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Protein sources diversity from Gunungkidul District, Yogyakarta Province, Indonesia

ENY PALUPI[1,♥], FAISAL ANWAR[1], IKEU TANZIHA[1], MADE ALIT GUNAWAN[2], ALI KHOMSAN[1], FITRIANINGRUM KURNIAWATI[3], MUSHLICH MUSLICH[4,5]

[1]Department of Community Nutrition, Faculty of Human Ecology, Institut Pertanian Bogor. Jl. Lingkar Akademik, Kampus IPB Dramaga, Bogor 16680, West Java, Indonesia, Tel.: +62-251-8625066, Fax.: +62 251 862 2276, ♥email. palupi2105@gmail.com

[2]Department of Nutrition, Politeknik Kesehatan Yogyakarta. Jl. Tatabumi No.3, Banyuraden, Gamping, Sleman 55293, Yogyakarta, Indonesia

[3]Department of Plant Protection, Faculty of Agriculture, Institut Pertanian Bogor. Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, West Java, Indonesia

[4]Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Institut Pertanian Bogor. Jl. Lingkar Akademik, Kampus IPB Dramaga, Bogor 16680, West Java, Indonesia

[5]Division of Standard and Quality Assurance, The Assessment Institute for Foods, Drugs and Cosmetics, Indonesian Council of Ulama, (Lembaga Pengkajian Pangan Obat-Obatan dan Kosmetika Majelis Ulama Indonesia). Global Halal Centre, Jl. Pemuda No.5, Bogor 16162, West Java, Indonesia

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Abstract. *Palupi E, Anwar F, Tanziha, Gunawan MA, Kurniawati AKF, Muslich M. 2020. Protein sources diversity from Gunungkidul District, Yogyakarta Province, Indonesia. Biodiversitas 21: 799-813.* This research aimed to identify forgotten side-dish diversity from food-insecure area, Gunungkidul District, Yogyakarta, Indonesia. A qualitative data were gathered by using Focus Group Discussion followed by in-depth interviews with 24 key persons from Pucung and Mertelu villages, Gunungkidul. Proximate analysis and enzymatic gravimetric fiber analysis were also performed to get the first impression concerning the nutrient quality of the selected sources. As many as six edible insects, five aquatic animals, eight legumes and seeds, five fermented foods, eight mushrooms, three by-products, more than ten protein-rich plants, and five aquatic plants were identified as forgotten indigenous protein source from Gunungkidul, Yogyakarta. All aspects about scientific name, local value, Halal assurance, handling method, processing technique, and serving method of these sources have been presented on this article. Early investigation on the nutrient quality of the identified source reveals that grasshopper, caterpillar, aquatic snail, came out as the highest protein content compared to egg as a standard. Tempe -*mlanding* and *-benguk* also could be great alternatives as future plant-based protein sources. This investigation uncovers abundant protein sources diversity potential as future protein sources for supporting future food and nutrition security and sustainability.

Keywords: Adaptive-species, dry-climate, forgotten-food, protein-alternatives

INTRODUCTION

Feeding the world becomes a critical challenge for sustainable development (FAO 2016). The megatrends of urbanization, climate change and dietary change fuse a strong prognosis on a formidable picture in the future on how the food should be available for supporting the human being. Protein and energy demands, as well as sufficient micronutrients, must be sustainably available to substantially reduce the risks of many community nutrition problems. Indonesia is one of the most biologically diverse nations in the world with very high levels of both terrestrial- and marine- diversities, and rich on indigenous natural resources (Clearly and DeVantier 2011). With sustainable management, those available resources might preserve abundant sources for current global problems.

Indonesian Ministry of Agriculture (2015) portrayed a rapidly changing dietary pattern in Indonesia during the last decade, particularly in the east part of Indonesia. There was a large shift on dietary habit from a local-diverse food pattern into a global-monotonous food pattern which was dominated with food high in saturated fats, sugars, salts, and processed foods but low in fibers and other nutrients (Fungo et al. 2016). The changing on staple-food pattern was obviously observed among those areas, from many cereals, tubers, sago into only rice and wheat flour (BKPP 2016). The changing on side-dish pattern seems also occurred since the staple-food and side-dish naturally side by side with a specific couple sensory characteristics. However, the shift on the side-dish is not yet well reported in Indonesia. Those areas have been predicted to treasure a lot of valuable indigenous knowledge among the ancestor about the forgotten side-dish which might be potential for future protein alternative sources. If these are not being immediately identified, recorded, and developed, then those will continue to be lost.

Based on the above phenomenon, the aim of this research is to identify the protein source diversity from Yogyakarta, Indonesia as future protein alternatives, so people in protein insecure due to the lack of availability and affordability enable to use it to fulfill their protein requirements.

MATERIALS AND METHODS

This study was conducted in Gunungkidul District, Yogyakarta, Indonesia. There were three reasons why it

was chosen. First, it has the highest number of food-insecure villages based on the current data of BKPP DIY (BKPP 2016). Second, as a part of Yogyakarta, it is one of Indonesian region which has prominent conserved local culture and wisdom which is still conserved by its local people so that predicted to treasure an abundant knowledge of forgotten protein source food. And third, it has long-wide area from mountainous- till coastal- area which represents Indonesia's topography with agrarian- and maritime- profile.

The exploration was performed through Focus Group Discussion (FGD) and in-depth interviews. FGD was performed by making a round table discussion with 16 and 9 respondents from Pucung and Mertelu villages, respectively, and led by a moderator. The FGD was initiated with the discussion about food and nutrition security, how to satisfy the people on the available local side-dish. The discussion flowed until all possible forgotten protein sources were identified. From this FGD, then the key persons who gave significant information continued recruited to get involved in further in-depth interviews. In the end, 12 respondents were involved the in-depth interview from each village (Table 1).

Forgotten food here means that the food is not usually consumed by the people outside Gunungkidul, but still or ever be consumed by the people in Gunungkidul. There were eight categories of the side-dish applied in this research, i.e. protein-rich plants, legumes and seeds, mushrooms, edible-insects, aquatic-plants, aquatic-animals, fermented-food, and by-products. Protein-rich category was derived according to EU Regulation (EU) No 1047/2012, which stated that "source of"- and "high"-protein may only be made where at least 12% and 20% of the energy value of the food is provided by protein, respectively (EC 2012). By-products here were particularly the "secondary" product resulted from agro-industry which is mostly produced largely and not used in common practices.

The questionnaire was constructing based on questions: What kind of side-dish usually consumed? Are the available side-dish sufficient? Are there any available foodstuffs that might be able to be protein alternative sources? Are those foodstuffs available (abundant and affordable)? What kind of side-dish consumed during famine or harsh climate conditions? What kind of side-dish considered inferior? These questions always refer to eight categories above and followed by these sub-questions, i.e. Why it is rarely consumed? How to cook, composition, how to prepare, how to cook, and how to serve? Are there any special occasions to serve? Are these foods still acceptable and preferable?

Seventeen respondents were involved in tryout in Patuk Village, Gunungkidul District (Table 1). After try out, the questionnaire and interview's method were set accordingly. The ethical clearance was obtained from the Ethical Committee from Health Polytechnics of Yogyakarta (Politeknik Kesehatan Yogyakarta), Indonesian Ministry of Health), number LB.01.01/KE-01/XLIII/889/2018.

