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# Chemical Profile of Earthworm Flour with *Kasgot* Media Enriched with Cow Blood and Date Pulp

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**Abstract*:*** Fish meal is used as an ideal protein source for feed with a high level of digestibility but its limited and costly. This study explores earthworm flour as an alternative protein source, cultivated in kasgot (maggot residue) media enriched with organic waste. The novelty of this research lies in using maggot residue as the living medium for earthworms, enhancing the nutritional value of the earthworm flour, making it more beneficial and suitable as an additive protein feed ingredient. The kasgot medium was formulated by mixing boiled cow blood with date pulp fermented with EM4 probiotics in three different ratios: 2:1 (P1), 1:1 (P2), and 1:2 (P3). The gravimetric, Kjeldahl, and Soxhlet were used to measure water, ash, protein, and fat content. High-Performance Liquid Chromatography (HPLC) with post-column derivatization was applied to identify and measure the amino acid level in earthworm flour. Gas Chromatography (GC) was used to analyze fatty acids using the esterification method. The results of the analysis showed that good earthworm flours were P1 and P3. Water, ash, protein, and fat content in P1 were 2.49%, 7.11%, 56.09%, and 18.70%, respectively. Meanwhile, P3 had a water content of 2.87%, ash content of 7.06%, protein of 54.25%, and fat of 23.77%. The highest content of amino acids in P1 was glutamine (7.66 ppm) and lysine (5.37 ppm). The highest content of fatty acids in P3 was oleic acid (13.41%) and palmitic acid (13.37%). These findings suggest that high protein earthworm flour, particularly from P1 formulations, is a promising alternative protein source for animal feed, offering a sustainable and cost-effective solution to the challenges associated with traditional protein sources.

**Keywords:** *Lumbricus rubellus*, feed, protein, amino acids, fatty acids

***Abstrak:*** *Tepung ikan sebagai sumber pakan protein yang ideal karena tingkat kecernaan yang tinggi, tetapi ketersediannya terbatas dan mahal. Penelitian ini mengkaji tepung cacing tanah sebagai alternatif sumber protein, yang dibudidayakan pada media kasgot (residu maggot) yang diperkaya dengan limbah organik. Kebaruan dari penelitian ini terletak pada penggunaan residu maggot sebagai media hidup cacing tanah, sehingga mampu meningkatkan nilai nutrisi tepung cacing dan membuatnya lebih bermanfaat serta cocok sebagai bahan tambahan sumber protein pada pakan. Media kasgot diformulasikan dengan mencampurkan darah sapi yang telah direbus dengan ampas kurma yang difermentasi menggunakan probiotik EM4 dalam tiga rasio berbeda: 2:1 (P1), 1:1 (P2), dan 1:2 (P3). Metode gravimetri, Kjeldahl, dan Soxhlet digunakan untuk mengukur kadar air, abu, protein, dan lemak. High-Performance Liquid Chromatography (HPLC) dengan derivatisasi pascakolom digunakan untuk mengidentifikasi dan mengukur kadar asam amino dalam tepung cacing. Gas Chromatography (GC) digunakan untuk menganalisis asam lemak menggunakan metode esterifikasi. Hasil analisis menunjukkan bahwa tepung cacing terbaik terdapat pada P1 dan P3. Kadar air, abu, protein, dan lemak pada P1 masing-masing adalah 2,49%, 7,11%, 56,09%, dan 18,70%. Sementara itu, P3 memiliki kadar air 2,87%, kadar abu 7,06%, protein 54,25%, dan lemak 23,77%. Kandungan asam amino tertinggi pada P1 adalah glutamin (7,66 ppm) dan lisin (5,37 ppm). Kandungan asam lemak tertinggi pada P3 adalah asam oleat (13,41%) dan asam palmitat (13,37%).Temuan ini menunjukkan bahwa tepung cacing tanah berprotein tinggi, khususnya dari formulasi P1, merupakan sumber protein alternatif yang menjanjikan untuk pakan ternak, menawarkan solusi yang berkelanjutan dan hemat biaya terhadap tantangan yang terkait dengan sumber protein konvensional.*

***Kata kunci:*** *Lumbricus rubellus, pakan, protein, asam amino, asam lemak*

## INTRODUCTION

Feed ingredients can be from agricultural, fishery, or livestock products and must be safely consumed by livestock. The nutritional content of feed is protein, fat, carbohydrates, vitamins, and minerals. Each nutrition will have a role in accordance with its function, especially protein and fat. Protein has a role in forming body tissues and is involved in metabolism, such as enzymes, hormones, and antibodies (Harningsih & Yaman 2023). Meanwhile, fat acts as the main energy reserve that livestock uses to perform activities (Wardhana 2017). Lack of protein and fat content results in growth deficiency and decreased immunity (Pratiwi & Sunarti 2017). Health problems that may occur in livestock are kidney problems, dehydration, and obesity, which can reduce the quality of livestock products. Providing balanced feed with enough of protein and fat can maintain livestock health.

