



Halal status and society acceptance of edible insects

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ABSTRACT

Feeding globally is considered a critical challenge for sustainable development, hence, protein, energy, and adequate micronutrients must be sustainably available to alleviate many community problems. In some parts of Indonesia, such as Gunungkidul, Yogyakarta, approximately 60% of people consume protein less than the adequacy level. Therefore, this study aimed to identify halal status of edible insects as a forgotten-fringe food to obtain a potential alternative source of protein-rich food in the future. The goal was to cover households with lower-middle income in fulfilling protein requirements, specifically in food-insecure areas. The results showed that six edible insects were identified as a forgotten indigenous protein source. These insects were forgotten majorly due to taste (yuck), allergies, inferior quality, complicated processing methods, and confusion over halal status. However, the identified forgotten foods had the potential to cover the insecurity condition in Gunungkidul. This might help poor households increase protein intake since often those forgotten foods are cheap and hunted freely.

ARTICLE INFO

Keywords:
Edible-insect
Generation
Halal
Sensory
Sustainability

History:
Received 10-02-2024
Revised 05-04-2024
Accepted 08-04-2024

1 Introduction

The world is predicted to face a significant challenge in the next 35 years on "How to feed 10 billion people in 2050?" Feeding the world presents a critical challenge for sustainable development (FAO 2016). The future of food availability is increasingly critical for supporting humanity with the global population expanding alongside megatrends such as urbanization, climate change, and shifting dietary habits. There is a pressing need to ensure sustainable access to protein, energy, and sufficient micronutrients for effective mitigation of risks associated with community nutrition issues including double-burden malnutrition, micronutrient deficiencies, and diet-related non-communicable diseases. This presents a formidable challenge to global agriculture, industry, and society, underscoring the need to reconsider dietary choices, not only in emerging and developing nations but on a global scale.

Indonesia is among the most biologically diverse nations globally, having exceptionally high levels of both terrestrial and marine biodiversity. It is abundant in indigenous natural resources, contributing significantly to the ecological richness (FAOSTAT 2014; WB WDI 2014; Clearly & DeVantier 2011). Moreover, Indonesia is the global 10th largest agricultural producer, contributing significantly to the nation economy. Agriculture contributed about 15% of the total GDP in 2012 and reached 1990 (WB WDI 2014). With sustainable management, the resources are expected to provide potential tools for addressing national socio-economic problems including poverty, hidden hunger, as well as other community health and nutritional problems. The potential resources might provide abundant potential solutions for current problems including global warming, double-burden malnutrition, non-communicable diseases, and micronutrient deficiencies.

In the 17th-18th centuries, stable agrarian societies were established along with a typical traditional "core-fringe" meal which enabled the people to meet the nutritional recommendations. "Core" refers to a starchy complex

carbohydrate commonly eaten at most meals. It is characterized by a homogeneous texture and color, a bland taste, and is typically consumed in bulk quantities. Meanwhile, "fringe" refers to elements used to enhance the palatability and appetizing qualities of the core, aiding consumption (Mintz & Schlettwein-Gsell 2001). This fringe nowadays is recognized as a protein source for human metabolism. The current trend of sedentary and hedonic lifestyles, as well as easy access to high-energy palatable foods or obesogenic environments, globalization, and industrialization have influenced the local balanced diet among people (Bojorquez *et al.* 2015; Vaanholt *et al.* 2015; Belasco 2008).

According to the Indonesian Ministry of Agriculture, there has been a rapid shift in dietary patterns over the last decade, particularly in areas such as South Sumatra, South Sulawesi, East Java, Madura, and eastern Indonesia. The shift has witnessed a move away from a locally diverse diet towards a global, monotonous food pattern. This new pattern is characterized by a dominance of foods high in saturated fats, sugars, salts, and processed ingredients, but low in fiber (Fungo *et al.* 2016; Bojorquez *et al.* 2015). The observed shift in staple food patterns among these areas is evident, transitioning from a variety that included cereals, tubers, sago, and others to predominantly relying on rice and wheat flour. The change in side-dish patterns has also occurred alongside shifts in staple foods, traditionally complementing each other with specific sensory characteristics. However, there is limited reporting on changes in fringe foods in Indonesia. These areas are believed to hold significant indigenous knowledge from ancestors about forgotten fringe foods, which could potentially serve as alternative protein sources in the future. The alternatives may include protein-rich plants, legumes and seeds, edible insects, microalgae, mushrooms, aquatic plants and animals, dairy substitutes, by-products, as well as other underutilized species. When these resources are not promptly identified, documented, investigated, and developed, there is a risk of losing valuable local food sources.