Seventeen available identified sources were further sampled (500g-1kg/sample, Figure 1). Five external samples also inserted as standard i.e. egg, red meat, soybean, fermented soybean, and *Moringa* leaves. Proximate analysis based on AOAC International (2019) standard was performed to gather the content of water, ash, protein, fat, and carbohydrate using gravimetric method 925.10, gravimetric method 923.03, Soxhlet extraction method 920.39, Kjeldahl method 955.04, and by-difference calculation, respectively (Nielsen 2010). The conversion factor used for crude protein calculation was derived from Nielsen (2010) and Yeoh and Wee (1994). While for the edible fiber was assessed using enzymatic gravimetric method 994.13 (Nielsen 2010). The nutrient content of the identified sources was expressed into two types of unit i.e. wet basis (%wb) and dry basis (%db). Wet basis expressed the real weight (gram) of nutrient content in 100 grams of fresh foodstuff. This is important for a nutritionist in serving food and calculating the nutrient content when the food served and compared with the Recommended Dietary Allowance. While the % dry basis unit expressed the gram nutrient content in 100 grams of dry matter. This %db is important while comparing among novel sources in order to provide equal comparison of the nutrition if the water is removed from the material.

Table 1. Research activity, location, and number of respondents

Research activity	Location (Dukuh or Sub-village)	Number of respondents
Questionnaire tryout	Patuk Village, Patuk Sub-district, Gunungkidul District	17
FGD in Pucung Village	Karang Tengah	13
	Pakelkopek	2
	Pucung	1
	Total	**16**
FGD in Mertelu Village	Gandu	4
	Mertelu Kulon	1
	Mertelu	2
	Guyangan Kidul	1
	Guyangan Lor	1
	Total	**9**
In-depth interview in Pucung Village	Pakelkopek	1
	Bengle	1
	Wonotoro	2
	Girisubo	1
	Pucung	1
	Traju	2
	Karang Tengah	3
	Wotawati	1
	Total	**12**
In-depth interview in Mertelu Village	Guyangan Kidul	1
	Gandu	2
	Krinjing	2
	Mertelu	5
	Baturturu	1
	Soka	1
	Total	**12**

Figure 1. Some identified forgotten-food sources from Gunungkidul, Yogyakarta-Indonesia. A. Javanese grasshopper (*Belalang Kayu/Valanga nigricornis*), B. Caterpillar of teak tree (*Ulat Jati/Hyblaea puera*), C. Aquatic snail (*Keong Emas/Pila ampullacea*), D. *Kacang Benguk* (*Mucuna pruriens*), E. *Kacang Tholo* (*Vigna unguiculata*), F. *Lamtoro* (*Leucaena leucocephala*), G. *Kacang Gude* (*Cajanus cajan*), H. *Tempe Benguk* (fermented product of "Benguk" bean), I. *Tempe Mlanding* (fermented product of "Lamtoro" bean), J. *Tempe Gembus* (fermented product made from by-product of tofu production), K. *Tempe Busuk* (over-fermented soy tempeh (>3 days)), L. Bran/*Bekatul* (outer layer of rice), M. *Jamur Grigit* (*Schizophyllum commune*), N. Seaweed (*Euchema cottoni*), O. *Beluntas* leaf (*Pluchea indica*), P. *Kenikir* leaf (*Cosmos caudatus*), Q. *Bayung* leaf (*Vigna unguiculata*)

Scientific name of the identified source was determined according to the morphological characteristics. The specific characteristics then were matched with specific literature. For the insects were referred to an insect book (Johnson et al. 2004). The snails were matched according to a Mollusca book (Marwoto et al. 2011). The morphology identification of plant based sources was referred to Siemonsma and Piluek (1993) and van der HAM Vossen and Umali (2002). The valuable information about the scientific name of the identified source was gathered from a botanical expert. While, the halal assurance of all the identified sources here was discussed and confirmed by the halal expert from MUI

(Majelis Ulama Indonesia/Indonesian Religious Leader) which takes into account three main sources, i.e. *Quran*, *Hadits*, and Islamic Scholars.

The qualitative data was tabulated and resumed. The protein data were explored using deviance analysis (Rosenberg et al. 2000). The difference of the protein content from egg (standard) was calculated using the mean data and weighted with the standard deviation. The positive deviance indicates that protein content is greater in the forgotten group, and vice versa.

RESULTS AND DISCUSSION

In the following writing, the results part is narrated based on the food categories, i.e. edible-insects, aquatic- and wild- animals, legumes and fermented-food, mushrooms, by-products, and protein-rich plants (included aquatic-plants). Whilst the discussion part is narrated into three main subchapters, i.e. (i) animal-based protein, (ii) plant-based protein, and (iii) safety and sustainability.

Results

Six edible-insects, five aquatic-animals, eight legumes&seeds, five fermented-food, eight mushrooms, three by-products, more than ten protein-rich plants, and five aquatic-plants were identified. All identified list of forgotten-dish is presented on Tables 2-5.

Edible insects

Six edible-insects commonly consumed are grasshopper, caterpillar, termite, bee, beetle, and stinkbug. It seems that only the elders preserved this entomophagy habit. This habit starts to be left behind by the young. Even majority mother explained that these sources were being neglected and do not be selected as the menu at home since the young family member tend to refuse these insects. Nevertheless, the elder still sometimes crave to consume these insects so that enable to envisage the taste that ever been experienced during their young.

There were five reasons why those insects started to be forgotten by the local people, i.e. yuck factor, allergy, inferior, complicated processing method, and confusion on halal status. **Yuck** is the main reason why people refuse to consume those insects. According to the focus group discussion and in-depth interview, there was changing perspective on those edible insects. This change was inferred from reluctance on discussing edible insects which coming from the second and the third generation (mother and daughter), but not from the first generation (grandparents). Even some respondents asked to discontinue the discussion about the insects and asked to switch the topics. The hard external skeleton, abundant small legs, and tickle movements made the overall disgust perception by most people. Another reason is **allergy**. Many people got an allergy reaction after consuming these insects like itchiness and respiratory problem. Key respondents explained that **inferior**ity also becomes the reason behind the reluctance. Common people have perception that insect is an inferior menu, so only suitable for the poor. Even some children protest if their parents are consuming insects. However, some key persons presented that last 50 years ago, grasshopper was perceived as *priyayi* food. *Priyayi* is an epithet for high-level people in a community based on knowledge- and wealth- level. Another forgotten reason is **complicated processing method.** This complicated process has begun from the hunt, cleaning, and cooking. Complicated handling is particularly due to the tiny size of the insects. **Confusion on halal status** also becomes the reason why these insects rarely consumed by Indonesian, since the majority of Indonesian are Muslim. Further, the halal status of each identified source is addressed.

There are three edible grasshoppers from Gunungkidul, i.e. Bird grasshopper, Javanese grasshopper, and Rice grasshopper. The key person stated that the fried rice grasshopper is the crunchiest compared to others. Grasshopper is hunted during harvest time, once in a year. But this might be available throughout the year if it is cultivated and sold until 7 USD/kg. As confirmed by halal expert from MUI, all kind of grasshopper is halal (Table 2). In the afternoon, the grasshopper is sleeping so that is easy to be collected by using bamboo with jackfruit's latex. Those grasshoppers are commonly processed as fried grasshoppers. This is prepared by cutting the wings, part of leg, and head, then washed and drained using *kukusan* (traditional bamboo sieve). Then it is boiled till red means half done. After that, it is marinated for 20 minutes using seasoning, and then fried. The seasoning mainly consists of salt, garlic and coriander. It is called *bacem* if added with palm sugar. The people believe that *bacem* might improve the taste and reduce the allergen. Traditionally this fried grasshopper is served together with *Thiwul* (traditional staple food made from cassava).

There were four edible caterpillars, i.e. *Hyblaea puera, Catopsilia pyranthe, Meganoton rubescens, Cricula trifenestrata* where their host are teak-, iron-, soursop-, and mahogany- three, respectively. Both adult caterpillar and its cocoon were fried and consumed. The used spices are similar to the seasoning ingredient for grasshopper. As confirmed by halal expert from MUI, basically caterpillar is halal, but haram if it is disgusting according to the eater. This is collected by hunting during transitional season once in a year and sold till 100 000 IDR which equal to 7.2 USD/kg. This insect could easily be collected in the morning using bamboo stick. In the early sunshine, the caterpillar is come down to form a cocoon. It is warned to avoid the itchy string. Unlike the grasshopper, caterpillar could directly be processed without separated some body parts.