Slaughterhouse (RPH) in West Java produces abundant blood waste from slaughtered cattle, which is approximately 1,162 tons per year (BPS 2022). The abundant livestock by-product waste must be processed sustainably to be environmentally friendly products, such as blood flour. Blood flour, which is a livestock by-product with a high content of protein (79.3%), can be used as potential raw materials for producing livestock rations (Utomo *et al*. 2014). Cow blood flour contains 80% of crude protein, 1.6% of fat, 1.5% of crude fiber, 4% of ash, and 8.40% of β-nitrogen, indicating an ideal nutritional profile to be used as the material of protein additive feed (Ramadhan *et al*. 2021). However, liquid cow blood requires solid material as an adsorbent for processing into feed ingredients. Cow blood waste is mixed with solid material, such as date pulp, which has a role as feed for earthworms to be decomposed more simply and processed as flour. This waste is a by-product of Ajwa date processing and is one of the abundant sources of agricultural waste (18,480 tons per year) in Indonesia (BPS 2022). (This waste has great potential to use because it has a lot of nutrition, such as 5.7% of protein, 1% of fat, and 65.02% of crude fiber (Fitro *et al*. 2015). The use of cow blood waste and date pulp is an effective solution to overcome waste problems.

Protein source feed that is commonly used is fish meal because it is easily digested by livestock, but the availability of fish meal is limited and has expensive production cost (Dharmayudha *et al*. 2022). Earthworm (*Lumbricus rubellus*) is one of the alternatives that can be used as a source of animal protein feed. Vermicomposting is one of the organic waste recycling methods that utilizes earthworms to accelerate the decomposition process. Earthworm flour is discovered to contain higher protein levels (54.6%) than feed from fish meal (53.9%) or donkey (43%) (Sun & Jiang 2017). The aim of this study is to analyze the nutritional content of high protein earthworm flour produced from cultivation in a kasgot (maggot residue) media as an alternative source of animal feed. The availability of earthworms as feed is influenced by the environment, one of which is the provision of suitable organic media so that earthworms can grow and reproduce optimally. Choosing media for earthworm habitats can utilize the digestive waste of black soldier fly larvae (*Hermetia illucens*) that have consumed organic waste, called kasgot (maggot residue).

## MATERIALS AND METHOD

This study was conducted for five months, from November 2023 to March 2024. This study was conducted in Arkan Quail Farm, Ciampea, for the cultivation and processing of earthworms. Cow blood waste was obtained from UPTD Rumah Pemotongan Hewan Terpadu (Integrated Slaughterhouse), Bubulak, and date pulp was obtained from PT Sari Kurma Sahara, Cilebut. Proximate analysis testing was conducted in the Integrated Chemistry Laboratory, Institut Pertanian Bogor Baranangsiang, to analyze the nutritional content of earthworms.

### The Preparation of Earthworm Media

26 cm x 19 cm x 9 cm cultivation containers were placed on anti-insect racks. The living media of earthworms was in the form of fermented kasgot, which was mixed every day to maintain aeration conditions. Fermented kasgot was made by mixing 800 g of kasgot and 20 mL of EM4 solution and fermented for 3 days in anaerobic conditions. The earthworms used were more than 3 months old.

### Processing Cow Blood Waste and Date Pulp

Cow blood was processed by steaming at 80 $^{o}$C for 20 minutes and adding curry powder to reduce water content and the activity of pathogenic bacteria. Meanwhile, date pulp waste was mixed with EM4 solution and left for 3 days. Processed cow blood waste and date pulp were weighed and sprinkled in a manner comparable to the weight of earthworms.

### Earthworm Cultivation

200 g of earthworm was placed in a container and acclimatized for 24 hours. The media is stated suitable if earthworms do not come out for 15 minutes. Media were replaced once a month, and feed was given every two days with the amount in accordance with the weight of the earthworm. Water spraying was carried out every day to maintain the humidity of the media. Treatments of feed variations and kasgot given are as follows:

P0: chicken manure media without additional feed (control)
P1: chicken manure + blood kasgot : date pulp (2:1) + blood : date pulp (2:1)
P2: chicken manure + blood kasgot : date pulp (1:1) + blood : date pulp (1:1)
P2: chicken manure + blood kasgot : date pulp (1:2) + blood : date pulp (1:2)

**Analysis of Earthworm Flour**

Proximate analysis consisted of water content, ash, crude protein, and crude fat using the AOAC method (2012) to observe the best nutritional content of earthworms cultivated with kasgot as media and organic waste feed into protein-rich flour. The best treatment variation was continued with amino acid and fatty acid tests. High-Performance Liquid Chromatography (HPLC) with post-column derivatization was applied to identify and measure the amino acid level in earthworm flour. Gas Chromatography (GC) was used to analyze fatty acids using the esterification method and the addition of $BF_3$ solution.

**Conditions of HPLC Instrument**

This study was conducted to determine the optimum operating conditions in the analysis of amino acids using HPLC. The analysis was carried out using ion-exchanged phase HPLC, Shimadzu brand, intersil CX colomn (4.6 x 150 mm). The composition of the mobile phase used was solution A (citrate buffer solutions pH 3) and solution B (borate buffer solution pH 9) with a flow rate 0,6 mL/min. The injection volume was 5 µL through a fluorescence detector (model 420) with a temperature of 60 °C and emisson at 425 nm and excitation at 338 nm.