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At the national level, Indonesia is projected to have a population of 366 million people in 2050. Aside from facing double-burden malnutrition, stunting, wasting, and many non-communicable diseases, in 2014, more than half of the population (53.4%) consumed protein below the recommended level, particularly among the lower class in rural areas (SDT 2014). Based on Study Diet Total (SDT) survey (2014), more than half (57.7%) of Yogyakarta population consume less protein than the adequacy level. A locally sustainable quality protein source is highly demanded to cover the national demand, specifically for poor people in food-insecure areas. Some protein-rich foods are known from animal resources that are difficult to be afforded by the poor. The forgotten fringe foods from the local area are expected to be the protein source alternatives for the poor which should be analyzed for quality and acceptability before usability. These types of foods are anticipated to contribute significantly to enhancing nutrition security for people.

United Nations Food and Agriculture Organization (FAO) published a report on insect consumption, which sparked global interest and garnered unprecedented cross-cultural acceptance. FAO mentioned that insects are rich sources of high-quality protein and minerals, suggesting consumption could effectively mitigate the projected global food shortage (Van *et al.* 2013). In general, the term "Halal" typically refers to permissible food consumption and includes moral as well as ethical conduct. This concept, in recent years, has gained considerable attention, particularly among Muslim consumers who prioritize ensuring that food adheres to halal principles (Omar & Zahrain 2012; Batu & Regenstein 2014).

The primary aim of this study was to ascertain halal status of edible insects, considered a forgotten fringe food, and a potential alternative source of protein-rich food in the future. This could enable people in protein-insecure areas, where availability and affordability are limited meet standard requirements. Gunungkidul Regency was selected as the study location for three main reasons. First, according to current data from Personnel, Education and Training Agency in Special Region of Yogyakarta (BKPP DIY), Gunungkidul has the highest number of food-insecure villages (BKPP DIY 2016). Secondly, as part of Yogyakarta, the regency is known for the strong conservation of local culture and wisdom, upheld by residents. This area is expected to possess abundant knowledge about forgotten fringe foods. Thirdly, Gunungkidul was selected due to the diverse topography, spanning from mountainous to coastal areas, which mirrors Indonesia agrarian and maritime profiles.

2 Methodology

This study used focused group discussions (FGD) and in-depth interviews. A total of 16 respondents from Pucung Village and 9 from Mertelu Village participated in FGD. From these interviews, some respondents who have significant knowledge about the forgotten fringe food from Gunungkidul were then followed up to take part in the in-depth interview process. Three additional key respondents who did not participate in FGD in Mertelu joined the in-depth interview. In the end, a total of 12 respondents from each village participated in the in-depth interviews, specifically from Pucung and Mertelu.

FGD process was implemented by three different generations, namely elderly, adult, and youth. For the elderly group, the composition of respondents was mixed between men and women (ratio about 1:4). This method aimed to gather information on the previous experience of both men and women regarding forgotten foods. In general, elderly men in Indonesia have faced many crisis periods which induce participation in the kitchen to help the mothers. For adults, only married women were selected as respondents, and for youth, only girls were selected. Moreover, some local cadres participated in FGD. Respondents were informed that during the FGD there was no correct answer or not.

The process of determining halal status of identified edible insects includes a systematic method rooted in Islamic jurisprudence. 1) Quran. Quran serves as the primary source of Islamic law, providing explicit prohibitions on certain foods. Verses such as Surah Al-Baqarah (2:173) and Surah Al-Ma'idah (5:3) specifically prohibit the consumption of pork, blood, and animals not slaughtered in the name of Allah. These verses are referenced to ensure that the identified edible insects do not fall under any explicit prohibitions. 2) Hadith. Hadith, which includes the sayings and practices of Prophet Muhammad (peace be upon him), is consulted for additional guidance on dietary laws. This step ensures that the consumption practices are consistent with Sunnah. 3) Schools of Thought. Different Islamic schools of thought including Hanafi, Shafi'i, Maliki, and Hanbali may have varying interpretations on certain issues. 4) Consensus (Ijma). For modern food items and processing methods not explicitly covered in classical texts, it is essential to find the consensus of contemporary scholars. This includes reviewing scholarly opinions and fatwas to ensure the decision is consistent with current Islamic legal perspectives. 4) Tayyib (Pure and Wholesome). Aside from being halal, the identified edible insects must also be tayyib, meaning pure, wholesome, and ethically sourced. This includes evaluating the ethical aspects of production, such as animal welfare, environmental impact, and labor practices, to ensure that the food adheres to Islamic ethical standards. By adhering to this methodological

framework, halal status of identified edible insects can be accurately determined, ensuring compliance with Islamic dietary laws and ethical considerations. Halal assurance of all identified sources was discussed and confirmed by halal expert from MUI (Majelis Ulama Indonesia/Indonesian Ulama Council).

This study examined the knowledge of forgotten fringe foods across three generations including youth (daughters aged 12-18), adults (parents aged 25-35), and the elderly (grandparents aged over 55). It also assessed the acceptability of these foods using a 9-point hedonic scale, with 25 respondents from each generation. The acceptability investigation focused on three key aspects including (1) raw form, (2) prepared traditional dishes, and (3) developed products, such as nuggets, sausages, or other derivatives. A questionnaire was designed to evaluate these aspects among the three generations, covering five main dimensions namely knowledge, eating experience, acceptability, preference, and the potential for acceptance.