Two edible-termites are *Macrotermes gilvus* (big size) and *Odontotermes javanicus* (small size). Similar to caterpillar, the original Islamic law of termite (as confirmed by the halal expert from Majelis Ulama Indonesia/Indonesian Religious Leader) is halal, unless it is disgusting by the eater. This insect is not yet cultivated, therefore it is collected by hunting. Usually, it is not for sale, but only for personal consumption, hunted during transitional season, once in a year. Termite usually is collected in the evening by turning on only one light and

placing water in a container exactly below the light. The termite will huddle in the container so that ready to be processed. The small size makes it quite difficult to be processed. This could be processed by frying or made traditional food like *pelas*, *rempeyek*, and *bumbu kelan*. This method believed enable to reduce the allergen effect and prolonged shelf life. *Bumbu kelan* is made by roasting the cleaned termite, then placed in bottle glass and used as flavoring agent when cooking and possible for multiple uses. Some key person mentioned that termite is no longer be consumed by the people even by the elderly since the distaste sensory appraisal, specifically fuggy flavor. This off-flavor is predicted due to air pollution which then affected their habitat.

There are three *Apis* species which are consumed, i.e. *Apis -mellifera*, *-cerana*, *-dorsata*. Basically, bee is haram, but for the bee -hive and -egg are halal. For bee larva is halal if only this larva is not able to be separated from the hive or honey (confirmed by halal expert from MUI). Bee could be collected directly from their nest. Sometimes these bees are available for sale in the market. Like termites, bees traditionally processed into *pelas* and *rempeyek*. This also could be added in making *besengek*, a thick coconut soup.

Beetle (*Phyllophaga* sp.) is normally live in banana-, chili-, and *sengon*- leaves. Beetle is halal if only not disgusting by the consumer (confirmed by halal expert from MUI). While *Scotinophara coarctata* which has round flat shape and close habitat with grasshopper is stated as haram. Similar to grasshopper, both enable to be captured in the evening after sunset when they start to sleep. After these are cleaned and heated until half done, these are traditionally processed as fried and served with *thiwul*.

Aquatic and wild animals

The identified aquatic forgotten sources were sea snail, aquatic snail, tiny crab, small crab, sea crab, and shells. As confirmed by halal expert from MUI, all of these identified sources are halal except aquatic snail. The Islamic scholars recommended that it has to be sure that the aquatic snail is not harmful in the term of toxicity. If it is safe then it is halal (as confirmed by the halal expert of MUI). Almost all those identified sources are gathered by hunting, not yet cultivated. The key persons explained that those sources, particularly the tiny ones, are being forgotten since it is rarely available in the market due to the difficultness to be caught. These sources are traditionally cooked as *rempeyek*, *pelas*, or other cooked dishes like sauted, baked, fried, boiled, steamed with many herbs and spices. Tiny crab also enables to be processed as flavoring agent like monosodium glutamate stock by roasted it then store in airtight container for multiple uses. Other founded sources were fish category. These identified fish types quite similar to other places have (Table 3). All kinds of these fish are halal. The favorite way to cook the fish is by baking it with soy sauce and eats it together with *urap* (from seaweed) and *thiwul*.

Local people were also usual with hunting activity in the forest to gather some wild animals. Those animals are squirrel, ferret, wild chicken, and hedgehog. But now, this activity has rarely been done due to the availability and reluctance since other choices are more easily found in the market. All of those wild animals are halal except ferret. As confirmed by halal expert from MUI, some Ulama said that ferret is haram because of the *khobaits* characteristics like rat. Those animals are commonly cooked similarly to chicken dishes.

Legumes and fermented-food

There were eight soybean alternatives identified from Yogyakarta, i.e. *Mucuna pruriens, Vigna unguiculata, Leucaena leucocephala, Canavalia ensiformis, Canavalia gladiate, Psophocarpus tetragonolabus, Sesbania grandiflora*, and *Cajanus cajan*. The most reason to be forgotten is the poisonous component. Therefore, extra efforts are needed for processing these indigenous legumes so that they reduce the harm component and increase the nutritive value. At least three days for soaking treatment is urgently required for removing the toxic compound from *M. pruriens.* The hard process made these sources less preferred and hard to be sold unless ready to be consumed like Tempe Benguk chips. Fermentation seems the most preferred processing technique.

Benguk, lamtoro, klenthang, koro, and *kecipir* were usually fermented into tempe *-benguk*, *-mlanding*, *-klenthang*, *-koro*, and *-kecipir* respectively. Tempe *-benguk* and *-mlanding* are the prominent ones. These legumes and tempes are sold only twice in five days. The legumes are usually harvested once a year. These indigenous tempes has lower price than soy-tempe. However, currently, these foods become less preferred by the young because of their specific taste. This specific perception seems to arise due to in-habitual consumption experience among the young. This preference among the young made these indigenous products were not easy to be sold compared to soy-tempe. Therefore those sources start to be forgotten even by the local people. Traditionally those indigenous legumes are also processed into at least eight dishes (Table 4).

Mushrooms and by-products

There were eight indigenous mushrooms identified i.e. Phycomycota, *Schizophyllum commune, Schizophyllum commune, Scleroderma aurantium, Clitocybe nebularis, Clavariadelphus truncatus, Morchella esculenta*, and *Oudemansiella canarii*. These mushrooms bloom during the transitional season. Most of these mushrooms are grown as wild plants and rarely found. These mushrooms started to be forgotten since some mushrooms have unique sensory quality. Even some people are afraid that these mushrooms are poisonous. The cooking dish for these mushrooms commonly quite similar to the dish type of legumes and tempe (Table 4). Traditionally these all dishes are served together with Thiwul. Some types need special treatment. For instance, Phycomycota has very tough texture. The local people have wisdom in processing this mushroom. Before further cooked and consumed, Phycomycota has to be washed by using hot water, then ponded with lumpang, pounder made from Sambi wood for some time for softening the texture. After this, the mushroom ready to be seasoned with many spices, then

stir-fried or added with grated coconut and wrapped with banana leaves to make so-called *bothok*.

The local people even were usual to use some by-products for cooking some dishes. From the soy-tofu central production, it leaves some pulp which is fermented to be *tempe gambus*. These by-product based foods still become a part of the people life, although these start to be less preferred by the young. *Tempe gambus* commonly processed by fried either with or without flour cover. Another useful by-product is outer skin of *benguk* which commonly cooked as milky soup and stir-fried. This dish is common in the production center of *tempe benguk*. Another unique food is rotten tempe. This is an over-fermented soy-tempeh (>3 days). The rotten process gives a specific flavor favored by the elderly. Another famous by-product as foodstuff in this area is *bekatul*, the outer skin of rice. This bekatul famously cooked as *jenang*, traditional candy. This is produced by long cooking the mix blend of rice brand, thigh coconut milk, and palm sugar, and then baked.

Protein-rich plants

Twenty-five leaves, five flowers, four stems, five fruits, and five aquatic-plants were identified as forgotten sources for making dishes (Table 5). Some of these sources believed as breast milk booster, i.e. *Pluchea indica*, *Mangifera indica* leaves (*Mango foliorum*), and *Sauropus androgynous*. Some believed that these very beneficial for non-communicable disease therapy, i.e. leaves of *Cosmos caudatus*, *Sechium edule*, *Morinda citrifolia*, *Annona muricata*, also flower of *Carica papaya*, *Sesbania grandiflora*, and *Cocos nucifera*. Most of them are able to be harvested once or twice a year. Those plant-based proteins could be processed into 17 dishes (Table 4). The most unique dish is *gudhek*, a soup made from coconut flower and young jackfruit mixed with palm sugar, seasoning, and coconut milk and cooked using special covered pan made from clay so that enable to maintain the special flavor from the ingredients.