**Conditions of GC Instrument**

This study was conducted to determine the optimum operating conditions in the analysis of fatty acids using GC-2014 Shimadzu with flame ionization detector (FID) at operating conditions: Quadrex 007-23-60-0.25F with a length of 60 m, a diameter of 0,23 mm, a film thickness of 0,50 µm. The colomn temperature was 185 °C for 5 minutes then increased to 225 °C with a temperature run of 10 °C/min and for 20 minutes the temperature was constant at 225 °C. The detector temperature was 220 °C, the injection temperature was 240 °C with helium carrier gas, a gas flow rate of 3 mL/min and a gas pressure of 100 kPa.

**RESULT AND DISSCUSION**

**Earthworm Biomass**

The results of observation during the study obtained a standard deviation of earthworm biomass, which is presented in Table 1.

The best increase in earthworm biomass was P3 (275.45 grams) compared to other treatments. This was because the nutritional content in kasgot was suitable for the growth of earthworms. Based on the observation, all kasgot treatments showed relatively the same physical characteristics, including dark in color with varying intensity of concentration, normal temperature, and odor-free (Figure 1). This statement is supported by Agustin *et al*. (2023), which kasgot that has been harvested for 14 days has various shapes, colors, and textures depending on the provision of organic waste feed that will be decomposed by maggot (black soldier fly). The use of kasgot has a positive effect in improving the structure and texture of earthworm media to increase aeration and drainage (Edyson *et al*. 2023).

**Table 1.** The average results of earthworm biomass

| Treatment | Initial weight (g) | Repetition (g) | | Average (g) |
|---|---|---|---|---|
| | | 1 | 2 | |
| P0 | 200 | 272.63 | 273.12 | 272.88 |
| P1 | 200 | 245.47 | 245.52 | 245.50 |
| P2 | 200 | 265.58 | 265.66 | 265.62 |
| P3 | 200 | 275.34 | 275.56 | 275.45 |

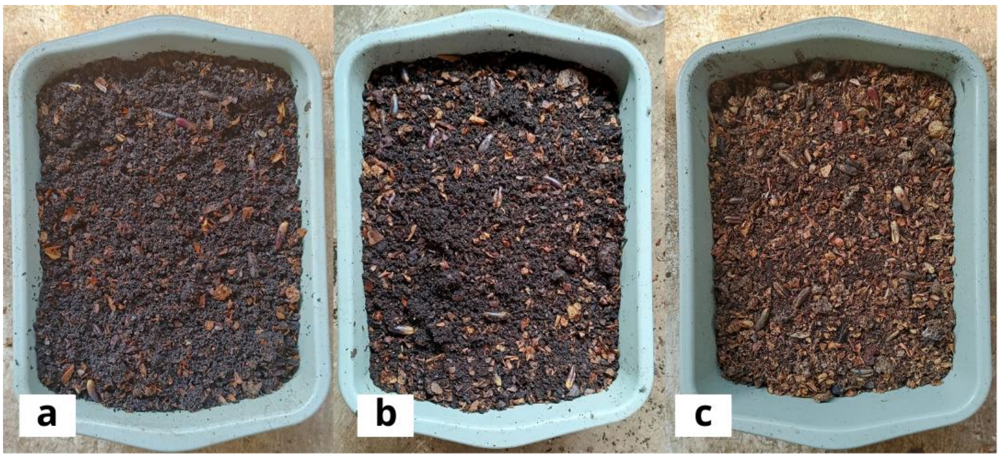


**Figure 1**. Kasgot (a) P1; (b) P2; (c) P3

Upon visual examination of the data, it can be seen that treatments with greater average weights, such as P0 (272.88 grams) and P3 (275.45 grams), tend to exhibit higher standard deviations (0.35 and 0.16 g, respectively), whereas those with lower averages like P1 (245.50 g) demonstrate minimal variability (0.04 g). This observation aligns with a moderate positive correlation ($r = 0.65$) between average weight and standard deviation, suggesting that variability tends to rise as the mean increases. The lack of statistical significance in the correlation ($p = 0.35$) is probably because of the small sample size. Therefore, although both the visual and statistical analyses indicate a potential connection, additional data would be required to confirm it confidently.

Earthworms play an important role in maintaining the health of the soil ecosystem. Based on the statement by Araina *et al*. (2020), the life of earthworms is influenced by several factors, including an ideal temperature of 15-25°C. Temperature above 25°C can be suitable for cultivation, but the humidity must be controlled to be optimal. Good humidity for the growth and reproduction of earthworms is 15-30%. The optimal condition of soil pH for earthworms is 5.8-7.2 (Harja *et al*. 2023). Too acidic or alkaline soil conditions can inhibit the absorption of nutrients by earthworms and result in death (Nurmaningsih & Syamsussabri 2021). The condition of kasgot during cultivation was 24.4 °C with a pH of 5.76-6.50. This data indicates that kasgot has suitable characteristics as a living medium for earthworms.

**Proximate Analysis of Earthworm Flour**

The results of the proximate analysis of earthworm flour were obtained from the nutritional content shown in Table 2.