3 Results

3.1 Edible Insects

From FGD and in-depth interviews, categories and types (local names) were gathered. Scientific names of identified sources were obtained from botanical experts. Halal assurance was discussed and confirmed with an expert from MUI. A total of six categories of edible insects commonly consumed as fringe food by people in Gunungkidul, Yogyakarta, were identified. These include grasshopper (*Schistocerca lineata*, *Valanga nigricomis*, *Oxya chinesis*), caterpillar (*Hyblaea puera*, *Catopsilia pyranthe*, *Meganoton rubescens*, *Cricula trifenestrata*), termite (*Macrotermes gilvus* (big), *Odontotermes javanicus* (small)), bee (*Apis mellifera*, *Apis cerana*, *Apis dorsata*), Beetle (*Phyllophaga sp.*), and stink bug (*Scotinophara coarctata*) (Table 1).

3.2 Survey Among Generations

Based on the anthropometric measurement using BMI z score, it was found that the third generation seemed to be more prone to the risk of being overweight and obese (Figure 1). Meanwhile, the first generation was more prone to the normal and underweight status. Status obese II only occurred among the second generation.

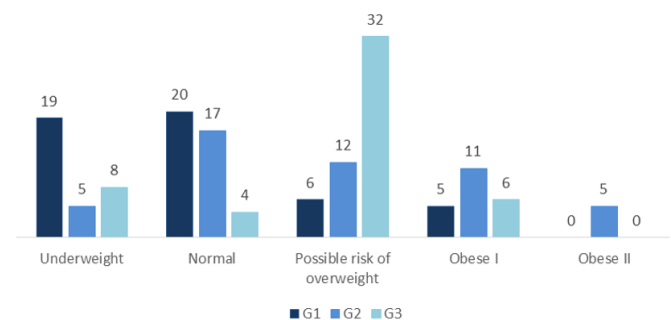


Figure 1: Number of under- and over-nutrition among the generations (G1 (first generation), G2 (second generation), G3 (third generation)) in Gunungkidul

Evaluation of the acceptance hedonic level showed that there was a large shift in the acceptance level between the current and previous generations. The shift was even more than one point level of hedonic. The first and second generations were on the same acceptance hedonic level, 5.59 ± 1.25 (A) and 5.56 ± 1.16 (A), respectively. Meanwhile, the third generation has a significantly lower acceptance level, at 4.36 ± 1.16 (B) (Figure 2).

A similar pattern in the acceptance level was found in the cooked forgotten food, where the third generation had a significantly lower acceptance level compared to the second at 4.81 ± 1.24 (A) and 5.92 ± 1.13 (B), respectively (Figure 3).

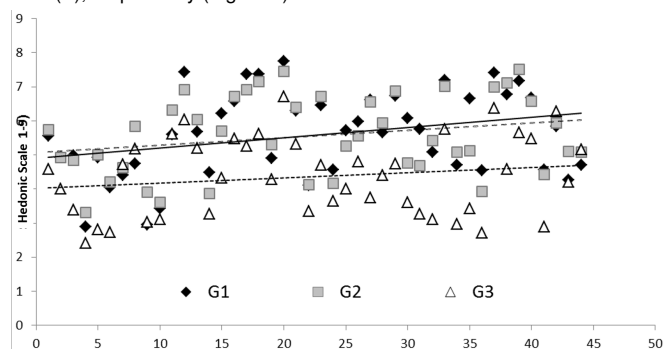


Figure 2: The shift of preference between three generations (food ingredients). Note: G1 (first generation): 5.59 ± 1.25 (A), G2 (second generation): 5.56 ± 1.16 (A), G3 (third generation): 4.36 ± 1.16 (B)

Table 1: Identified forgotten protein source from edible insects in Gunungkidul, Yogyakarta, Indonesia