Nutrients content

Seaweed and aquatic snail have the highest ash content, 32.73±0.54 and 25.05±0.43%db, respectively. This even higher compared to *Moringa* leave. This indicated that these sources reserve potential abundant mineral sources useful for human health. For protein evaluation, grasshopper and caterpillar were coming out has the highest protein content, i.e. 73.47±1.24 and 70.32±0.82%db, respectively, higher compared to red meat (63.80±0.93%db), followed by aquatic snail (58.99±1.07%db). Based on the % energy contribution from protein indicates that the identified edible insects, legumes, fermented food, some by-products (fermented tofu by-product and over-fermented soybean), some plants (longyardbean leave and papaya flower), and aquatic snail were categorized as high protein. Whilst, *Moringa* leaves, *beluntas* leaves, *kenikir* leave and seaweed were categorized as source of protein.

The forgotten food made from by-product presents the noticeable crude fat content, *tempe busuk*, *tempe gembus*, and *bekatul* showed high content of crude fat, 32.51±0.71, 11.34±0.27, and 7.13±0.01%db, respectively. Dietary fiber analysis revealed that three kinds of prominent salad leaves contain the highest fiber, i.e. *beluntas*, *bayung*, and *kenikir*, 77.43±2.46, 74.23±1.46, and 69.76±7.66, respectively. Further research seems very interested to be taking into account regarding the detail content and type of these dietary fibers, since all these three leaves were prominent as traditional breast milk booster (Table 6).

A deviance plot (Figure 2) presents that grasshopper, caterpillar, aquatic-snail, and *tempe busuk* came out as the highest protein deviance compared to egg protein, i.e. (19.31±6.9; 17.65±6.32; 11.71±4.26; and 7.67±2.89, respectively). Surprisingly, protein content of tempe *mlanding* came out as not significantly different compared to the standard (-0.84±1.04), followed by *tempe benguk* which is nearly similar to the standard (-2.75±1.40). Whilst another identified source found has significantly lower protein content compared to the standard.

Beyond the above result, the evaluation also provides a hypothesis that the fermented process using *Rhizopus* might metabolize the carbohydrate so that raise the protein and fat content. This is showed from the protein, fat, and carbohydrate content of raw legumes compared to their fermented and over-fermented product. This is clearly shown in Figure 3. However, the nutrient per yield has to be confirmed in the context of equal input basis.

Discussion

This exploration reveals many forgotten sources which might be potential for future protein sources, both plant- and animal- based protein. All above-identified sources are unfamiliar and underutilized to be consumed by the people in region other than Yogyakarta. Therefore, some selection criteria are demanded before allocating some efforts to develop and disseminate that forgotten food for other regions. Some notable criteria that need to be taken into account are nutritional aspects, food culture, safety aspect, and production system. Each aspect is briefly discussed in the following writing.

Animal-based protein

In this early investigation, edible-insects seem the most attractive this nutritive criterion. They have high protein content, even >70%db. Nowadays, edible-insect is widely considered has notable nutritive value so that might lead to improve the global food and nutrition security (Murefu et al. 2019; Patel et al. 2019). Not only they have important nutrients and health-promoting compounds, but insects are also recognized as sustainable protein sources with abundance availability (Patel et al. 2019; Govorushko et al. 2019). As globally known that red med production significantly contributes to the methane emission causing global warming (Vinnari and Tapio 2009; Steinfeld et al. 2006). Therefore, nowadays the global situation demands a non-read meat quality protein (Alfieri 2019).

Edible-insects have a very low carbon print due to it needs less land and energy compared to the macro-ruminant production (Premalatha et al. 2011). Thus, edible-insects seem a promising protein in the current era. However, yuck factor needs also taking into consideration

when advising these insects as the food protein for the community (Powell et al. 2019). Further advance processing technology might tune out this yuck issue. For instance, the grasshopper is processed into nugget, sausage or other prominent foods. However, the current research presented that current food consumer prefers a unique and traditional food product with sensorial experience (Mărcuţă et al. 2014). The community acceptability also might be raised if nutritional education followed the effort to introduce these insects.

However, food-culture, particularly the religious aspect should come as fundamental requirement when developing those sources. In the global food production, halal and kosher food regulation become a notable religious food law that should be considered because almost a quarter of consumer worldwide is Muslim and Jewish (Featherstone 2015). Facing the Indonesian food-culture found that some edible-insects like grasshopper, caterpillar, and termite enable to fulfill the halal assurance criteria. As a note, these edible-insects include non- kosher ingredients so that prohibited to be consumed by Jewish consumers (Regenstein 2019). Even all products have to be inspected as insect-free so that enables to get kosher assurance (Featherstone 2015). Therefore, other identified forgotten food sources above also have to be evaluated so that enable to fulfill the kosher assurance.

