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Integration of Proximate Levels and Sensory Quality of Organic Fish Feed Based on Fermented Coconut Flour and Cricket Flour

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Abstract

Background: Feed is a determining factor in the success of fish farming, but in some cases, fish feed on the market contains chemicals such as pesticides, heavy metals, and synthetic chemicals. Organic, safer, and readily available materials combine plant-based and animal ingredients such as cricket (Acheta domesticus) and coconut pulp. Cricket has a high nutritive value, especially protein content, and coconut pulp was potentially high in carbohydrate content. The study aims to determine the carbohydrate and protein content and the color, aroma, and density assessment of the combination of fermented coconut pulp flour and cricket flour. **Methods:** The design pattern was a 1-factor Completely Randomized Design (CRD) pattern with two repetitions of 3 treatments (A1, A2, and A3) of fermented coconut pulp flour and cricket flour. Feed is subjected to tests on carbohydrate and protein proximate levels and sensory assessments of its color, aroma, and texture. **Results:** The average carbohydrate content in formulas A1, A2, and A3 is 30.51%, 26.04%, and 28.45%, while the protein content is 10.64%, 20.88%, and 16.86%. ANOVA test results on color, aroma, and overall texture show significant differences in each fish feed formula. **Conclusions:** The level of fermented coconut pulp flour had a significant effect ($P<0.05$) on increasing the carbohydrate content, while cricket flour content had a significant impact ($P <0.05$) on increasing protein levels. The highest level of sensory preference for color, aroma, and texture was observed in the combination of formula A2. Formula A1 is suitable for herbivorous fish, formula A2 for carnivorous fish, and formula A3 for omnivorous fish.

Keywords: Coconut Pulp, Crickets, Fish Feed, Proximate, Sensory

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Introduction

Fish is a crucial component of a balanced diet that addresses community nutrition issues (Kharisma, 2023). According to statistical data, Kementerian Kelautan dan Perikanan 2023 reported that fish consumption in 2022 was 56.48 kg per capita, 2.39 percent higher than the previous year. The number of fish farms also increased due to this increase.

The quality of the feed largely determines the success of fish farming (Pongkorung et al., 2022). As in research by Karimah et al. (2018), the quality of fish feed dramatically affects the growth rate of fish. However, in some cases, fish feed in the market contains chemicals such as pesticides, heavy metals, and synthetic chemicals (Cocon, 2019). Fish that consume feed containing harmful chemicals can hurt humans if consumed. Therefore, it is necessary to substitute feeding with organic materials that are both safer and readily available. In addition, according to Susanto (2019), alternative feeding for farmed fish is vital in increasing production.

The development of organic feed from locally sourced (readily available) ingredients for fish has the following advantages: a) it helps overcome the problem of feed availability

(Azrita, 2022), b) helps reduce negative impacts on the environment (Yunaidi et al., 2019; Supriatna, 2021; Azrita, 2022), c) making the fishing industry more sustainable (Yunaidi et al., 2019; Supriatna, 2021), d) has a high nutritional content, and has a low price (Sayuti et al., 2021). According to Susanto (2019), in making fish feed, ingredients must be available for a long time, easy to obtain, and have a good taste and aroma that fish like. An innovative method is necessary to make fish feed that can overcome these issues by using natural organic ingredients such as coconut pulp and crickets as substitutes for feed ingredients. According to Azrita (2022), improving the quality of feed that can optimally meet the nutritional needs of fish can be done by combining vegetable and animal proteins. In many studies, coconut pulp has been found to have high carbohydrate content and is readily available and environmentally friendly. One of the nutrients needed as an energy source in feed is carbohydrates (Djonu et al., 2020). According to Wulandari et al. (2018), the highest nutritional content of coconut pulp is carbohydrates at 38.1%, followed by crude fiber at 31.6%, fat at 16.3%, protein at 5.6%, water at 5.5%, and ash at 2.6%. Although coconut pulp has good nutritional potential, it also has anti-nutritional compounds that inhibit fish's absorption of nutrients, such as lignin, lignocellulose, and phytic acid. High crude fiber reduces nutrient digestibility, meaning that fish are not optimal in digesting the feed. As a result, the necessary nutrients cannot be adequately absorbed (Surahman, 2022). The crude fiber content required in feed is no more than 30% (Husma, 2017). Therefore, fermentation can effectively overcome this obstacle and improve the nutritional quality of coconut pulp flour (Ayuningtyas et al., 2022). As in the study of Mubaraq et al. (2022), it was found that the crude fiber content of coconut pulp before fermentation was 16.7%, while after fermentation, it decreased to 12.4- 16.5%.