| Category and type (local name) | Scientific name | Halal status (as confirmed by Halal expert from MUI) | Scriptural evidence |
|--|---|---|--|
| Grasshopper | | | |
| 1. Bird grasshopper (Belalang Gambuh) | <i>Schistocerca lineata</i> | Halal | Quran Surah Al Baqarah: 173, hadist: Ash-Shafi'i, Ahmad, Ibn Majah, and Ad-Daraqutni |
| 2. Javanese grasshopper (Belalang kayu) | <i>Valanga nigricomis</i> | | |
| 3. Rice grasshopper (Belalang dami) | <i>Oxya chinensis</i> | | |
| Caterpillar | | | |
| 1. Caterpillar of teak tree (Ulat Jati) | <i>Hyblaea pueria</i> | 1. Halal 2. Haram when disgust according to consumer | Quran Surah Al Baqarah: 173 and Al A'raf: 157 |
| 3. Caterpillar of iron tree (Ulat Besi) | <i>Catopsilia pyranthe</i> | | |
| 4. Cocoon of iron tree (Enthung Johar) | | | |
| 5. Caterpillar of soursop tree (Ulat Sirsak) | <i>Meganoton rubescens</i> | | |
| 6. Cocoon of mahogany/cashew/kedondong tree (Ungkrung/Enthung pohon mahoni/mete/kedondong) | <i>Cricula trifenestrata</i> | | |
| Termite (Laron) | <i>Macrotermes gilvus</i> (big), <i>Odontotermes javanicus</i> (small) | 1. Halal 2. Haram if disgust according to consumer | Quran Surah Al Baqarah: 173 and Al A'raf: 157 |
| Bee (Tawon madu) Bee, Bee hive, Bee eggs, Bee larva | <i>Apis mellifera</i> , <i>Apis cerana</i> , <i>Apis dorsata</i> | Bee: Haram Bee hive: Halal Bee eggs: Halal Bee larva: Halal if only unable to be separated from the hive/honey | Quran Surah Al Baqarah: 173 and Hadist Abu Daud no. 5267 |
| Beetle (Kumbang/Puthul/Rampal) | <i>Phyllophaga sp.</i> | Halal if not disgust according to consumer | Quran Surah Al A'raf: 157 |
| Stink Bug (Lembing batu) | <i>Scotinophara coarctata</i> | Haram | Quran Surah Al Baqarah: 173 |

Interesting result was revealed when the respondents were asked about their preference if the identified forgotten food is developed into current product trend such as meatball, nugget, sausage, snack bar, instant canned food, etc. compared to the original recipe such as fried grasshopper, fried caterpillar, bothok Tempe, etc. (Figure 4).

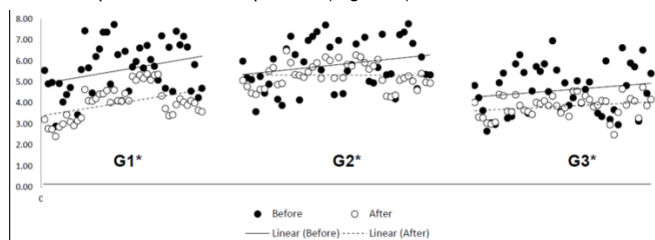


Figure 3: The shift of preference between three generations (cooked food). Note: G1 (first generation): 5.17±1.41 (A), G2 (second generation): 5.92±1.13 (B), G3 (third generation): 4.81±1.24 (A)

When respondents were asked about the potential product for further product development, meatball sausages and nuggets were identified as the most preferred choice (Figure 5). This is in line with the development effort by using grasshopper as meat analogues (Priyatnasari et al. 2024). However, according to the general acceptance, the people in Gunungkidul

prefer the traditional recipe. More information regarding the opinion of people outside Gunungkidul about preference for these identified forgotten foods and the potential of the developed product needs to be further explored for wider community acceptance. Differences in opinion among generations appear in the product nugget and snack bar, while the other products have no significant difference in the preference level among the generation. For nugget as a developed option, young generation (G3: 4.42) had a higher preference level compared to old (G1: 3.88). Meanwhile, the older generation had a higher preference for snack bars (G2: 1.98) than the young generation (G1: 2.72).

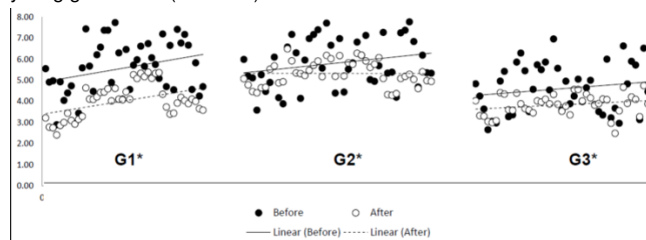


Figure 4: Opinion among the generations on the product development of the identified forgotten food. Note: G1 (first generation), before: 5.59 ± 1.25 (A), after 4.03 ± 0.80 (B); G2 (second generation), before: 5.56 ± 1.16 (A), after 5.06 ± 0.59 (B); G3 (third generation): before: 4.36 ± 1.16 (A), after 3.59 ± 0.50 (B)

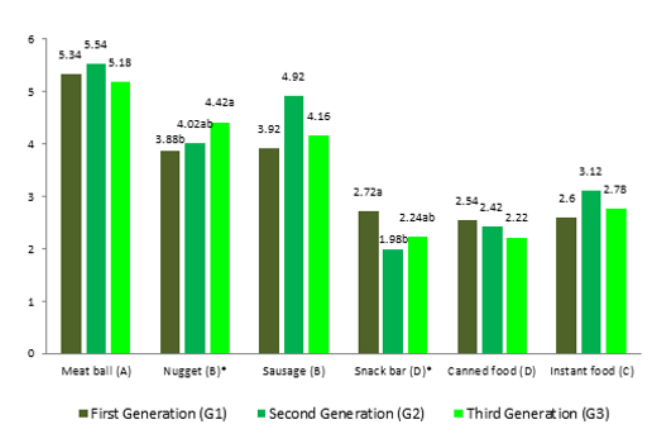


Figure 5: Overall preference for the potential developed forgotten food among three generations in Gunungkidul. Note: The same capital letter code has a hedonic rating value that is not significantly different (p>0.05); symbol * means significantly different among generations