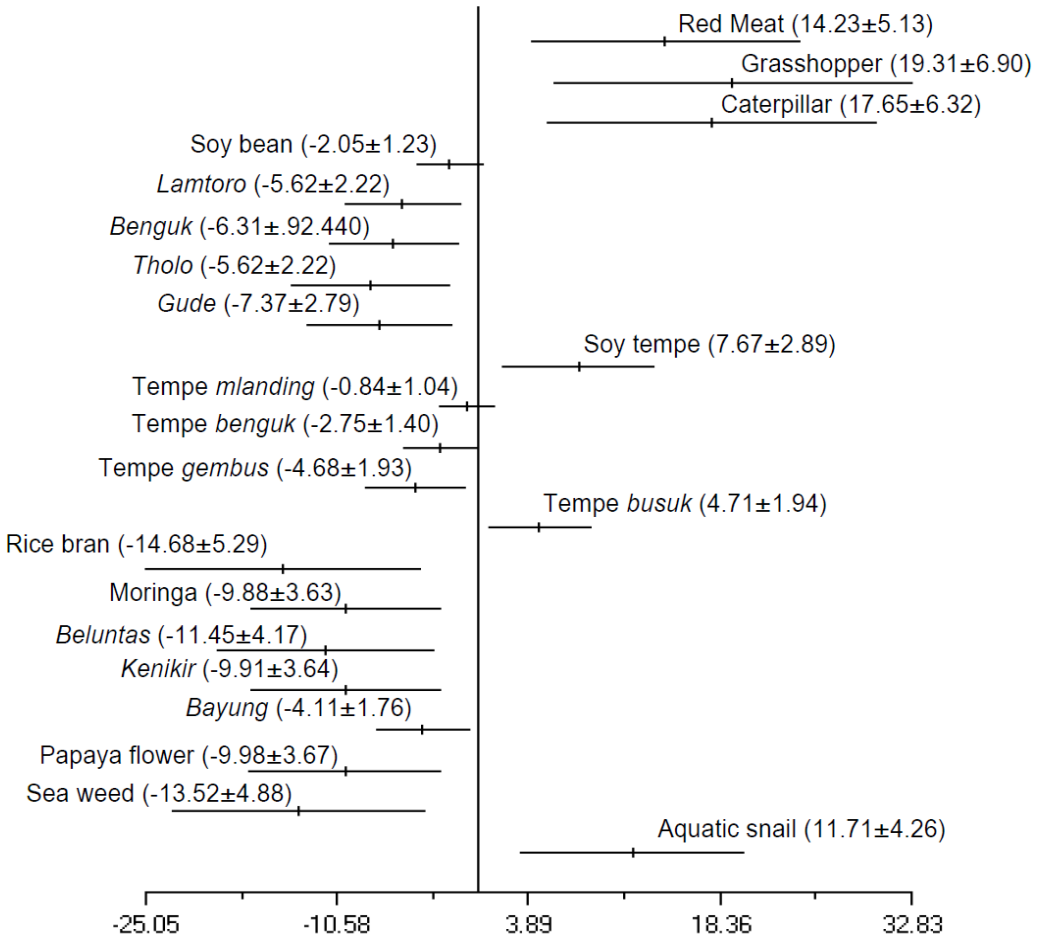

Figure 2. Protein difference of the selected identified forgotten protein source compared to egg protein as standard. Note: Grasshopper: Javanese grasshopper (*belalang kayu/Valanga nigricornis*); Caterpillar: Caterpillar of teak tree (*ulat jati/Hyblaea puera*); *Lamtoro*: *Leucaena leucocephala*; *Benguk*: *Mucuna pruriens*; *Tholo*: *Vigna unguiculata*: *Gude*: *Cajanus cajan*; Tempe *mlanding*: fermented product of "*lamtoro*" bean; Tempe *benguk*: fermented product of "*benguk*" bean; Tempe *gembus*: fermented product made from by-product of tofu production; Tempe *busuk*: over-fermented soy tempeh (>3 days); Rice bran: outer layer of rice; *Beluntas*: *Pluchea indica*; *Kenikir*: *Cosmos caudatus*; *Bayung*: *Vigna unguiculata*; Seaweed: *Euchema cottoni*; Aquatic snail: *keong emas/Pila ampullacea*).

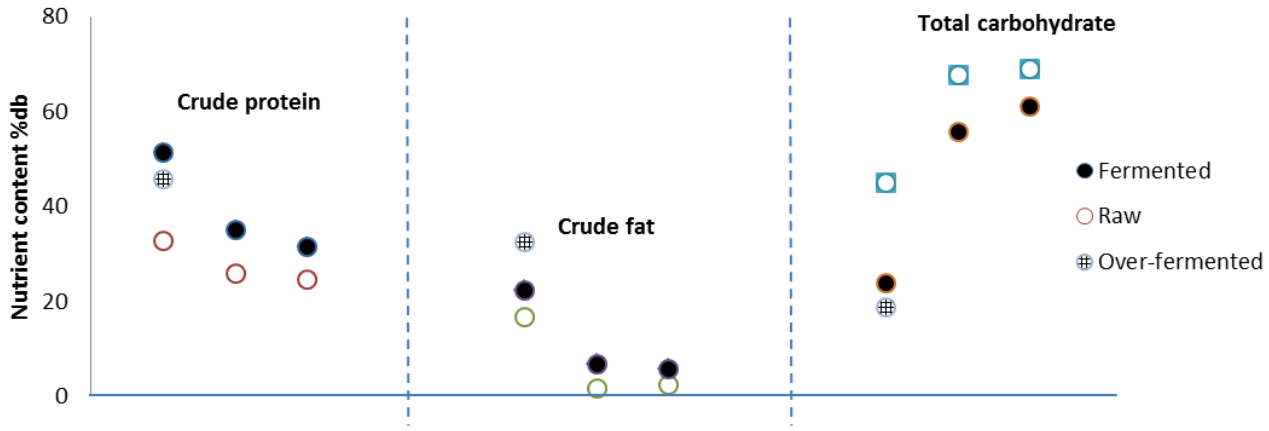

Figure 3. Graph of the content of crude protein, crude fat and total carbohydrate of the selected sources, i.e. soybean (*Glycine max*); *lamtoro* (*Leucaena leucocephala*); and *benguk* (*Mucuna pruriens*); which gathered from the Gunungkidul Market, Yogyakarta, Indonesia as row beans, fermented tempe, and over-fermented tempe

Plant-based protein

Fermented legumes come as the leading plant-based forgotten protein in this research. Above fermented legumes have protein content >30%db. Tempe *mlanding* and tempe *benguk* might be the excellent plant-based sources. Both have high protein content and adaptive in drought climate conditions. Even both legumes, *mlanding* and *benguk* have higher yield capacity compared to common soy-bean (Palupi et al. 2019). The only minus characteristics of legumes are the existence of anti-nutrients like mimosine, anti trypsin, cyanide, *etc.* (Savelkoul et al. 1992; Agbede and Aletor 2005). However, Tempe technique which combines some processes soaking, heating, and fermentation has been proved enable to significantly reduce unwilling component of legumes (Agbede and Aletor 2005). Further investigation on this seems interesting and very supporting for next development and utilization.

Not only high protein, but fermented legumes is also possible to cover both cultural criteria halal and kosher. Plant-based protein is kosher ingredient if it is insect-free (Featherstone 2015). This intention on halal and kosher regulation attracts wider consumers, even by non-Muslim and non-Jewish. They perceive that halal and kosher food might assure the food in the aspect of hygiene, cleanliness, and quality. So these assurances not only contain religious value, but also the food quality itself (Mathew et al. 2014).

In spite of the other plant-based dishes has lower protein content, about 10-28% db, those indigenous plant resources prominently have health functional properties (Barba et al. 2014). Current research reported that *beluntas*, *papaya* leaves, *katuk* (*Sauropus androgynus*), and *kelor (M. citrifolia*) contain high antioxidant and bioactive compounds (Barba et al. 2014; Andarwulan et al. 2012; Otsuki et al. 2010). *Chayote* leaves prominently have anti-hypertensive properties and anti-diabetic properties (Vieira et al. 2019). *M. citrifolia* leaf ethanol proved has larvicidal and pupicidal activities (Lopes et al. 2018). Even, soursop leaves extract reported has antitumor and anticancer (Roduan et al. 2019; Gavamukulya et al. 2017; Roduan et al. 2017). Further in-vitro and in-vivo clinical study on those detail functional components and the effect on the metabolism would be useful for further investigation.

Although plant-based protein has been well reported has lower protein quality compared to animal-based protein, assessed from digestibility, amino acid score, and solubility (Balandran-Quintana et al. 2019, Wu 2016), but for plant-based it seems easier to pass the cultural criteria since almost all plant material is halal and kosher except if it is toxic or non-insect free, respectively (Featherstone 2015). Moreover, plant-based protein has higher probability to get people acceptance, unlike edible-insect which is disguised by the majority of people (Powel et al. 2019).

Safety and sustainability

The next issue that needs to be considered is the safety aspect. Food safety is a first priority criterion in developing food for the global community (Murefu et al. 2019). Issue about toxic components in those forgotten sources has to be further investigated. Many studies reported that edible-insects might contain some toxic and allergens like arginine kinase, tropomyosin, chitinase, hemocyanin, etc. (de Gier and Verhoeckx 2018). In addition, most of those sources were collected as a wild species in which the feed and environment were uncontrolled. However, the current review (Murefu et al. 2019) concluded that, although the knowledge of safety hazard and anti-nutrient of edible-insect leaves a big-gap, the existing processing methods like frying and roasting have been proved enable to improve their safety. Further research on the effect of traditional processing techniques on the anti-nutrient and hazard components might provide a significant knowledge on wider utilization of those insects.

The ability to be constantly produced during harsh climate conditions also becomes an important criterion. Gunungkidul has limestone soil type and dry-warm climate with quite low rain intensity, so that best representative for searching natural sources that adaptive in harsh climate conditions. Almost all above identified sources are enabled

to be obtained either wild harvesting or farming in dry climate conditions (Govorushko 2019). Moreover, some tropical indigenous plants like *M. oleifera* and *M. pruriens* were known to enable to be grown in dry climate condition with low rain intensity and has many functional properties so that prominently as miracle plants (Lampariello et al. 2012; Oyeyinka and Oyeyinka 2018).

