologies* (Vol. 17, pp. 1–11). Elsevier Ltd. https://doi.org/10.1016/j.ifset.2012.11.005

Sabri, N. S. A., Kamardan, M. I. F., Wong, S. X., Azman, N. F., Akhir, F. N. M., Othman, N., Awang, N., Kuroki, Y., & Hara, H. (2023). Future aspects of insects' ingestion in Malaysia and Indonesia for human well-being and religion regulation. In *Future Foods* (Vol. 8). Elsevier B.V. https://doi.org/10.1016/j.fufo.2023.100267

Sánchez-Estrada, M. de la L., Aguirre-Becerra, H., & Feregrino-Pérez, A. A. (2024). Bioactive compounds and biological activity in edible insects: A review. In *Heliyon* (Vol. 10, Issue 2). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2024.e24045

Santi, S. M., Rusdiyana, M. F., Sari, R. N., Putri, R. N. A., Ulilalbab, A., Utami, N. D., & Triatmaja, N. T. (2025). Acceptability of Grasshopper Nugget Flour as a High-Protein Functional Food. *Health Dynamics*, *2*(4), 143–148. https://doi.org/10.33846/hd20402

Selenius, O., Korpela, J., Salminen, S., & Gomez Gallego, C. (2018). Effect of Chitin and Chitooligosaccharide on In vitro Growth of Lactobacillus rhamnosus GG and

Escherichia coli TG. *Research Article APPLIED FOOD BIOTECHNOLOGY*, *5*(3), 163–172. https://doi.org/10.22037/afb.v%vi%i.20468

Serrato-Salas, J., & Gendrin, M. (2023). Involvement of Microbiota in Insect Physiology: Focus on B Vitamins. In *mBio* (Vol. 14, Issue 1). American Society for Microbiology. https://doi.org/10.1128/mbio.02225-22

Setiawan, D. (2019). *Pengembangan Bakso Substitusi Belalang (Valanga nigricornis) sebagai Pangan Tinggi Protein dan Mengandung Asam Lemak Esensial untuk Balita* [Undergraduate Thesis]. IPB University.

Setyawati, A. R., & Magfirah, A. (2024). Potensi Serangga sebagai Pangan Fungsional untuk Peningkatan Kesehatan dan Ketahanan Pangan di Indonesia: Literature Review. *Journal of Nutrition College*, *13*(4), 347–358. https://doi.org/10.14710/jnc.v13i4.42107

Sinaga, V. (2024, March 4). *Kuliner Ekstrim Papua Sate Ulat Sagu*. Rri.Co.Id. https://www.rri.co.id/kuliner/578767/kuliner-ekstrim-papua-sate-ulat-sagu

Suprayogi, A. (2019). *Formulasi dan Nilai Gizi Camilan Berbahan Tepung Belalang (Valanga Nigricornis) sebagai Pangan Alternatif untuk Perbaikan Gizi Balita* [Undergraduate Thesis]. IPB University.

Suthar, T. R., Mhaswade, S. A., & Malakar, P. R. (2020). Edible Insects: The Future of Food? *Research Review International Journal of Multidisciplinary*, *5*(04), 85–90. www.rrjournals.com[Peer

Syabana, R. A., Yuniastri, R., Matlubah, H., & Wise, N. (2025). Nutritional Status and Safety Assessment on Edible Insect Reared in Indonesia. *Majalah Kesehatan Indonesia*, *6*(1), 17. https://doi.org/10.47679/makein.2025220

Syauqiyyah, A. N. (2023). *Formulasi dan Profil Gizi Dimsum Ikan Tenggiri Substitusi Belalang Kayu (Valanga nigricornis) sebagai Makanan Camilan Berprotein Tinggi untuk Anak Prasekolah*. IPB University.

Tajudeen, A. L. (2020). Halal Certification of Insect-Based Food: a critique. *International Journal of Islamic Business Ethics*, *5*(2), 100. https://doi.org/10.30659/ijibe.5.2.100-112

Tao, J., & Li, Y. O. (2018). Edible insects as a means to address global malnutrition and food insecurity issues. In *Food Quality and Safety* (Vol. 2, Issue 1, pp. 17–26). Oxford University Press. https://doi.org/10.1093/fqsafe/fyy001

Tedjakusuma, F., Linggadiputra, J., Cahya, A. D., & Surya, R. (2022). Development of cricket flour-enriched cookies. *IOP Conference Series: Earth and Environmental Science*, *1115*(1). https://doi.org/10.1088/1755-1315/1115/1/012092

Tuhumury, H. C. D. (2021). Edible insects: Alternative protein for sustainable food and nutritional security. *IOP Conference Series: Earth and Environmental Science*, *883*(1). https://doi.org/10.1088/1755-1315/883/1/012029 van Huis, A. (2015). Edible insects contributing to food security? In *Agriculture and Food Security* (Vol. 4, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s40066-015-0041-5

van Huis, A. (2020). Insects as food and feed, a new emerging agricultural sector: A review. In *Journal of Insects as Food and Feed* (Vol. 6, Issue 1, pp. 27–44). Wageningen Academic Publishers. https://doi.org/10.3920/JIFF2019.0017

Van Huis, A., Rumpold, B., Maya, C., & Roos, N. (2021). Nutritional Qualities and Enhancement of Edible Insects. *Annual Review of Nutrition*, *41*, 551–576. https://doi.org/10.1146/annurev-nutr-041520

Veldkamp, T., Meijer, N., Alleweldt, F., Deruytter, D., Van Der Borght, M., Vandeweyer, D., Gasco, L., Roos, N., Smetana, S., Fernandes, A., & van der Fels-Klerx, H. J. (2024). Sustainable integration of insects into European food chains. *Journal of Insects as Food and Feed*. https://doi.org/10.1163/23524588-00001240

Wassmann, B., Siegrist, M., & Hartmann, C. (2021). Correlates of the willingness to consume insects: a meta-analysis. *Journal of Insects as Food and Feed*, *7*(5), 909–922. https://doi.org/10.3920/JIFF2020.0130