4 Discussion

4.1 Edible Insects

The insects are still consumed by the local people, but FGD and in-depth interviews show that the majority are only the elders who preserve this entomophagy habit. The response and explanation suggest that this tradition is becoming less common among the younger generation. Mothers observe that the food sources are neglected and not selected as part of the family menu because younger family members often refuse to eat. However, older generations still occasionally crave the insects, reminiscing about the tastes experienced during childhood and youth.

4.2 Halal Status of Edible-Insect

Foods of plant and animal origin are generally considered halal in Islam, except for those explicitly prohibited by Quran and Sunnah, the teachings and practices of Prophet Muhammad (Halim et al. 2014). Halal food refers to those permissible under Islamic Shari'ah law, as outlined in Quran, Hadith (teachings of Prophet Muhammad), and scholarly doctrines. Dietary guidelines include which animals are permitted and the specific methods of slaughter. In contrast, haram animals are explicitly prohibited, clearly identified by Prophet Muhammad and established scholarly doctrines (Benzertaha et al. 2018). The Maliki school of thought permits the consumption of all hasharaat (animals and creatures), except those considered harmful or repugnant to people. This ruling is based on Surah Al-Ma'idah (verse 93) of Quran, which allows the consumption of everything on earth except what Shariah prohibits or poses harm to humans (Bakharudin & Yahaya 2018; Rahim 2018; Tajudeen 2020).

Based on the collected data, several reasons were identified for the neglect and forgetting of insects among the common and local people of Gunungkidul. The reasons include the "yuck" factor, allergies, inferior quality, complicated processing methods, and confusion regarding halal status. In Indonesia, halal status is crucial in food choices, given that the majority of the population is Muslim. The next discussion focuses on addressing halal status of each identified insect species.

The scriptural evidence of edible-insect is shown in Surah Al-Baqarah, verse 173, which reads:

أَمَّا حَرَّمَ عَلَيْكُمُ الْمَيْتَةَ وَالْدَّمَ وَالْحَمَّ الْخَيْزِيرَ وَمَا أَهَلَ بِهِ لِغَيْرِ اللَّهِ فَمَنْ اضْطُرَّ غَيْرَ بَاطِعٍ وَلَا عَادٍ فَلَا إِثْمَ عَلَيْهِ إِنَّ اللَّهَ غَفُورٌ رَحِيمٌ

"He has only forbidden you 'to eat' carrion, blood, swine, and what is slaughtered in the name of any other than Allah. But if someone is compelled by necessity, neither driven by desire nor exceeding immediate need, they will not be sinful. Surely Allah is All-Forgiving, Most Merciful." (QS. al-Baqarah [2]: 173).

According to Tafsir Ibn Kathir, Allah has not prohibited anything except for dead animals that perish before being slaughtered. This includes animals that die by strangulation, a violent blow, a headlong fall, goring by horns, or being partially eaten by a wild animal. However, dead animals of the sea are excluded from this ruling, as will be explained later, Allah willing, as Allah said:

أُجِلَّ لَكُمْ صَيْدُ الْبَحْرِ وَطَعَامُهُ

"Lawful to you is (the pursuit of) water game and the use for food." (QS. Al-Ma'idah [5]: 96).

The Musnad, Al-Muwatta' and the Sunan recorded the Prophet saying about the sea:

هُوَ الطَّهْوَرُ مَأْوَةٌ وَالْحِلُّ مَيْتَةٌ

"Its water is pure and its dead are permissible."

Ash-Shafi'i, Ahmad, Ibn Majah, and Ad-Daraqutni reported that Ibn 'Umar said that the Prophet said:

أُجِلَّ لَنَا مَيْتَانِ وَدَمَانِ، السَّمَكُ وَالْحِرَادُ وَالْكَبِدُ وَالطَّلْحَالُ

"We have been allowed two dead things and two bloody things: fish and locusts; and liver and spleen."

According to Ash-Shafi'i and other scholars, milk and eggs found inside dead, unslaughtered animals are deemed impure. In one narration, Malik stated that both food items are pure but become impure due to the location. Similarly, there is a difference of opinion regarding cheeses made with the milk of dead animals. The popular view among scholars is that this cheese is impure, although the Companions ate cheese made by the Magians (fire worshippers). Al-Qurtubi commented: 'Since only a small part of the dead animal is mixed, it is permissible because a minute amount of impurity does not matter when mixed with a large amount of liquid.' According to Ibn Majah, when Allah Messenger was asked about butter, cheese, and fur, Salman recounted saying:

الْحَلَالُ مَا أَحَلَّ اللَّهُ فِي كِتَابِهِ، وَالْحَرَامُ مَا حَرَّمَ اللَّهُ فِي كِتَابِهِ، وَمَا سَكَتَ عَنْهُ فَهُوَ مِمَّا عَفَا عَنْهُ

"The allowed is what Allah has allowed in His Book and the prohibited is what Allah has prohibited in His Book. What He has not mentioned is a part of what He has pardoned."