In achieving the optimal nutrition and health status, animal-based protein could not come as a single power. Plant-based protein is also very important to complement the whole body requirement (Wu et al. 2014). It was counted that plant-based protein contributes about 65% of global protein consumption (Mărcuţă et al. 2014). Intake of animal based protein less than 30% might cause protein deficiency. Whilst the over intake of animal-based protein might induce unhealthy aging and other non-communicable diseases (Mariotti 2017). About one billion people worldwide have chronic inadequate intake of protein (Wu et al. 2014), so that investigating potential sources for future global protein is urgently in call.

However, this exploration is an early investigation. Further study on the whole chain food system on the correlation with basic nutrition, cultivation, community acceptance, clinical nutrition, product development, national impact, and global protein demand would be an excellent future establishment.

ACKNOWLEDGEMENTS

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Table 3. Identified forgotten protein sources from aquatic and wild animals in Gunungkidul, Yogyakarta, Indonesia

Category and type (local name)	Morphology	Scientific name	Halal status
Aquatic animal			
Sea snail (*Ungsal*/*Keong laut*)	Various color and shape	*Gibbula divaricate*	Halal
Aquatic snail (*Keong sawah*)	Golden brown	*Pila ampullacea*	Halal if not harmful
Crabs			
• *Kejung*	Tiny crabs (smaller than *Yuyu kecil*)	*Parathelphusa convexa*	Halal
• *Yuyu kecil*	Small crabs	*Parathelphusa convexa*	Halal
• *Jingking/rajungan*	Sea crabs	*Portunus pelagicus*	Halal
Shells (*Remis*)	Baby shells	*Pilsbryoconcha exilis*	Halal
Fish			
• *Panju*	Snake-like	*Belone belone*	Halal
• *Layur*	Long and flat shape	*Trichiurus lepturus*	Halal
• *Ikan wader*	Baby fish	*Barbodes binotatus*	Halal
• *Ikan cethul*	New hatchling fish	*Poecilia reticulate*	Halal
• *Ikan teropong*	Has yellow line	*Rastrelliger* sp.	Halal
• *Ikan lakar*	Roundhead shape	*Caranx ignobilis*	Halal
• *Ikan keting*	Has mustache	*Mystus*	Halal
Wild animal			
Squirrel (*Tupai*)		*Scandentia*	Halal
Ferret (Musang)		*Paradoxurus hermaphrodites*	Haram, halal by some *Ulama*
Wild chicken (*Ayam hutan/pithik alas*)		*Gallus gallus*	Halal
Hedgehog (*Landak*)		*Hystrix brachyuran*	Halal

Table 2. Identified forgotten protein source from edible insects in Gunungkidul, Yogyakarta, Indonesia

Category and type (local name)	Morphology	Scientific name	Halal status (as confirmed by halal expert from MUI)	Harvest period and local value	Processed product	How to hunt	How to prepare	How to cook and serve
Grasshopper				• Hunted during harvest time of rice/maize, once in a year • Locally cultivated • Along the year if cultivated • For sale till 100 000 IDR/kg	Fried	Afternoon after sunset the grasshopper is sleeping so that is easy to be collected by shaking the rice leaves using bamboo, abundant when the rice is yellowish	Cut the wings, part of leg, and head-washed-drained using *kukasan* add hot water/boiled till red (half done)-marinade (using palm sugar and spices)-fried	• *Bacem* (salt, garlic, palm sugar, coriander) • Salty (salt, garlic, coriander) • Spicy (salt, garlic, coriander, chili) • Serve together with *Thiwul* (staple food made from cassava)
Bird grasshopper (*Belalang Gambuh*)	Pre-adult: green, big size Adult: yellowish-brown, yellowish or green with bluish-black marks	*Schistocerca lineata*	Halal					
Javanese grasshopper (*Belalang kayu*)	Yellowish-brown	*Valanga nigricornis*	Halal					
Rice grasshopper (*Belalang dami*)	Punctate, small size, abundant in number	*Oxya chinensis*	Halal					
Caterpillar				• Not yet cultivated • Collected by hunting • For sale till 120 000 IDR/kg • Hunted during transitional season, once in a year	Fried	Morning, when sunshine the caterpillar come down to form a cocoon, avoid the itchy string, collect the caterpillar reaches the ground using bamboo	Add hot water/boiled (half done)-drained using *kukasan*-marinade (using palm sugar and spices)-fried	• *Bacem* (salt, garlic, palm sugar, coriander) • Salty (salt, garlic, coriander) • Spicy (salt, garlic, coriander, chili) • Serve together with *Thiwul* (staple food made from cassava)
Caterpillar of teak tree (*Ulat jati*) Cocoon of teak tree (*Enthung jati*)	Black, small	*Hyblaea puera*	• Halal • Haram if disgust according to consumer					
Caterpillar of iron tree (*Ulat besi*) Cocoon of iron tree (*Enthung johar*)	Green	*Catopsilia pyranthe*	• Halal • Haram if disgust according to consumer					
Caterpillar of soursop tree (*Ulat sirsak*)	Green, quite big size	*Meganoton rubescens*	• Halal • Haram if disgust according to consumer					
Cocoon of mahogany/ cashew/ kedondong tree (*Ungkrung/ enthung*)	Gold, fatty	*Cricula trifenestrata*	• Halal • Haram if disgust according to consumer					

Termite (*Laron*)	Flying termite	*Macrotermes gilvus* (big) *Odontotermes javanicus* (small)	• Halal • Haram if disgust according to consumer	• Not yet cultivated • Collected by hunting • Not for sale • Only for personal consumption, hunted during transitional season, once in a year • Difficult processing • Distaste due to pollution	• Fried • *Pelas* • *Rempeyek* • Roasted as glutamate stock (*bumbu kelan*)	Direct collected from their nest or hunted in the evening by turning on only one light and put water in a container. The termite will huddle in the container so that ready to be processed	Add hot water/boiled (half done)-drained using *kukasan*	• Fried • *Pelas*: steamed in wrapped banana leaves with many herbs and spices • *Rempeyek*: crispy fried using rice flour and spices • *Bumbu kelan*: roasted-washing-used as flavoring agent-possible for multiple use
Bee (*Tawon madu*) *Bee* *Bee hive* *Bee eggs* *Bee larva*	Common bee	*Apis mellifera* *Apis cerana* *Apis dorsata*	• Bee: haram Bee hive: halal Bee eggs: halal Bee larva: halal if only unable to be separated from the hive/honey	• Sometimes for sale	• • *Besengek* • *Pelas* • Fried • *Rempeyek*	Collect from the nest	Add hot water/boiled (half done)-drained using *kukusan*	• • *Besengek*: cooked with thick coconut milk and mixed with Koro Benguk bean • *Pelas*: steamed in wrapped banana leaves with many herbs and spices • *Rempeyek*: Crispy fried using rice flour and spices
Beetle (*Kumbang*/*puthul*/*rampal*)	Live in banana leaves, chilli leaves, and *sengon* leaves	*Phyllophaga* sp.	Halal if not disgusting according to consumer	• Not yet cultivated • Collected by hunting along the year • Not for sale • Only for personal consumption	• Fried	Along the year after the sunset	Add hot water/boiled (half done)-drained using *kukasan*-marinade (using palm sugar)-fried	• • *Bacem* (salt, garlic, palm sugar, coriander) • Spicy (salt, garlic, coriander, chilli) • Salty (salt, garlic, coriander) • Serve together with *Thiwul*
Stinkbug (*Lembing batu*)	Round flat shape, close habitat with grasshopper	*Scotinophara coarctata*	Haram	• Hunted during harvest time of rice/maize, once in a year • Not for sale	Fried	Evening	Add hot water/boiled (half done)-drained using *kukasan*	Served with onion sauce

Table 4. Identified forgotten protein sources from legumes, fermented food, mushrooms and by-products in Gunungkidul, Yogyakarta, Indonesia