Based on the data collected from the experiment, which was conducted in triplicate, there are observable differences in the nutritional composition among the treatments (P0 to P3), particularly in ash, protein, and fat content. The results of the proximate analysis showed that the dry ingredient content in earthworm flour was included in the high category of 97.06-97.51%. This value indicates that feed has many concentrated nutrients, so it is more efficient for livestock. Dry ingredient value is influenced by the composition and properties of feed ingredients, such as carbohydrates, fats, proteins, vitamins, and minerals (Pinotti & Ottoboni 2021). The feed with high dry ingredient content has several advantages, including being long-lasting and not easily damaged by microorganisms. The percentage of dry ingredients refers to the non-water composition, while water content refers to the proportion of water in the ingredient. Low water content in earthworm flour (2.49-3.78%) shows that drying with microwave is effective. Low water content shows that feed has a high percentage of dry ingredients with a longer shelf life. This statement is supported by Handayani *et al*. (2019), there is a negative correlation between water content and dry ingredients in feed.

The microwave drying method uses electromagnetic waves to generate heat directly on the ingredient through molecular interaction (Sari *et al*. 2024). This mechanism allows a faster drying process than using the oven to get the desired results in just a few minutes. The drying process of earthworm flour obtained a water content of 17.15-28.51% for 20 minutes (2x10 minutes) at a microwave power level of 600 W, which did not get results in accordance with SNI 2715:2013 (maximum 12%). Re-testing in 15 minutes (3x5 minutes) and a power of 300 W resulted in more optimal water content in earthworm flour, which is 2.49-2.94%. This indicates that the microwave drying process depends on the duration, power level, and number of feed ingredients being dried. This statement is supported by Moses *et al*. (2014), microwave drying can reduce drying time by 25-90%, increase drying rate by 400-800%, and save energy up to 32-71% compared to a conventional drying method.

The results of analyzing ash content in earthworm flour for P0, P1, P2, and P3 were 6.88, 7.11, 7.08, and 7.06 percent, respectively (Table 2). These results indicate that earthworm flour contains good minerals as animal feed and meets SNI requirements, a maximum of 14%. Earthworm flour was in a good range as an alternative source of feed after a fish meal (maximum 12%) (SNI 2354.1-2006). Ash content in earthworm flour indicates the amount of mineral residue remaining after burning the dry ingredients. Minerals contained in earthworms come from media and feed provided (cow blood kasgot and date pulp). Based on Sukarno et al. (2023), cow blood contains minerals consisting of magnesium (Mg), copper (Cu), sodium (Na), zinc (Zn), calcium (Ca), and phosphorus (P). Moreover, date pulp has mineral content in the form of phosphorus, potassium, calcium, sodium, and magnesium (Hasanah *et al*. 2023).

**Table 2.** Proximate analysis result of earthworm flour

| Treatment | Dry matter (%) | Water (%) | Ash (%) | Protein (%) | Fat (%) |
|---|---|---|---|---|---|
| P0 | 97.06 | 2.94 | 5.32 | 52.30 | 18.53 |
| P1 | 97.51 | 2.49 | 7.11 | 56.09 | 18.70 |
| P2 | 97.34 | 2.66 | 7.08 | 53.70 | 20.74 |
| P3 | 97.13 | 2.87 | 7.06 | 54.25 | 21.17 |

Based on the results of proximate analysis (Table 2), all earthworm cultivation treatments showed a protein content of more than 20%. Protein content in P1 had the highest result (56.09%) due to the protein source from the different ratios of cow blood used. Meanwhile, P2 and P3 were analytically in almost the same range of 53.70% and 54.25%. The results of analyzing protein content in earthworm flour met requirements as animal feed stipulated in SNI 7700-6:2023, approximately 18-22%. However, the results were still under the minimum limit for crude protein levels in fish meal (SNI 2715:2013). The composition of media and feed used in the cultivation stage can influence the quality and quantity of protein in earthworm flour (Ningrum *et al*. 2021). Good absorption of date pulp allows it to absorb blood in large amounts. High protein content in cow blood, which is more than 79.3%, has a positive contribution between the amount of blood absorbed and its protein content (Ramadhan *et al*. 2021).

The high-fat content in earthworm flour in this study (18.53-21.17%) demonstrated its potential advantages as an energy source and a nutritional enhancer. This result indicates higher fat content than fish meal, which commonly only contains 6.5% of fat. The fat content of earthworm flour in this study was found 3-4 times higher than the previous studies (Medina *et al*. 2003; Gunya *et al*. 2016; Abigail, 2023). Factors influencing changes in nutritional composition in earthworm flour are the type of feed during cultivation and its drying method. Earthworm flour contains fat as an energy source and a medium for the absorption of fat-soluble vitamins (Telahigue *et al*. 2013). Vitamin absorption can improve the taste of animal feed, thus increasing its palatability (Gunya *et al*. 2016).

The one-way ANOVA analysis revealed a significant variation ($p < 0.05$) among the treatments (P0–P3) for at least one of the measured parameters. This shows that the therapy had a noticeable impact on the nutritional makeup, such as protein and fat contents. The variances indicate that different treatments affect the quality characteristics of the samples. Further analysis after the fact is suggested in order to determine which particular treatments show significant differences.

**Amino Acid Profile**

Earthworm (*L. rubellus*) flour in this study is a potential raw material for animal feed with high protein content equivalent to fish meal (55-60% of crude protein) as a source of poultry feed. Earthworm flour also contains "lumbricin," which has antibacterial activities and is included in the peptide group that contains 62 amino acids (Istiqomah *et al*. 2009). *Lumbricus terristris* flour has 32.6% protein (Istiqomah *et al*. 2009), while *Perionyx excavatus* flour contains 57.2% protein, and both have a complete amino acid composition (Tram *et al*. 2005; Musyoka *et al*. 2019). Seventeen amino acids consisting of nine essential amino acids and eight non-essential amino acids were obtained from each earthworm flour in this study (Figure 2).