Allah has prohibited the consumption of swine meat, whether slaughtered or not, which also extends to the fat, either implicitly or by the term 'Lahm'. Similarly prohibited are offerings made to entities other than Allah, such as meat slaughtered in any other name, whether for monuments, idols, divination, or other practices of the Jahiliyyah era. Al-Qurtubi mentioned that 'A'ishah was asked about food slaughtered by non-Muslims for festivals and then presented as gifts to Muslims. The advice was as follows, 'Do not eat from what has been slaughtered for that occasion, but you may eat vegetables.'

Allah later permitted the consumption of such foods in cases of necessity or when permissible foods were unavailable. Allah said:

فَمَنْ اضْطُرَّ غَيْرَ بَاطِعٍ وَلَا عَادٍ

"But if one is forced by necessity without willful disobedience nor transgressing due limits, meaning, without transgression or overstepping the limits,"

فَلَا إِثْمَ عَلَيْهِ

"then there is no sin upon him." This means that if one consumes such items, for

إِنَّ اللَّهَ غَفُورٌ رَحِيمٌ

"Truly, Allah is Oft-Forgiving, Most Merciful."

Mujahid explained, "Permission to consume prohibited items due to necessity applies only when there is no willful disobedience or transgression of established limits. For instance, when abstaining would result in resorting to highway robbery, rebellion against rulers, or other forms of disobedience to Allah, then the permission applies. However, when one exceeds the limits, persists in wrongdoing, or consumes out of disobedience to Allah, this permission does not apply, even in dire need." Said bin Jubayr expressed a similar view. Said and Muqatil bin Hayyan clarified that without willful disobedience means "without believing it is permissible."

4.2.1 Grasshopper

There are three types of grasshopper commonly consumed in Gunungkidul namely Bird (Belalang Gambuh), Javanese (Belalang Kayu), and Rice (Belalang Dami). According to local knowledge, the rice grasshopper is considered the crunchiest when fried compared to the other types. Grasshopper is typically hunted during the rice or maize harvest season, occurring once a year but can be available in the year when cultivated and sold, sometimes fetching prices up to IDR 100,000 per kilogram. Based on the Fatwa Commission of Islamic Scholars, all types of grasshopper are considered halal. Specific Hadith mentions that grasshopper is permissible for consumption.

According to Ash-Shafi'i, Ahmad, Ibn Majah, and Ad-Daraqutni, Ibn 'Umar narrated that the Prophet said:

أُجِلَّ لَنَا مَيْتَانِ وَدَمَانِ، السَّمَكُ وَالْحِرَادُ وَالْكَبِدُ وَالطَّلْحَالُ

"We have been allowed two dead things and two bloody things: fish and locusts; and liver and spleen."

The interview results showed that grasshopper in Gunungkidul are commonly fried. The preparation comprises several steps where the wings, parts of the legs, and the head are initially removed. The grasshopper is then washed and drained using a traditional bamboo sieve called "kukasan." Treatment is carried out subsequently using hot water or boiling until red color forms, indicating half-cooked. The marination was performed for about 20 minutes using seasonings, primarily consisting of salt, garlic, and coriander. When palm sugar is added during marination, it is known as "bacem." Some individuals enhance the flavor by incorporating additional spices and herbs such as turmeric, galangal, lime leaves, and ginger. The bacem method not only improves the sensory qualities but also reduces allergens associated with grasshopper.

4.2.2 Caterpillar

There are four main species of edible caterpillar identified in Gunungkidul namely *Hyblaea puera*, *Catopsilia pyranthe*, *Meganoton rubescens*, and *Cricula trifenestrata*, which are hosted by teak, ironwood, soursop, and mahogany trees, respectively. People commonly consume both the adult caterpillar and the cocoon using the fried method. The spices used are similar to those for seasoning grasshopper.

Caterpillar is not yet cultivated and are typically collected through hunting during the transitional season once a year, fetching prices up to IDR 120,000 per kilogram. Caterpillar thrives during the rainy season and are easily collected in the morning using bamboo sticks. This insect descends to form cocoons in the early sunlight, and caution is advised to avoid touching irritant hairs. In contrast to grasshopper, caterpillar can be processed without separating body parts.

In Islamic dietary guidelines, caterpillar is generally considered halal. However, when an individual finds the insects disgusting, personal halal may not be considered.

وَيُحِلُّ لَهُمُ الطَّلِيَّاتِ وَيُحَرِّمُ عَلَيْهِمُ الْخَبَائِثَ

"And he makes lawful for them the pure things, and he makes unlawful for them the impure things." (QS. al-A'raf [7]: 157).