Category and type (local name)	Morphology	Scientific name	Negligence reason	Processed product	How to cook
Legumes					
Kacang benguk	Harder than soybean	*Mucuna pruriens*	• Hard to be processed	• *Tempe* (fermented)	• Soaked at least 3 days (*kacang benguk*)
Kacang tholo	Pale brown with black germ	*Vigna unguiculata*	• Poisonous	• *Thokolan* (sprouted)	• Grown in humid media
Lamtoro	Green and slimy	*Leucaena leucocephala*	• Rarely found	• *Bothok, pepes, bongko*	• Seasoned, wrapped with banana leaves, steamed
Kacang koro	Brown flat	*Canavalia ensiformis*	• Less preferred	• Porridge	• Cooked with abundant water
Kacang koro pedang	Giant and red	*Canavalia gladiate*	• Unable to be sold	• *Trancam* (fresh salad)	• Mixed with cucumber, cabbage, grated coconut
Kacang kecipir	Round and brown	*Psophocarpus tetragonolobus*		• *Urap* (cooked salad)	• Mixed with papaya leaves, grated coconut
Klenthang		*Sesbania grandiflora*		• *Rempeyek*	• Fried with flour cover
Kacang gude	Black, small size, soy bean-like	*Cajanus cajan*		• *Brongkos* (milky soup)	• Soup mixed with young jackfruit, coconut milk/candlenut, garlic, shallot, pepper, coriander
Fermented food					
Tempe benguk	Fermented product of "*benguk*" bean	*Mucuna pruriens*		• Clear soup	• Mixed with other leaves with garlic and shallot spices, some add tamarind
Tempe mlanding	Fermented product of "*lamtoro*" bean	*Leucaena leucocephala*			
Tempe klenthang	Fermented product of "*klenthang*" seed	*Sesbania grandiflora*			
Tempe koro	Fermented product of "*koro*" bean	*Canavalia ensiformis*			
Tempe biji kecipir	Fermented product of "*kecipir*" seed	*Psophocarpus tetragonolobus*			
Mushrooms					
Jamur gagang	Very tough texture	*Phycomycota*	• Tough texture	• Stir-fried	• Served together with "*thiwul*"
Jamur grigit	Growing in weathered wood	*Schizophyllum commune*	• Poisonous	• Bothok, pepes, bongko	• *Gagang* mushroom is very tough (washed using hot water-pounded with *lumpang* pounder made from Sambi wood-seasoned with shallot, garlic, salt, chili-added with grated coconut-*bothok*)
Jamur trucuk	White, some black	*Schizophyllum commune*	• Rarely found	• Porridge	
Jamur so	Yellow, bitter, have to be peeled	*Scleroderma aurantium*	• Less preferred	• Fresh salad	
Jamur barat	As wide as hand	*Clitocybe nebularis*		• Cooked salad	
Jamur cepaki	White, small caps	*Clavariadelphus truncatus*		• Fried with flour cover	
Jamur krucu	Growing on the ground	*Morchella esculenta*		• Milky soup	
Jamur gajih	Similar to *gagang* mushroom	*Oudemansiella canarii*		• Clear soup	
By-products					
Tempe gembus	Fermented product made from by-product of tofu production	*Glycine max*	Less preferred particularly by the young generation	Fried	
Kulit benguk	Outer skin of kacang benguk	*Mucuna pruriens*		Milky soup	
Tempe busuk	Over fermented soy tempeh (>3 days)	*Glycine max*		Stir-fried	
Bekatul	Outer skin of rice	*Oryza sativa*		*Jenang*	Long cooking with coconut and palm sugar-baked

Table 5. Identified forgotten protein sources from protein-rich plant in Gunungkidul, Yogyakarta, Indonesia

Category and type (local name)	Morphology	Scientific name	Negligence reason	Processed product
Leaves				
Daun beluntas	Aromatic leave	*Pluchea indica*	Rarely found	• Fresh salad
Daun bayung	Leaves of long beans	*Vigna unguiculata ssp.*	Complicated handling	• Cooked salad
Kenikir	Hedgerow	*Cosmos caudatus*	Not practical	• Keripik/crispy snack: thin-sliced-fried
Daun plikacu/ tali kacu	Butterfly-like	*Bauhinia purpurea*		• Tumis: stir-fried with seasoning
Daun jambu monyet	Green reddish	*Anacardium occidentale*		• Jangan bening : clear soup
Daun putri malu	Bush with small leaves	*Mimosa pudica*		• Lodeh: milky soup using coconut milk
Daun ubi jalar	Wide and purplish	*Ipomea batatas*		• Urap kencur : fresh salad with "kencur" leaves
Selada air	Small leaves and watery	*Nasturtium officinale*		• Pecel: cooked salad using peanut sauce
Daun besaran	Like berry leaves	*Morus australis Poir*		• Trancam: fresh salad with grated coconut
Daun simbuan	Specific flavor	*Paederia foetida*		• Rempeyek: seasoned-mixed with rice flour-fried crispy
Daun labu siam	Wide with curly tail	*Sechium edule*		• Urap/Gudangan: cooked salad with graded seasoned coconut
Daun labu kuning	Wide and hairy	*Cucurbita moschata*		• Lalapan: boiled with some salt
Daun krokot	Red color	*Portulaca villosa Cham.*		• Bobor: porridge with milky seasoning
Daun katuk	Dark green and small	*Sauropus androgynus*		• Bothok: mixed with grated coconut and spices, wrapped with banana leaves, steamed
Daun kelor	Small and tender	*Moringa oleifera*		• Brongkos (milky soup): Soup mixed with young jackfruit, coconut milk/candlenut, garlic, shallot, pepper, coriander
Daun lamtoro	Tree with small leaves	*Leucaena leucocephala*		• Gembrot/bongko: mixed with grated coconut and spices, wrapped with banana leaves, steamed
Daun so/mlinjo	Long, green reddish	*Gnetum gnemon*		• Gudhek: milky soup mixed with palm sugar (coconut flower and young jackfruit)
Daun Jlidri	Long, tight and green	*Elaeocarpus ganitrus*		
Daun bunga turi	Tree with small leaves	*Sesbania grandiflora*		
Daun papaya	Wide fig leaf	*Carica papaya*		
Daun pace	Wide, green yellowish	*Morinda citrifolia*		
Daun cikra-cikri	Long, thin fig leave	*Polyscias fruticosa*		
Daun sirsak	Green tight leave	*Annona muricata L.*		
Daun mangga	Green yellowish tight leave	*Mango foliorum (Mangifera indica leaves)*		
Daun nangka muda	Wide round green yellowish	*Artocarpus heterophyllus*		
Flowers				
Bunga papaya	Flowers of papaya	*Carica papaya*		
Bunga turi	Flowers of klenthang	*Sesbania grandiflora*		
Manggar	Flowers of coconut	*Cocos nucifera*		
Jantung pisang	Flowers of banana	*Musa paradisiaca*		
Bunga duren	Flowers of durian	*Durio zibethinus*		
Stem				
Lompong	Young stem of taro	*Colocasia esculenta*		
Benalu kemladean	Parasite plant of "Kelor" (*Moringa oleifera)*			
Rebung	Young stem of bamboos	*Gigantochloa atter*		
Ares	Young stem of banana	*Musa paradisiaca*		
Fruits				
Nangka muda	Young fruit of jackfruit	*Artocarpus heterophyllus*		
Sukun	Breadfruit	*Artocarpus altilis*		
Kluwih	Like small jackfruit	*Artocarpus camansi*		
Bligo	White, pumpkin-like	*Benincasa hispida*		
Gayam	Like giant nut	*Inocarpus fagifer*		
Aquatic plants				
Seaweed/*Rumput laut*	Green	*Euchema cottoni*		
(5 colors)	Red	*Eucheuma spinosum*		
	Green, small leaves	*Caulerpa corynephora*		
	Red	*Acanthophora spicifera*		
	Green, wide leaves	*Ulva lactuca*		