The highest number of amino acids in earthworm flour for each treatment was P1, which was 56.02 ppm. Essential amino acid in P1 was dominated by leucine (5.37 ppm), while non-essential amino acid was glutamic acid (7.66 ppm). Lysine is very important for protein synthesis in muscle growth and glucose metabolism in livestock bodies, while glutamic acid is involved in nitrogen metabolism, signal transmission, and as a precursor to glutathione. This study is in accordance with the findings by Tram *et al*. (2005) regarding the amino acid composition of *P. excavatus*, which is rich in leucine and glutamic acid. Further study has demonstrated that earthworm flour is not only a protein source but also rich in essential amino acids, especially leucine, which is limited in many feed ingredients (Dedeke *et al*. 2010).

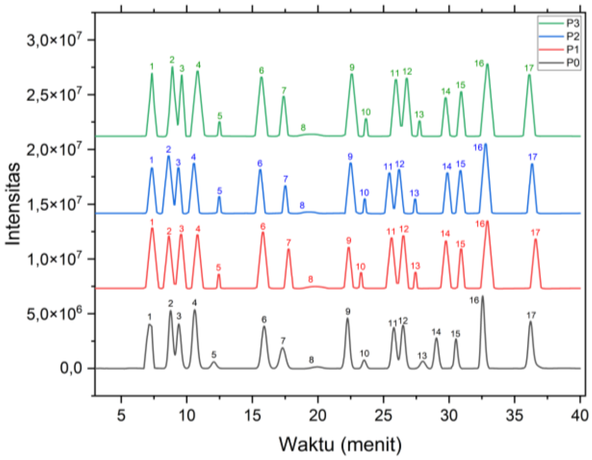


**Figure 2.** Overlay of four chromatograms of earthworm meal measured by HPLC: P0, P1, P2, P3
Identification: (1) Asp, (2) Thr, (3) Ser, (4) Glu, (5) Pro, (6) Gly, (7) Ala, (8) Cys, (9) Val, (10) Met, (11) Ileu, (12) Leu, (13) Tyr, (14) Phala, (15) His (16), Lys, dan (17) Arg

**Fatty Acid Profile**

The advantages of earthworm flour as animal feed are its complete essential amino acid content and the presence of essential fatty acids that support livestock nutritional needs (Gabriel *et al*. 2010; Fadaee 2012; Gunya *et al*. 2016). The presence of essential fatty acid, linoleic acid, and linolenic acid contributes to the growth, development, and reproduction of healthy and productive livestock. *Lumbricus rubellus* flour in this study contained a high level of fatty acid with a high amount of omega-3 and omega-6 (8.34%) compared to conventional feed (1-3%). Various types of fatty acids are found in quite high concentrations in earthworm flour (Table 4).

Amino acids level in P0 was higher (44.55%) than other treatments, followed by P3 (39.38%), P1 (32.09%), and P2 (11.2%). The fatty acid profile of earthworm flour shows the variation in composition in each treatment. This indicates that feed factor and earthworm media conditions can affect fatty acid levels. Analysis of P3 earthworm flour showed the presence of 19 fatty acids with compositions of 9 saturated fatty acids, 5 monounsaturated fatty acids, and 5 polyunsaturated fatty acids (Figure 3). The most dominant saturated fatty acid (SFA) was palmitic acid (C16:0) (13.37%), monounsaturated fatty acid (MUFA) was oleic acid (C18:1n9c) (13.41%), and polyunsaturated fatty acid (PUFA) was linoleic acid (C18:2n6c) (6.56%). Palmitic acid has a role in the absorption of fat and fat-soluble vitamins in the intestine, oleic acid has anti-inflammatory properties that help the immune system of livestock, and linoleic acid is important for brain and eye development in young livestock. The fatty acid profile of earthworm flour makes it a promising alternative lipid source for feed, mainly if it has high PUFA content (Isea-León *et al*. 2019). Earthworm flour has an ideal ratio of omega-6 and omega-3 fatty acids for livestock health (4:1), which is in accordance with the results of a study in P3 that showed a ratio of 4.28:1.

**Table 3.** Amino acid compositions found in earthworm flour (ppm)

| Amino Acid | P0 | P1 | P2 | P3 |
|---|---|---|---|---|
| **Essential** | | | | |
| Phenylalanine (Phala) | 2.39 | 2.52 | 2.6 | 2.79 |
| Valin (Val) | 2.65 | 2.55 | 2.61 | 2.84 |
| Methionin (Met) | 0.68 | 0.82 | 0.85 | 0.8 |
| Isoleusin (Ileu) | 2.7 | 2.67 | 2.82 | 3.3 |
| Treonin (Thr) | 2.58 | 2.55 | 2.62 | 2.43 |
| Hystidin (His) | 1.66 | 2.37 | 2.18 | 2.18 |
| Arginin (Arg) | 3.95 | 4.4 | 3.98 | 4.12 |
| Lysin (Lys) | 4.38 | 3.92 | 3.92 | 3.87 |
| Leusin (Leu) | 4.9 | 5.37 | 5.12 | 5.02 |
| Cystein (Cys) | 0.59 | 0.69 | 0.86 | 0.59 |
| Tyrosin (Tyr) | 1.57 | 1.99 | 2.43 | 1.98 |
| **Non-essential** | | | | |
| Aspartic Acid (Asp) | 5.5 | 6.56 | 5.79 | 6.22 |
| Glutamic Acid (Glu) | 8.84 | 7.66 | 6.97 | 7.08 |
| Serin (Ser) | 2.44 | 2.89 | 2.97 | 2.68 |
| Glysin (Gly) | 2.73 | 2.96 | 2.98 | 2.72 |
| Alanine (Ala) | 2.87 | 3.03 | 3.04 | 2.96 |
| Proline (Pro) | 1.82 | 3.06 | 1.84 | 2.45 |

