Physicochemical, nutritional, and functional properties of Javanese grasshopper (Valanga nigricornis Burm.) flour

Dita Kristanti
Departemen Urusan Riset Nasional: Lembaga Ilmu Pengetahuan Indonesia

Ade Chandra Iwansyah
chandra.iwansyah@gmail.com

LIPI: Lembaga Ilmu Pengetahuan Indonesia

Woro Setiaboma
Lembaga Ilmu Pengetahuan Indonesia

Woro Faisal Setiaboma
Lembaga Ilmu Pengetahuan Indonesia

Dini Ariani
Lembaga Ilmu Pengetahuan Indonesia

Ervika Rahayu Novita Herawati
Lembaga Ilmu Pengetahuan Indonesia

I Gusti Made Raka Alpin Aditya
Lembaga Ilmu Pengetahuan Indonesia

Gradia Martin Jati Pramareti
Lembaga Ilmu Pengetahuan Indonesia

Ashri Indriati
Lembaga Ilmu Pengetahuan Indonesia

Hazrulrizawati Abd Hamid
Universiti Malaysia Pahang Al-Sultan Abdullah

Research Article

Keywords: digestibility, edible insects, Javanese grasshopper, sodium bicarbonate, ultrasound

Posted Date: April 9th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4209615/v1
Abstract

The flour prepared by the edible Javanese grasshopper (*Valanga nigricornis* Burm.) is an innovative and sustainable food source which is high in protein and other essential nutrients. The study focused on the pre-treatment effect on the nutritional and functional properties of Javanese grasshopper (JG) flour. The nutritional properties, protein digestibility, and amino profile of JG flour were evaluated. The physical properties, microstructure, and functional groups of JG flour were also measured. The results show that pre-treatment on JG flour significantly affected the yield, color, total solid, activity water, microstructure, ash, fat, and protein content (*p* < 0.05). Based on nutritional, physical, and functional properties of JG flour, pre-treatment using 0.3% sodium bicarbonate for 15 mins and blanched 2–3 mins has the highest ash, fat, and protein content with a complete essential amino acid such as histidine, threonine, methionine, valin, phenylalanine, isoleucine, leucine, and lysine. The JG flour, with good pre-treatment, can be used as an alternative functional and fortifying ingredient food.

1. Introduction

Eating insects has been practiced in Asian, African, Australian, and European countries, even though the Greeks named it entomophagy (Lim et al., 2022; Toti et al., 2020). Insect feeding has been practiced since prehistory. This technique is still practiced today, and there are several benefits to eating insects, such as lower pesticide use and higher vitamin content.

In Indonesia, edible insects such as crickets, grasshoppers, dragonflies, and bees are commonly consumed (Paulin and Purwanto, 2020). Although edible grasshoppers were determined to be a pet, it offers potential protein value. Mexican grasshopper (*Sphenarium purpurascens*) comprises 60.70-63.94% crude protein, 23.15–31.81% dietary fiber, 10.37–14.86% crude fat, and 87.92–90.01% protein digestibility; additionally, the nutrient values were altered by its diets (Ibarra-Herrera et al., 2020). The Javanese grasshopper (JG) is particularly popular in Gunungkidul, Yogyakarta. The Javanese grasshopper (*Valanga nigricornis* Burm) has a moisture content of 7.05%, an ash content of 3.04%, a fat content of 9.45%, and a protein content of 72.50% (Paulin and Purwanto, 2020). The grasshopper is often served fried, but the current food trend has been produced as a substitution for foods such as sausage or baby biscuits. The flour can be applied in simple ways and possibly to prolong the shelf-life (Cruz-López et al., 2022; Dewi et al., 2020).