Table 6. Macronutrient content of selected identified protein source

Identified forgotten food	Local name	Scientific name	Moisture	Ash		Conver-sion factor	Crude protein		Crude fat		Total carbo-hydrate		Protein as % energy	Edible fiber	
			%wb	%wb	%db		%wb	%db	%wb	%db	%wb	%db		%wb	%db
Egg (as standard)	Local egg	*Broiler domesticus*	75.40±0.52	0.90±0.03	2.51±0.11	6.25	12.76±0.01	36.67±0.03	8.45±0.04	24.18±0.14	2.50±0.47	5.91±1.90	37.23	na	na
Edible insects															
Local red meat	*Daging sapi*	*Bos taurus*	71.38±0.07	1.44±0.04	4.98±0.14	6.25	18.26±0.31	63.80±0.93	8.59±0.14	30.01±0.57	0.39±0.01	1.35±0.03	48.08	2.81±0.01	11.62±0.02
Grasshopper	*Belalang kayu*	*Valanga nigricornis*	69.45±0.04	1.05±0.01	3.44±0.05	6.25	22.45±0.35	73.47±1.24	3.49±0.04	11.42±0.15	3.70±0.25	12.11±0.82	66.02	9.41±0.32	30.79±1.00
Caterpillar	*Ulat jati*	*Hyblaea puera*	60.67±0.63	3.21±0.01	8.23±0.15	6.25	27.45±0.76	70.32±0.82	5.84±0.08	14.97±0.05	2.82±0.20	7.22±0.62	63.23	23.77±1.47	47.70±4.66
Legumes															
Soybean	*Kacang kedelai*	*Glycine max*	9.51±0.15	4.95±0.02	5.46±0.03	5.52	29.65±1.27	32.76±1.34	15.19±0.11	16.79±0.10	40.72±1.21	44.99±1.41	28.36	16.43±0.01	18.16±0.05
Lamtoro bean	*Mlanding*	*Leucaena leucocephala*	71.28±0.25	1.39±0.01	4.82±0.02	5.52	7.46±0.37	25.96±1.54	0.47±0.01	1.62±0.01	19.42±0.62	67.60±1.54	26.70	17.86±0.17	62.19±0.04
Benguk bean	*Kacang benguk*	*Mucuna pruriens*	21.70±0.16	3.21±0.01	4.10±0.03	5.52	19.30±0.19	24.64±0.29	1.80±0.02	2.29±0.02	54.00±0.33	68.97±0.28	24.95	22.30±0.01	28.48±0.07
Tholo bean	*Kacang tholo*	*Vigna unguiculata*	12.56±0.14	3.49±0.01	3.99±0.01	5.52	18.54±0.33	21.20±0.34	0.61±0.01	0.70±0.02	64.80±0.21	74.11±0.36	21.89	35.53±0.06	40.63±0.13
Gude bean	*Kacang gude*	*Cajanus cajan*	15.59±0.07	4.10±0.01	4.85±0.00	5.52	19.10±0.29	22.62±0.36	0.81±0.02	0.95±0.02	60.42±0.33	71.57±0.33	23.48	33.05±0.04	39.15±0.01
Fermented food															
Fermented soybean	*Tempe kedelai*	*Glycine max*	65.70±0.19	0.94±0.01	2.74±0.06	6.25	17.59±0.38	51.28±0.83	7.65±0.05	22.29±0.02	8.13±0.23	23.70±0.79	40.97	9.91±0.04	28.88±0.26
Fermented *lamtoro* bean	*Tempe mlanding*	*Leucaena leucocephala*	73.48±0.35	0.66±0.01	2.47±0.06	6.25	9.30±0.11	35.07±0.03	1.80±0.25	6.77±0.84	14.78±0.01	55.71±0.75	33.06	14.04±0.01	52.94±0.74
Fermented *benguk* bean	*Tempe benguk*	*Mucuna pruriens*	66.88±0.27	0.63±0.01	1.89±0.04	6.25	10.41±0.23	31.42±0.96	1.88±0.05	5.66±0.10	20.22±0.46	61.04±0.89	29.86	13.75±0.11	41.52±0.68
By-product															
Fermented tofu by-product	*Tempe gembus*	*Glycine max*	82.28±0.57	0.51±0.02	2.85±0.03	6.25	4.92±0.06	27.74±0.54	2.01±0.11	11.34±0.27	10.30±0.38	58.13±0.28	24.92	8.80±0.08	49.66±2.08
Overfermented soybean	*Tempe busuk*	*Glycine max*	63.53±1.19	1.19±0.05	3.25±0.02	6.25	16.65±0.59	45.64±0.02	11.86±0.16	32.51±0.71	6.79±0.38	18.62±0.38	33.22	11.08±0.08	30.38±0.38
Rice bran	*Bekatul*	*Oryza sativa*	13.13±0.06	6.58±0.03	7.57±0.04	5.17	7.54±0.01	8.68±0.02	6.19±0.01	7.13±0.01	66.56±0.08	76.62±0.05	8.57	15.58±0.47	17.93±0.53
Protein-rich plant															
Moringa leaves	*Kelor*	*Moringa oleifera*	80.57±0.11	1.79±0.04	9.19±0.24	4.43	3.47±0.01	17.83±0.07	0.93±0.02	4.76±0.08	13.25±0.11	68.19±0.19	18.45	na	na
Beluntas leaves	*Beluntas*	*Pluchea indica*	87.97±0.41	2.04±0.08	16.92±0.07	4.43	1.79±0.08	14.84±0.14	0.24±0.01	2.00±0.05	7.98±0.25	66.29±0.20	17.36	9.32±0.02	77.43±2.46
Kenikir leave	*Kenikir*	*Cosmos caudatus*	85.83±1.48	1.50±0.20	10.59±0.30	4.43	2.52±0.30	17.78±0.24	0.22±0.02	1.52±0.01	9.94±0.96	70.15±0.53	19.45	9.89±0.05	69.76±7.66
Longyardbean leave	*Bayung*	*Vigna unguiculata* ssp.	88.90±0.14	1.06±0.01	9.55±0.01	4.43	3.20±0.07	28.83±1.00	0.28±0.00	2.52±0.03	6.57±0.19	59.14±0.97	30.77	8.24±0.06	74.23±1.46
Pepaya flower	*Bunga pepaya*	*Carica papaya*	87.93±0.06	1.96±0.04	16.20±0.38	4.43	2.13±0.00	17.65±0.09	0.54±0.00	4.47±0.02	7.45±0.10	61.72±0.49	19.73	7.24±0.03	59.98±0.08
Aquatic sources															
Seaweed	*Rumput laut*	*Euchema cottoni*	33.05±0.09	21.92±0.39	32.73±0.54	4.43	7.30±0.13	10.90±0.22	0.34±0.01	0.50±0.01	37.42±0.17	55.89±0.33	16.05	30.46±0.34	45.50±0.57
Aquatic snail	*Keong sawah*	*Pila ampullacea*	83.93±0.15	4.03±0.11	25.05±0.43	6.25	9.48±0.08	58.99±1.07	0.42±0.01	2.61±0.02	2.15±0.12	13.35±0.62	75.39	3.75±0.01	23.30±0.17

Note: %wb: percentage in wet basis w/w; %db: percentage in dry basis w/w or equal to g/100g dry matter; na: data is not available; protein as % energy is energy contribution from protein in calorie calculated from energy value from protein per total energy = [g protein content x 4 cal/g)/[(g protein content x 4 cal/g) + (g fat content x 9 cal/g) + (g carbohydrate content x 4 cal/g)]] x 100%

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