**Table 4.** Fatty acid composition of earthworm flour (%bahan kering)

| Fatty Acid | P0 | P1 | P2 | P3 |
|---|---|---|---|---|
| Saturated fatty acid | | | | |
| C4:0 | 0.05 | 0.07 | 0.07 | 0.09 |
| C6:0 | - | 0.07 | 0.03 | - |
| C12:0 | 0.78 | 0.46 | 1.32 | 0.49 |
| C13:0 | 0.06 | - | 0.21 | 0.07 |
| C14:0 | 0.57 | 0.48 | 0.24 | 0.56 |
| C15:0 | 0.06 | 0.09 | 0.11 | 0.08 |
| C16:0 | 13.85 | 10.02 | 0.38 | 13.37 |
| C17:0 | 0.16 | 0.26 | 0.50 | 0.21 |
| C18:0 | 1.90 | 1.81 | 1.04 | 1.96 |
| C20:0 | 0.20 | 0.18 | 0.13 | 0.20 |
| C22:0 | - | 0.13 | 0.28 | - |
| C23:0 | - | - | 0.11 | - |
| C24:0 | - | 0,05 | 0.13 | - |
| Monosaturated fatty acid | | | | |
| C15:1 n-6 | 0.07 | 0.05 | 0.09 | 0.13 |
| C16:1 n-7 | 0.19 | 0.26 | 0.28 | 0.16 |
| C18:1n9t | - | - | - | 0.09 |
| C18:1n9c | 16.23 | 10.03 | 0.38 | 13.41 |
| C20:1 | 0.06 | 0.05 | - | 0.05 |
| Polyunsaturated fatty acid | | | | |
| C18:2n9t | 0.05 | 0.15 | - | 0.13 |
| C18:2n6c | 9.39 | 5.18 | 1.75 | 6.56 |
| C18:3n3 | 0.09 | 0.09 | 1.40 | 0.11 |
| C20:2 | 0.15 | 0.35 | 0.41 | 0.24 |
| C20:3n6 | - | 0.21 | 0.25 | - |
| C20:5n3 | 0.69 | 2.10 | 2.09 | 1.47 |
| Total | 44.55 | 32.09 | 11.2 | 39.38 |

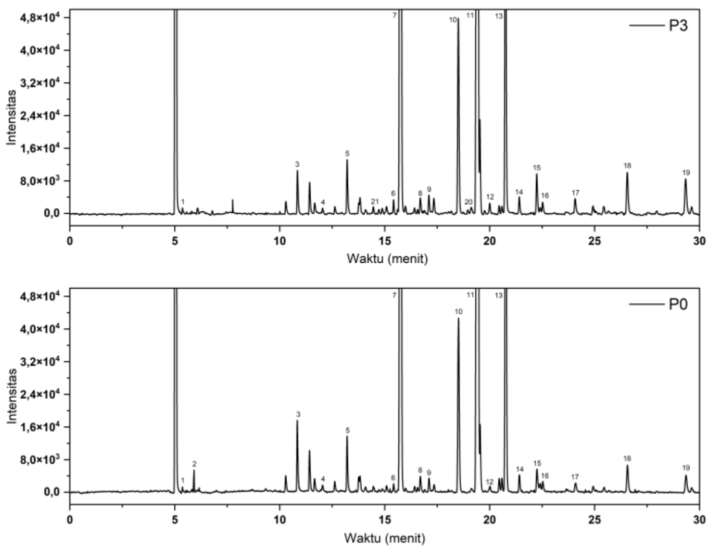


**Figure 3.** Overlay of two chromatograms of earthworm flour: P0 dan P3
Identification: (1) C4:0, (2) C6:0, (3) C12:0, (4) C13:0, (5) C14:0, (6) C15:1, (7) C16:0, (8) C16:1, (9) C17:0, (10) C18:0, (11) C18:1n9c, (12) C18:2n9t, (13) C18:2n6c, (14) C20:0, (15) C20:1, (16) C18:3n3, (17) C20:2, (18) C20:4n6, (19) C20:5n3, (20) C18:1n9t, (21) C15:0

## CONCLUSION

The use of kasgot as a living medium and a feed mixture of feed in the form of cow blood waste and date pulp can increase the nutritional content of earthworm flour. The results of the analysis showed that a good proximate value (water, ash, protein, and fat) was found in the mixture of cow blood and date pulp feed with a ratio of 2:1 (P1). The highest content of amino acids in P1 were glutamine and lysine. Therefore, earthworm flour made from kasgot has the potential to serve as a protein supplement in animal feed, particularly for animals like chickens or quails, but further testing is required.