4.2.3 Termite

There are two species of edible termite found in Gunungkidul namely *Macrotermes gilvus*, which is larger in size, and *Odontotermes javanicus*, smaller in size. Similar to caterpillar, the original Islamic law considers termite halal, unless deemed disgusting from the consumer perspective (Al-A'raf: 157). This insect is not cultivated and is typically hunted for personal consumption. The collection is during the transitional season, once a year. Termite is usually gathered directly from the nests or hunted in the evening using a method where only one light is turned on, and water is placed in a container directly below the light. It is attracted to the light and gather in the container, making ready for processing after washing. The small size of *Odontotermes javanicus* makes it quite challenging to process.

Termite can be processed in various ways in Gunungkidul, including frying or using in traditional dishes such as pelas, rempeyek, and bumbu kelan. Pelas entails cooking termite with a blend of herbs and spices such as lemongrass, garlic, shallots, pepper, and chili, wrapped in banana leaves and steamed. This method is believed to reduce allergen effects and prolong shelf life. Rempeyek, similar to crackers, is made by frying a mixture of termite, rice flour, and spices until crispy. It is often served with tiwul, a traditional cassava-based staple food. Bumbu kelan, a typical seasoning from Yogyakarta, is made by roasting cleaned termite and placing in glass bottles for use as a flavoring agent in cooking. This seasoning can be used multiple times.

Despite these culinary practices, termite is no longer widely consumed in Gunungkidul, even among the elderly. This reluctance is due to a negative sensory appraisal, particularly the fuggy flavor attributed to environmental pollution that has affected the habitat.

4.2.4 Bee

In Gunungkidul, three species of bee are consumed namely *Apis mellifera*, *Apis cerana*, and *Apis dorsata*. According to Islamic dietary rules, consuming bee is generally not allowed, but the hive and eggs are considered halal. Bee larvae are considered halal only when the hive or honeycomb cannot be separated. The collection is carried out directly from the nests and is sometimes available for sale in markets. Similar to termite, bee is traditionally processed into dishes such as pelas and rempeyek. This insect is also used in making besengek, a traditional method where the insect is cooked with various herbs and spices and then simmered in thick coconut milk.

Animals that are forbidden to be killed are also not consumed. These animals are ants, bees, the hoopoe bird, the shrike bird with a large head, white belly, greenback, reportedly preying on sparrows, and frogs.

From Ibn Abbas, he said,

نَبِيٌّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ نَهَى عَنْ قَتْلِ أَرْبَعٍ مِنَ الدَّوَابِّ التَّمَلَّةِ وَالنَّمْلَةِ وَالْهُدُودِ وَالصَّرَدِ

"The Prophet (peace and blessings be upon him) prohibited the killing of four animals namely ants, bees, the hoopoe bird, and the shrike bird." (Narrated by Abu Dawud no. 5267, Ibn Majah no. 3224, and Ahmad 1/332. Sheikh Al-Albani said that this hadith is authentic)

4.2.5 Beetle and Stink Bug

Beetles, scientifically known as *Phyllophaga sp.*, typically inhabit banana, chili, and sengan leaves. According to the Fatwa Commission, these beetles are halal unless considered disgusting by the consumer (Al-A'raf: 157). On the other hand, the stink bug (*Scotinophara coarctata*), which has a round flat shape and shares a habitat with grasshopper, is deemed not halal by the Islamic Commission.

Both beetles and stink bugs can be captured in the evening after sunset. Following cleaning and partial cooking, traditional frying was carried out with various seasonings such as bacem (sweet), salty, or spicy. The insects are often served with Tiwul, a traditional cassava-based staple food.

The concept of thoyyib also needs to be considered in addition to halal aspect. This criterion not only considers the nutritional value, and suitability for consumption, but also the safety. The evaluation of edible insect species, such as grasshopper, caterpillar, termite, bee, beetle, and stink bug, entails considering potential toxic components, allergic reactions, and other health risks (Van Huis *et al.* 2013). For instance, grasshopper, which includes species such as *Schistocerca lineata*, is generally considered safe and halal for consumption. The insects may carry risks associated with pesticide residues from natural habitats, which could lead to toxicity when not properly managed. Caterpillar, such as *Hyblaea puera* and *Cricula trifenestrata*, is also considered halal, but may contain toxic substances including cyanogenic glycosides in some species. Additionally, contact with hair or consuming improperly can trigger allergic reactions, such as dermatitis or gastrointestinal discomfort. Proper identification, preparation, and cooking methods are crucial to mitigate the risks.