The pre-treatment process used in food preparation is applied to improve the quality of the product. The common pre-treatment used in food preparation are physical treatment (blanching, drying, ultrasonic, microwave, radiation) or chemical treatment (enzymatic, adding the acid, base, or salt solution). Ultrasonic treatment is a non-toxic processing technology that has been explored in various edible insects (Kingwascharapong Chaijan and Karnjanapratum, 2021; Rivero-Pino Espejo-Carpio and Guadix, 2020; Wang et al., 2021). Ultrasonic treatment might unfold the protein structure and reduce particle size so that it contributed to functional properties (Kang et al., 2022). An ultrasound-assisted process on Bombay locusts (*Patanga succinta* L.) proven to enhance yield and protein recovery, alter hydrophobicity, changes
in free α-amino concentration, improve solubility, affect the emulsion activity and stability, affect the isoelectric point and molecular features of protein (Kingwascharapong Chaijan and Karnjanapratum, 2021). The ultrasonic pre-treatment lead to the changes in particle dimension, sulfhydryl content, increased hydrophobicity on the surface, and strengthened the emulsifying capacity of *Clanis bilineata* protein (Wang et al., 2021).

Pretreatment using sodium bicarbonate in legumes has been shown to increase protein digestibility and crude protein content (Kalpanadevi Mohan and Technology, 2013). An increase in *Na₂CO₃* concentration affected the increase in pH, protein solubility, the number of unbound sulfhydryl groups, emulsification capacity, surface hydrophobicity, and pale, soft, and exudative (PSE) meat myofibrillar proteins emulsion stability (Zou et al., 2022). Sodium bicarbonate infiltrates in bonding between an anion (*HCO₃⁻*) and water (*H₂O*), where it would change the functional properties. A combination of blanching and sodium bicarbonate should be done to keep color and to decrease antinutrients (Ayele Latif and Müller, 2022). The pre-treatment of salt pork protein using combined ultrasonic and sodium bicarbonate affected the myofibrillar protein characteristics (Kang et al., 2022). However, there is limited information about pre-treatment using ultrasonic, and sodium bicarbonate for edible insect flour preparation especially in Javanese grasshoppers. Thus, the study aims to determine the pre-treatment (fresh, ultrasonic, and sodium bicarbonate) effect on the nutritional and functional properties of JG flour.

**2. Materials and Methods**

**2.1 Materials**

The study materials include fresh Javanese grasshopper (*Valanga nigricornis*) purchased from Extreme Food MSME, Wonosari, Gunungkidul district, Yogyakarta. Sodium bicarbonate (*NaHCO₃*) was purchased from Sigma-Aldrich (Singapore). This study was carried out from June until September 2022, located at Food Product Development Laboratory, Research Center for Food Technology and Processing (PRTPP), National Research and Innovation Agency (BRIN), Playen, Gunung Kidul, D.I. Yogyakarta, Indonesia.

**2.2 Sample preparation**

Fresh grasshopper (*Valanga nigricornis* Burm.), 6–8 cm in size, sorted by removing the wings, hind legs, and removing the entrails (known as "betet") (Fig. 1), then washing. Then draining is carried out, put into the dryer (B0: control); soaked in water and ultrasonicated, 35 KHz, for 60 minutes (B1); soaked in 0.3% sodium bicarbonate in water and blanched for 2–3 mins, at temperature 70–80 C (B2). Then the drying process is performed with a temperature of 50–60 C using a cabinet dryer until the water content of the dried grasshoppers reaches 4–6%, the dried grasshoppers are then crushed for the flouring process using a disk machine, hygienically. The Javanese grasshopper flour obtained is then carried out by a screening process using a separating machine with a screen size of 60 mesh. The Javanese grasshopper flour is obtained with a size of 60 mesh, then packaged.
2.3 Experimental design

Current study utilized a completely randomized design (CRD) method with with type of pre-treatment as factor (B), namely B0 = control, B1 = ultrasonic at 35 KHz, for 60 mins, and B2 = 0.3% sodium bicarbonate and blanched at 70–80 °C for 2–3 mins., three repetitions, 9 experimental units.

2.4 Physicochemical Analysis

2.4.1 Physics properties

Physicochemical properties including response viz., yields, pH, total solid, water activity \( (a_w) \), and solubility, were determined. pH, total solid, water activity, yields, and solubility were determined by (Iwansyah et al., 2022) and (Solichah et al., 2021) methods.

2.4.2 Fourier Transform Infrared (FTIR) Spectroscopy

Chemical bonds in Javanese grasshopper flour were examined by FTIR Spectroscopy. FTIR spectrometer (Vertex 70, Germany) operating in ATR mode (Platinum accessory) between 4000 and 400 cm\(^{-1}\) was used to make this examination.