Crickets are a sustainable local resource besides coconut pulp. The cultivation of crickets is increasingly developing as a food and feed ingredient because it has the following advantages: a) high protein and nutrient content (Dharmawati et al., 2022; Razid et al., 2020), b) high reproductive power (Dharmawati et al., 2022). Protein in crickets can also be a source of protein to replace fish flour and soybean flour, which are usually used as animal feed (Trisnawati, 2022). Hamsana (2021), cricket flour contains protein levels of 56.02 - 61.58% in wet material. Increasing the use of crickets has resulted in various kinds of processing updates, one of which is processing into flour (Setiawan et al., 2018). Cricket flour is a product produced from drying and grinding whole crickets. It contains various essential nutrients fish need, including protein, fat, essential amino acids, vitamins, and minerals (Hamdan, 2020). Processing crickets into other forms, such as flour, is highly recommended to increase consumer acceptance of crickets as it is easily added to other products (Laroche et al., 2019).

There has been no previous research on using a combination of fermented coconut pulp flour and cricket flour as organic fish feed. In previous studies, it has been known that fermented coconut pulp flour and cricket flour each have carbohydrate, protein, fat, and crude fiber content in complementary amounts, so it is thought that they can be applied as organic fish feed. This research aims to determine the carbohydrate and protein content and the color, aroma, and density assessment of the combination of fermented coconut pulp flour and cricket flour as organic fish feed.

Methods

This research was conducted from Dec 25, 2023, to Jan 25, 2024, at the Biology Laboratory, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. Proximate testing of carbohydrates and proteins by SNI 01-2891-1992 at the Balai Pengujian dan Sertifikasi Mutu Barang, Surakarta. The raw materials used in the research include coconut pulp, crickets, and tapai yeast. Coconut pulp is obtained from coconut grinding waste in Kleco Market, Surakarta, while the crickets are obtained from Depok Animal Market, Surakarta. The phase of crickets used in this research is the nymph phase towards adulthood, ranging in age from 30 – 35 days with a body length of 1.3 – 1.8 cm.

Research Design

This research is an experimental research that explores new ingredients that can be applied as organic fish feed. The study used a completely randomized design (CRD) pattern where 1 factor was repeated twice. Each repetition consisted of 3 fermented coconut pulp flour and cricket flour treatments. The ratio of fermented coconut pulp flour and cricket flour is as follows.

A1 = 1: 2 ratio (35 g of cricket flour and 70 g of fermented coconut pulp flour)
A2 = 2: 1 ratio (70 g of cricket flour and 35 g of fermented coconut pulp flour)
A3 = 1: 1 ratio (52.5 g of cricket flour and 52.5 g of fermented coconut pulp flour) (Sajuri, 2018).

The organic fish feed formula of this research is in Table 1.

Table 1. Organic Fish Feed Formula of Fermented Coconut Pulp Flour and Cricket Flour

Raw Materials	Formulas (g)		
	A1	A2	A3
Cricket flour	35	70	52,5
Coconut pulp flour	70	35	52,5
Bran	10	10	10
Tapioca flour	30	30	30
Total	145	145	145

Fermented Coconut Pulp Flour Processing

The processing of coconut pulp begins with weighing the coconut pulp using digital scales to prevent inaccuracies in the target protein content produced (Safir et al., 2020). Steam for 45 minutes, then allow to cool. Mixing of tapai yeast in a ratio of 1: 0.002, which is 2 g of tapai yeast for every 1 kilogram of coconut pulp. Incubation process for 2 days in a glass jar covered with plastic and a small hole with a needle. After harvesting, coconut pulp was dried using an oven (Merdekawati et al., 2023). Dry the coconut pulp by baking it at 100^{0}C for 30 minutes. A 40-mesh sieve filters coconut pulp flour (Putri, 2014).

Cricket Flour Processing

The making of cricket flour begins with crickets killed by depleting their oxygen levels by vacuuming, then letting them die for approximately 30 minutes to 1 hour. Drying crickets in an oven at 60^{0}C for 24 hours (Maulana et al., 2023) and pulverizing dried crickets with a grinder.

Organic Fish Feed Processing

Processing of organic fish feed starts with weighing each ingredient according to the formulation that has been made. Mix all the ingredients with an adhesive in tapioca flour that has been cooked with boiling water until it changes its texture to become like glue (Deran et al., 2023). Tapioca starch is used as an adhesive in feed (Saifuddin et al., 2020). Bran uses as much as 5 g of tapioca starch and 10 g per treatment per 50 g of formula (Setyaningrum et al., 2017). Then, water was added to this mixture to form a dough. The grinding process used a grinding machine. Drying using an oven with a temperature of 100 for 30 minutes until completely dry aims to preserve the pellets so they do not mold (Saifuddin et al., 2020). Storage in a closed container and dry place.

Data Collection and Analysis

The parameters observed were carbohydrate and protein content (proximate test) and each feed formula's aroma, color, and texture (sensory test). Sensory test samples were given to 20 respondents. The samples were placed in a cup and presented to the panelists. The panelists were asked to complete a questionnaire consisting of a statement table about the color, aroma, and texture of the tested fish feed. Each sensory test product assessment criteria is shown in Table 2.