Bees, specifically *Apis mellifera* and related species, present a unique challenge from a safety perspective. Although bee larvae and eggs are halal when inseparable from the hive, bees are generally not allowed for consumption under Islamic law. From a health standpoint, consuming bee products can cause allergic reactions, specifically in individuals sensitive to stings or pollen. Termite, such as *Macrotermes gilvus*, is considered halal unless deemed repugnant by the consumer but may harbor contaminants from the environment, including heavy metals, which pose health risks when not adequately managed. Beetles can also trigger allergic reactions, and consumption may lead to the intake of toxic substances when not properly prepared. Finally, stink bugs (*Scotinophara coarctata*) are considered haram due to the presence of compounds with strong odors and tastes, which can be harmful when ingested. Ensuring the safety of these insects requires strict adherence to hygienic collection, processing, and preparation practices, alongside a thorough understanding of the potential health implications (Belluco *et al.* 2013).

4.3 Survey Among Generations

In the current situation, global warming, high population, crisis of health and nutrition status, the world demands a projective "disruptor technology" which enables the preservation of an adaptive system and provides important components for covering community needs. With the high rate of food-insecure households, Gunungkidul preserves precious natural resources using indigenous knowledge. These indigenous sources and knowledge might be dedicated as a sustainable future protein source for the community. Edible insects not only have high nutrient content, but could also be produced more sustainably with less water use, land use, and energy use. Therefore, this source is considered to have low carbon print.

Gunungkidul, characterized by limestone soil and a dry-warm climate with low rain intensity, is an ideal setting for exploring natural sources that thrive in harsh climate conditions. Six edible insects have been identified as forgotten indigenous protein sources. Factors such as the "yuck", allergies, inferior quality, complicated processing methods, and confusion over halal status have contributed to these foods being forgotten and consumed less

by the majority of people. Grasshopper and caterpillar were found to have the highest protein content, with values of $73.47 \pm 1.24\%$ db for grasshopper and $70.32 \pm 0.82\%$ db for caterpillar. The advanced analysis using PDCAAS showed that only caterpillar was able to fulfill all essential amino acid requirements, even higher than the red meat ($63.80 \pm 0.93\%$ db). This was followed by grasshopper (Palupi *et al.* 2020b). A meta-analysis concluded that edible insects provide promising protein and minerals compared to red meat (Nasir *et al.* 2023; Nasir *et al.* 2024; Palupi *et al.* 2020a).

Previous studies about changing consumers perspectives on forgotten foods showed that there was no significant difference in forgotten foods eating habits between the two villages representing coastal (Pucung) and mountainous areas (Mertelu). Forgotten foods consumption frequency was categorized infrequently (1-3x/week) (Palupi *et al.* 2020b). Three groups joined the consumer survey, namely grand- parents as the first generation (G1), parents being the second generation (G2), and children being the third generation (G3). The number of families who joined this survey from each village at Pucung and Mertelu was 25. Each family has three generations in one line. Therefore, in total, 150 respondents have taken part in this consumer study. There were four main aspects observed in this survey, namely knowledge, experience, acceptance, and preference for the conventional and the processing of identified forgotten food.

The people in Gunungkidul seem reluctant to get new product development from the identified forgotten foods. The preference is oriented towards foods processed and served as original. The highest reluctance was from the first generation. Some people from the second generation seemed interested in trying newly developed products, although the original is still preferred. Consumer promotion methods such as a public campaign on the functional properties, supported by advanced sustainable production and processing might be a solution to connect these forgotten foods with insecure households and other community nutrition and health problems.

5 Conclusion

In conclusion, six indigenous edible insects were identified as forgotten protein sources in Gunungkidul, Yogyakarta, namely grasshopper, Caterpillar, termite, bee, beetle, and stink bug. Halal status of the edible insects varied. Grasshopper was considered halal based on a specific Hadist. Caterpillar, termite, and beetle were considered halal in Islamic dietary laws. However, when an individual finds the insects disgusting, then halal status is invalid. This reflects the principle that while certain foods are generally permissible, personal aversion can render impermissible for an individual. Bee and Stink Bug are not allowed (Haram) to be consumed according to Islamic rule.

Studies among generations showed that the current generation was more prone to overnutrition compared to the previous generation. Evaluation of acceptance hedonic level indicated that there was a large shift in the acceptance level between current and previous generations. The shift was even more than one point level of hedonic. The third generation had a significantly lower acceptance level compared to the previous (first- and second-generation). However, the people in Gunungkidul seem reluctant to get new product development from the identified forgotten foods. The preference is oriented toward processing and serving as original. The highest reluctance was from the first generation.

Acknowledgement

The authors are grateful to The Neys – van Hoogstraten Foundation (NHF), the Netherlands, for the generous support and funding of this study titled "Forgotten fringe-food for future protein source: A study among households in a food-insecure area of Gunungkidul, Yogyakarta," under grant number IN288. The authors are also grateful to Dana Abadi Perguruan Tinggi-Lembaga Pengelola Dana Pendidikan (DAPT-LPDP) for the support provided through the national research collaboration funding program (Riset Kolaborasi Nasional) with Grant No. 486/IT3.D10/PT.01.03/P/B/2023.

Conflict of Interest

The authors declare no conflict of interest.

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