2.4.3 Scanning Electron Microscope (SEM)

The microstructure of JG flour was scrutinized using SEM at the Research Center of Food Technology and Processing, National Research and Innovation Agency (BRIN), Playen, D.I. Yogyakarta. Approximately 0.2 g of materials were placed on the tape's sticky side to create samples. Vacc 5 kV SI 30% Coating Au 20 mA.

2.5 Nutritional properties

2.5.1 Proximate analysis

Nutritional properties of JG flour was analyzed based on AOAC, 2005, which included: ash (gravimetric method), moisture (moisture analyzer), protein (DuMas method), fat (Soxhlet method), carbohydrate (by difference method), fiber and energy calculation with At-Water factor (Horwitz and Latimer, 2007).

2.5.2 Protein digestibility

The digestibility of JG flour was analyzed by in vitro enzymatic assay (Ratnawati et al., 2021). The sample was weighed (100–200 mg), then dissolved with 9 mL Walpole buffer (pH 2.0; 0.1 N). Then added one mL of pepsin enzyme (2%) and incubated in an incubator shaker at 37°C for 5 hours, pellet and digestion results were separated using a centrifuge (3000 rpm; 20 minutes), then filtered. 5 mL of supernatant was dissolved in 5 mL of TCA (20%) and incubated for 15 hours at ambient temperature. Filtered with Whatman paper No. 41. The micro Kjeldahl method was used to further examine the protein residue in the filtrate.
2.5.3 Amino acids quantification

Samples (60 mg) were added to 4 mL of HCl 6N and then heated at 110°C for 24 hours. It was further cooled and neutralized with NaOH 6N, added aquabidest up to a volume of 10 mL and filtered using Whatman paper. The sample (50 µL) was then added to an orthopthaldehyde (OPA) solution (300 µL) and stirred for 5 minutes (MannebergLahm and Fountoulakis, 1995). Thermo Dionex UltiMate 3000 HPLC with a LiChrospher 100 RP-18 (5mm) column was used to measure amino acid content. The operating conditions were as follows: 10 µL of sample injected at a flow rate of 1.5 mL/min, 300 and 500 nm of excitation and emission wavelengths using an RS Fluorescence Detector (FLD). The mobile phase A consists of a mixture of CH$_3$OH:50mM sodium acetate: THF pH 7.8 in a ratio of 2:96:2, and the mobile phase B used was 65% CH$_3$OH. Amino acid standards were also injected separately to quantify amino acids in the samples.

2.6 Data and statistical analysis

Data measurement results are displayed as mean ± standard deviation. Normality of the data was tested with Saphiro-Wilk. Variance among the group was investigated using ANOVA and Duncan as the posthoc test. The best JG flour was determined according to the protein content and in vitro digestibility. Pearson's correlation test was utilized to describe the relationship between physicochemical properties and protein digestibility.

3. Results and Discussion

3.1 Physical and functional properties

The physical properties of JG flour (Table 1) shows that a significant difference between the treatment and control groups in yields, total solids, and water activity (a$_w$) parameters ($p < 0.05$). The a$_w$ value of JG flour ranged from 0.53 to 0.44. This low value allows Javanese grasshopper flour to be preserved for a long time. The influence of a$_w$ on the growth of bacteria in food is crucial. Most bacteria require ideal temperatures with a water activity (a$_w$) level between 0.9 and 1 (Allen Jr, 2018). Since some halophilic bacteria can grow at 0.75 aw, these microbes are not frequently seen in food contamination (Stevenson et al., 2015). In addition to moisture and water activity, the pH factor influences various chemical and microbiological interactions. Furthermore, pH affects the color and taste of food products (Shi et al., 2022). Javanese grasshopper flour tends to have neutral pH.
Table 1