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## REFERENCES

Abigail G.A. (2023). A rapid study for proximate composition and sensory evaluation of Eisenia foetida earthworm meal as a protein source. *Current Research in Nutrition and Food Science*. **11(1)**: 412–421.

Agustin, H., Warid, W. & Musadik, I. M. (2023). Kandungan nutrisi kasgot larva lalat tentara hitam (*Hermetia illucensi*) sebagai pupuk organik. *Jurnal Ilmu-Ilmu Pertanian Indonesia*. **25(1)**: 12-18.

Araina, E., Yuliana, Y., Haryono, A. & Savitri, S. (2020). Pengaruh komposisi media terhadap pertumbuhan cacing tanah (*Lumbricus terrestris*). *Wahana-Bio: Jurnal Biologi dan Pembelajarannya*. **12(1)**: 41-47.

Association of Official Analytical Chemists [AOAC]. (2012d). *AOAC International Method 996.03 about Fat (Crude) in Animal Food Gravimetric Method.* Ed ke-19. Washington. Amerika Serikat.

Association of Official Analytical Chemists [AOAC]. (2012a). *AOAC International Method 905.3 About Ash Of Animal Feed*. Ed ke-19. Washington. Amerika Serikat.

Association of Official Analytical Chemists [AOAC]. (2012b). *AOAC International Method 934.01 about Moisture in Animal Feed Drying at 105°C*. Ed ke-19. Washington. Amerika Serikat.

Association of Official Analytical Chemists [AOAC]. (2012c). *AOAC International Method 992.23 about Protein (Crude) in Animal Feed Kjeldahl Method*. Ed ke-19. Washington. Amerika Serikat.

Badan Pusat Statistik. (2022). Statistik Lingkungan Hidup Indonesia 2022. Badan Pusat Statistik. Jakarta. Available from: https://www.bps.go.id/id/publication/2022/11/30/eb06d1c8e37285cac10c3086/statistik-lingkungan-hidup-indonesia-2022.html.

Badan Pusat Statistik. (2022). Statistik Pemotongan Ternak 2022. Badan Pusat Statistik. Jakarta. Available from: https://www.bps.go.id/id/publication/2023/05/12/1f5d4217a0a266c5f3013c9f/statistik-pemotongan-ternak-2022.html.

Dedeke, G.A., Owa, S.O. & Olurin, K.B. (2010). Amino acid profile of four earthworms species from Nigeria. *Agriculture and Biology Journal of North America*. **1(2)**: 97-102.

Dharmayudha, A.A.G.O., Ardana, I.B.K., Budiasa, K., Merdana, I.M. & Gunawan, I.W.N.F. (2022). Soil worms *(Lumbricus rubellus*) as feed additives for piglets' growth, blood profile and immunomodulators. *Bali Medical Journal*. **11(1)**: 250-255.

Edyson, E., Indawan, R., Hapsari, I., Karamina, H. & Hastuti, P.I. (2023). Kasgot lalat tentara hitam sebagai pupuk organik untuk pertanian berkelanjutan. *Agrika: Jurnal Ilmu-Ilmu Pertanian*. **17(1)**: 156–168.

Fadaee, S. (2012). *Social movements in Iran: Environmentalism and civil society*. Routledge. London.

Fitro, R. & Dihansih, E. (2015). Performa ayam pedaging yang diberi ransum komersial mengandung tepung ampas kurma sebagai pengganti jagung. *Jurnal Peternakan Nusantara*. **1(1)**: 1-8.

Gabriel, D., Sait, S.M., Hodgson, J.A., Schmutz, U., Kunin, W.E. & Benton, T.G. (2010). Scale matters: the impact of organic farming on biodiversity at different spatial scales. *Ecology Letters*. **13(7)**: 858-869.

Gunya, B., Masika, P. J., Hugo, A. & Muchenje, V. (2016). Nutrient composition and fatty acid profiles of oven-dried and freeze-dried earthworm *Eisenia foetida*. *Journal of Food and Nutrition Research*. **4(6)**: 343-348.

Handayani, I.S., Tampubolon, B.I.M., Subrata, A. & Pujaningsih, R.I. (2019). Evaluasi organoleptik multinutrien blok yang dibuat dengan menggunakan metode dingin pada perbedaan aras molases. *Jurnal Ilmu Nutrisi dan Teknologi Pakan*. **17(3)**: 64-68.

Harja, Y., Yusnaini, S., Prasetyo, D., Lumbanraja, J. (2023). Pengaruh pemberian biochar dan pupuk kandang ayam terhadap populasi dan biomassa cacing tanah pada pertanaman jagung (*Zea mays* L.). *Journal of Tropical Upland Resources*. **05(01)**: 15–30.

Harningsih, I. S., Allaily, A. & Yaman, M. A. (2023). Pengaruh penggunaan tepung maggot dan tepung azolla dalam pakan fermentasi terhadap kadar protein, glukosa dan uric acid darah ayam hibrida. *Jurnal Ilmiah Mahasiswa Pertanian*. **8(3)**: 306-314.