Physical properties of Javanese grasshopper flour

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yields (%)</td>
<td>17.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.86&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>28.92&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH</td>
<td>6.08 ± 0.01</td>
<td>6.12 ± 0.02</td>
<td>6.69 ± 0.01</td>
</tr>
<tr>
<td>Total solid (%brix)</td>
<td>1.67 ± 0.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.05 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.05 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aw</td>
<td>0.53 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.44 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.39 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Solubility (%)</td>
<td>13.75 ± 2.08</td>
<td>13.75 ± 2.08</td>
<td>13.75 ± 2.08</td>
</tr>
<tr>
<td>Colour:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*L</td>
<td>35.16 ± 0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>103.28 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>103.28 ± 0.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>*a</td>
<td>10.92 ± 0.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.02 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.02 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>*b</td>
<td>22.74 ± 0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.20 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.20 ± 0.00&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are displayed as mean ± standard deviation (s.d) (n = 3). a > b > c. Significant differences are denoted by different letters in the same row (p < 0.05).

The amounts of organic acids and sugars were related to the number of soluble solids (Zhang and Vardhanabhuti, 2014). The flour control has 1.67 Brix and B1 and B2 flour have 0.05 Brix (Table 1). The components in the JG flour have a solubility of 13.75%. Another physical parameter observed in JG flour is color. Colors were denoted by the letters L, *a, and *b, with L values ranging from black to white, *a values from red to green, while *b ranging from yellow to blue. L value describes brightness. The B1 and B2 of JG flour have a high brightness with an L value of 103.28, while the flour control has an L value of 35.16. The color (*a) value of B1 and B2 JG flour was 0.02, whereas the control 10.92 L value. The B1 and B2 *b values tend to be yellow, and control flour tends to have a blue color. Overall, the color is related to consumer acceptance, and the high value of L makes the food acceptance rate high.

The surface morphology and microstructure of Javanese grasshopper flour and protein concentrates are shown in Fig. 2. SEM was used to analyze the impact of pre-treatment on the surface structure of JG flour. The microstructure of B0 displays irregular fractional aggregate that is clearly visible on the surface, which is affected by the drying process, leaving the aggregate and porous structure (Monisha and Loganathan, 2022). There is no visible porous structure on the surface of B1 flour; the compact surface structure and the observed granule shape are smaller because of the influence of ultrasonic processes, which can break large particles into smaller particles so that the resulting granule aggregates form smaller particles, and the resulting small particles form a compact structure on the flour surface. In addition, smaller particle sizes can improve protein solubility (Liu et al., 2022). The microstructure on the surface of B2 flour shows greater aggregation and has a porous structure; thus, the surface is not
smooth. This condition is influenced by the pre-treatment of the soaking and blanching process, which causes swelling of particles owing to the absorption ability during the pre-treatment process (Locali-Pereira et al., 2022). Figure 2 show the morphology of JG flour by different pre-treatment techniques.

The FTIR spectra showed that certain flour samples had shifted peaks, based on FTIR functional group analysis. Variations in peak values were primarily caused by chemical links formed between the functional groups in Javanese grasshopper flour (See Fig. 3).

Figure 3 shows the IR spectra of JG flour which various pretreatments. The IR spectra of both pretreatments and control (B0, B1, and B2) were not significantly different. The peak of IR spectra was seen in wavelengths of 1056.87, 1226.59, 1396.31, 1519.74, 1627.74, 2850.48, 2919.91, and 3267.05 cm⁻¹. This result showed that the ultrasonic and sodium bicarbonate pre-treatments in the JG do not change the IR group of the JG flour spectra. Nevertheless, the lower amplitude of the peak of IR spectra was observed for B1 and B2. These outcomes are in accordance with (KingwascharapongChaijan and Karnjanapratum, 2021), the peak IR spectra in Bombay locusts did not differ markedly but there was a decrease in amplitude after sonication treatment.

The IR spectra in Bombay locusts displayed the prevailing band for protein Amide A (3300–3440 cm⁻¹), protein Amide B (2900–3200 cm⁻¹), protein Amide I (1700–1600 cm⁻¹), protein Amide II (1600–1500 cm⁻¹) and protein Amide III (1300–1200 cm⁻¹) (KingwascharapongChaijan and Karnjanapratum, 2021). The protein Amide A and Amide B accordance with N-H and C-H stretching vibrations (–NH3), protein Amide I correspond to N–H bending vibrations paired with C = O stretching vibrations, protein Amide II represent to bending vibration of N–H paired with C–N and protein Amide III band accordance to a combination of β-sheet and α-helix (Horvatinec and Svečnjak, 2020).

3.2 Nutritional properties

One aspect of using Javanese grasshopper flour for food is its high nutrient content. The nutritional composition of JG flour with various preparation methods is summarized in Table 2. The Javanese grasshopper flour has nutritional content, namely: water content 6–10%, ash content 3–5%, fat 7–11%, protein 74–76%, carbohydrates 1–4%, energy 376–415 kcal, fiber 8–13%, and protein digestibility 33–35%. Pre-treatment in the manufacture of JG flour affected the nutrient and energy content \( p < 0.05 \), except protein digestibility \( p > 0.05 \). The findings are consistent with Das et al. (2022) which disclosed the ultrasonic treatment process affected nutritional value, allergens, and damage or degradation of alternative proteins.
Table 2
Nutritional properties of Javanese grasshopper flour per 100 g

<table>
<thead>
<tr>
<th>Constituents</th>
<th>B0</th>
<th>B1</th>
<th>B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>10.49 ± 0.10a</td>
<td>6.13 ± 0.02bc</td>
<td>6.13 ± 0.02bc</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>4.86 ± 0.30b</td>
<td>3.92 ± 0.01c</td>
<td>5.77 ± 0.16a</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>7.57 ± 0.29c</td>
<td>11.18 ± 0.43ab</td>
<td>11.52 ± 0.43ab</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>75.06 ± 0.15bc</td>
<td>74.99 ± 0.23bc</td>
<td>76.30 ± 0.13a</td>
</tr>
<tr>
<td>Carbohydrates (%)</td>
<td>2.03 ± 0.38b</td>
<td>3.78 ± 0.18a</td>
<td>0.28 ± 0.19c</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>376.49 ± 0.49c</td>
<td>415.70 ± 4.07a</td>
<td>406.94 ± 2.59b</td>
</tr>
<tr>
<td>Fiber (%)</td>
<td>12.85 ± 0.01a</td>
<td>9.75 ± 0.60b</td>
<td>8.56 ± 0.75c</td>
</tr>
<tr>
<td>Protein digestibility (%)</td>
<td>34.58 ± 0.80</td>
<td>34.52 ± 0.20</td>
<td>33.76 ± 0.09</td>
</tr>
</tbody>
</table>

Data are displayed as mean ± standard deviation (s.d) (n = 3). a > b > c, Significant differences are denoted by different letters in the same row (p < 0.05).

Based on these results, preparation method before drying (pre-treatment) significantly affected the nutritional content and protein digestibility of the resulting JG flour (p < 0.05). The soaking method with sodium bicarbonate and blanched for 2–3 minutes (B2) is produced the best grasshopper flour with a yield of 28.92%; pH 6.69; total solids 0.05 brix; a<sub>w</sub> 0.39; moisture content 6.13%; ash 5.77%, fat 11.52%; protein 76.30%; carbohydrates 0.28%; 8.56% crude fiber and 33.76% protein digestibility. The amino acids profile JG flour B2 is shown in Table 3. The quality of protein in food could be seen from the completeness of the amino acid components. High-value food protein with more complete amino acids contained. A deficiency of essential amino acids can disrupt metabolism and affect growth; it can cause stunting.
<table>
<thead>
<tr>
<th>Amino acids</th>
<th>B2 (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspartic acid</td>
<td>424.50</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>564.92</td>
</tr>
<tr>
<td>Serin</td>
<td>195.77</td>
</tr>
<tr>
<td>Histidine*</td>
<td>45.74</td>
</tr>
<tr>
<td>Glycine</td>
<td>211.09</td>
</tr>
<tr>
<td>Threonine*</td>
<td>170.11</td>
</tr>
<tr>
<td>Arginine</td>
<td>362.53</td>
</tr>
<tr>
<td>Alanine</td>
<td>509.22</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>432.64</td>
</tr>
<tr>
<td>Methionine*</td>
<td>27.13</td>
</tr>
<tr>
<td>Valin*</td>
<td>265.32</td>
</tr>
<tr>
<td>Phenylalanine*</td>
<td>152.22</td>
</tr>
<tr>
<td>Isoleucine*</td>
<td>211.49</td>
</tr>
<tr>
<td>Leucin*</td>
<td>366.85</td>
</tr>
<tr>
<td>Lysine*</td>
<td>393.46</td>
</tr>
</tbody>
</table>