Hasanah, A.M., Kurniawan, K. & Fadholah, A. (2023). Perbandingan kadar total flavonoid metode infusa dan rendaman buah kurma Ajwa (*Phoenix dactylifera* L.) menggunakan spektrofotometri Uv-Vis. *Jurnal Ilmiah Global Farmasi (JIGF)*. **1(1)**: 09-17.

Isea-León, F., Acosta-Balbás, V., Rial-Betancoutd, L. B., Medina-Gallardo, A. L., & Célestin, B. M. (2019). Evaluation of the fatty acid composition of earthworm Eisenia andrei meal as an alternative lipid source for fish feed. *Journal of Food and Nutrition Research*. **7(10)**: 696–700.

Istiqomah, L., Sofyan, A., Damayanti, E. & Julendra, H. (2009). Amino acid profil of earthworm and earthworm meal (*Lumbricus rubellus*) for animal foodstuff. *Journal of the Indonesian Tropical Animal Agriculture*. **34(4)**: 253-257.

Medina, A.L., Cova, J.A., Vielma, R.A., Pujic, P., Carlos, M.P. & Torres, J.V. (2003). Immunological and chemical analysis of proteins from *Eisenia foetida* earthworm. *Food and Agricultural Immunology*. **15(3-4)**: 255-263.

Moses, J.A., Norton, T., Alagusundaram, K. & Tiwari, B.K. (2014). Novel drying techniques for the food industry. *Food Engineering Reviews*. **6(3)**: 43-55.

Musyoka, S.N., Liti, D.M., Ogello, E. & Waidbacher, H. (2019). Utilization of the earthworm, *Eisenia fetida* (Savigny, 1826) as an alternative protein source in fish feeds processing: A review. *Aquaculture Research*. **50(9)**: 2301-2315.

Ningrum, S.E., Nafiu, L.O. & Napirah, A. (2021). Pertumbuhan dan perkembangan cacing tanah (*Lumbricus rubellus*) dengan jenis pakan berbeda. *Jurnal Ilmiah Peternakan Halu Oleo*. **2(2)**: 165–167.

Nurmaningsih, N. & Syamsussabri, M. (2021). Komposisi dan distribusi cacing tanah (*Lumbricus terrestris*) di daerah lembab dan daerah kering. *Indonesian Journal of Engineering (IJE)*. **2(1)**: 1-9.

Pinotti, L. & Ottoboni, M. (2021). Substrate as insect feed for bio-mass production. *Journal of Insects as Food and Feed*. **7(5)**: 585-596.

Pratiwi, H., Atmomarsono, U. & Sunarti, D. (2017). Pengaruh pemberian pakan dengan sumber protein berbeda terhadap persentase potongan karkas dan massa protein daging ayam lokal persilangan. *Jurnal Peternakan Indonesia (Indonesian Journal of Animal Science)*. **19(1)**: 23-29.

Ramadhan, R.F., Wizna, W., Marlida, Y., Mirzah, M. & Supratman, H. (2021). Kandungan dan kualitas nutrisi campuran darah sapi dan limbah pertanian yang difermentasikan oleh *Bacillus Amyloliquefaciens* sebagai pakan broiler. *Jurnal Peternakan*. **18(1)**: 77-86.

Sari, I.P., Sjofjan, O. & Widodo, E. (2024). Pengaruh metode pengeringan oven dan microwave terhadap kualitas fisik pakan. *Jurnal Nutrisi Ternak Tropis*. **7(1):** 34-44.

Standar Nasional Indonesia. 2013. Standar Nasional Indonesia Nomor 2715 tahun 2013 tentang Tepung Ikan sebagai Bahan Baku Pakan.

Standar Nasional Indonesia. 2023. Standar Nasional Indonesia Nomor 7700 tahun 2023 tentang Pakan Bibit Induk Ayam Ras Tipe Petelur - Bagian 6.

Sukarno, R., Indana, K. & Manullang, J. (2023). Kandungan mineral sapi bali bunting dan tidak bunting di kabupaten Kutai Kartanegara. *Jurnal Ilmiah Peternakan*. **4(2)**: 15–25.

Sun, Z. & Jiang, H. (2017). Nutritive evaluation of earthworms as human food. *Future Foods*. **10**: 128-141.

Telahigue, K., Hajji, T., Rabeh, I. & Cafsi, M.E. (2013). The changes of fatty acid composition in sun dried, oven dried and frozen hake (*Merluccius merluccius*) and sardinella (*Sardinella aurita*). African Journal of Biochemistry Research. **7(8)**: 158-164.

Tram, N.D.Q., Ngoan, L.D. & Ogle, B. (2005). Culturing earthworms on pig manure and the effect of replacing trash fish by earthworms on the growth performance of hybrid catfish (*Clarias macrocephalus* × *Clarias gariepinus*). Hue University of Agriculture and Forestry.

Utomo, J.W., Sudjarwo, E. & Hamiyanti, A. A. (2014). Pengaruh penambahan tepung darah pada pakan terhadap konsumsi pakan, pertambahan bobot badan, konversi pakan serta umur pertama kali bertelur burung puyuh. *Jurnal Ilmu-Ilmu Peternakan*. **24(2)**: 41-48.

Wardhana, A.H. (2017). Black soldier fly (*Hermetia illucens*) as an alternative protein source for animal feed. *Indonesian Bulletin of Animal and Veterinary Sciences*. **26(2)**: 1-69.