Data are displayed as mean (n = 3). Essential amino acids. n.a: data not available

Table 3 shows that grasshopper B2 flour has essential amino acids. The essential amino acids comprise valine, histidine, lysine, methionine, leucine, phenylalanine, isoleucine, and threonine. Lysine is the amino acid with the highest content, while methionine is the limiting amino acid in JG flour. This finding agrees with a study reported the limiting essential amino acid in Javanese grasshopper flour is methionine of 7.80 mg/kg (Dewi et al., 2020).

### 3.3 Correlation between physicochemical and protein digestibility

Food processing affects the physicochemical composition and consequently affect the digestibility of protein (Joye, 2019). The correlation between physicochemical factors and protein digestibility was investigated by Pearson's correlation test (Supplementary 1). The results demonstrated that the pH has a strong and significant negative correlation on protein digestibility. Lower pH will significantly increase protein digestibility. This result is in line with Salelles et al. (2021) which shows that the most optimal degree of hydrolysis occurs at pH 2.0. Another study also shows that lower pH increases the digestibility
of protein isolate digested using pepsin enzyme (Zhang and Vardhanabhuti, 2014). Lower pH causes an increase in the pepsin digestive activity which increases proteins breakdown into small peptides and amino acids. Pepsin optimally works at low pH around 1.2–2.5 (Del Rio et al., 2021).

Other physicochemical properties including total solid, solubility, moisture, water activity and color do not show a significant correlation with protein digestibility. Although not statistically significant, several factors have a strong correlation \( R^2 > 0.5 \) with protein digestibility. Solubility is widely known to have a positive correlation with protein digestibility. Higher solubility indicates a lesser protein aggregation which makes the protein more accessible to the enzyme active site and hence makes it more digestible (Deng et al., 2020). Water activity and moisture were found to have a positive correlation with protein digestibility. Different findings which shows that higher moisture tends to decrease the digestibility of protein (Sumargo et al., 2016). Moisture's effects on the digestibility of proteins is varied depending on the protein characteristic, hydrophilic proteins become more soluble in the high moisture environment which makes their digestibility higher, while hydrophobic proteins will aggregate in the high moisture condition.

4. Conclusion

The Javanese grasshopper is given physical treatment with sodium bicarbonate and ultrasonication. For ultrasonic pretreatment and sodium bicarbonate increased the yield, fat, and lightness values. Sodium bicarbonate pretreatment increased the ash and protein content. Ultrasonic and sodium bicarbonate pretreatments did not affect the pH, solubility, protein digestibility, micrograph, and IR spectra profile of the Javanese grasshopper flour. In vitro protein digestibility was significantly correlated with the pH of the Javanese grasshopper flour. The essential amino acid of B2 sample was histidine (45.74 ppm), threonine (170.11 ppm), methionine (27.13 ppm), valine (265.32 ppm), phenylalanine (152.22 ppm), isoleucine (211.49 ppm), leucine (366.85 ppm), and lysine (393.46 ppm).

Declarations

Acknowledgment

We would like to thank the National Research and Innovation Agency (BRIN), Research Food and Agriculture Organization, and Research Center on Food Technology and Processing, Yogyakarta for financial, facilitating, and supporting our research activities through e-science services (ELSA-BRIN). We would like to extend our appreciation to the Universiti Malaysia Pahang Al-Sultan Abdullah for their support and for providing the grant, RDU2230093 to Hamid HA.

Conflicts of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References


**Figures**

![Javanese grasshopper (*Valanga nigricornis* Burm)](image1.png)

(A) Sorted fresh grasshopper (A), and dried grasshopper flour (B)

![Dried grasshopper flour](image2.png)

(B)

**Figure 1**

Javanese grasshopper (*Valanga nigricornis* Burm). Sorted fresh grasshopper (A), and dried grasshopper flour (B)
Figure 2

Figure 3