Furthermore, the data of both tests were analyzed using ANOVA (Analysis of Variance) with a significance level of 5%. If $P < 0.05$ is, continued with Duncan's Multiple Range Test (DMRT) to determine the significant difference between each treatment and the level of panelist liking (Purdi et al., 2020). The hedonic quality assessment test aims to measure consumer responses related to product acceptance (Adawiyah et al., 2020).

Table 2. Criteria for the Sensory Test of Organic Fish Feed

Value	Color	Aroma	Texture
4	Very dark	It is very similar to commercial feed, very fishy	Very hard, very dense, tight, smooth
3	Dark	Similar to commercial feed, fishy	Hard, solid, smooth
2	Pale	Not similar to commercial feed, musty	Smooth, brittle, fibrous
1	Very pale	It is not very similar to commercial feed; it is very musty and rancid	Very smooth, crumbly, hollow

Results

The results of testing the carbohydrate and protein content of fish feed fermented coconut pulp flour and cricket flour are presented in Table 3.

Table 3. The Carbohydrate and Protein Content of Organic Fish Feed from Fermented Coconut Pulp Flour and Cricket Flour

Formulas / Replication	Carbohydrate (%)			Protein (%)		
	1	**2**	**ANOVA Test**	**1**	**2**	**ANOVA Test**
A1	30.21	30.81**	$30,51 \pm 0,424^{a}$	10.27	11.01*	$10,64 \pm 0,523^{a}$
A2	26.01	26.07*	$26,04 \pm 0,042^{b}$	20.43	21.33**	$20,88 \pm 0,636^{b}$
A3	28.23	28.67	$28,45 \pm 0,311^{c}$	16.58	17.14	$16,86 \pm 0,395^{c}$

Notes: A1 = 1: 2 ratio (35 g of cricket flour and 70 g of fermented coconut pulp flour); A2 = 2: 1 ratio (70 g cricket flour and 35 g of fermented coconut pulp flour); A3 = 1: 1 ratio (52.5 g of cricket flour and 52.5 g of fermented coconut pulp flour); (**) highest; and (*) lowest. Carbohydrate and protein content indicated in 100 g of feed. Mean values in each superscripted row are significantly different ($P < 0.05$, Duncan test), and the symbol ± represents the standard error.

Table 3. shows the differences in carbohydrate and protein levels in each organic fish feed formula. The highest carbohydrate content was obtained in formula A1, while the lowest carbohydrate content was found in formula A2. The highest protein content was obtained in formula A2, while the lowest was in formula A1. ANOVA test results obtained $P < 0.05$; significant differences in organic fish feed formulas (A1, A2, and A3) on carbohydrate and protein content exist. The increase in fermented coconut pulp flour percentage is directly related to increased carbohydrate content in organic fish feed. The increase in protein content is directly correlated with the rise in cricket flour.

The research results on processing fermented coconut pulp flour and cricket flour into organic fish feed are shown in Figure 1.

Figure 1. The organic fish feed of fermented coconut pulp flour and cricket flour; A. A1 formula, B. A2 formula, C. A3 formula (Source: Personal documentation)

Table 4. ANOVA Test on Color, Aroma, and Texture of Organic Fish Feed from Fermented Coconut Pulp Flour and Cricket Flour

Component	Formula		
	A1	**A2**	**A3**
Color	2.35 ± 0.489^{a}	3.85 ± 0.336^{b}	3.50 ± 0.688^{c}
Aroma	2.45 ± 0.605^{a}	3.75 ± 0.444^{b}	3.30 ± 0.470^{c}
Texture	2.60 ± 0.503^{a}	3.70 ± 0.470^{b}	3.30 ± 0.657^{c}

Description: Mean values in each superscripted row are significantly different (P < 0.05, Duncan test), and the symbol ± represents the standard error.

Table 4. the results of the ANOVA test obtained P < 0.05, shows significant differences in organic fish feed formulas (A1, A2, and A3) on feed color, aroma, and texture. Duncan's test shows differences in feed color, aroma, and texture from all formulas, A1, A2, and A3.

Each formula is significantly different; the formula that has the highest average points is formula A2, with 3.85 points, indicating a dark to very dark feed color. Formula A2 also has the highest average point on the aroma test, scoring 3.75, indicating a feed aroma similar to commercial and fishy feeds. The textural test of formula A2 also has the highest average point with a score of 3.70, indicating that the texture is hard, dense, and smooth on the surface.

Formula A1 has the lowest average, with a 2.35 score indicating a pale feed color. Formula A1 also has the lowest average score of 2.45 on the aroma test, indicating a feed aroma that is not similar to commercial and musty. Formula A1 has the lowest average, scoring 2.60 on the textural test, displaying smooth, crumbly, and fibrous feed texture.

Discussion

Proximate Test

Carbohydrate Content

The results of the ANOVA analysis in Table 4 showed that the average carbohydrate content was 26.04 - 30.51%. The highest carbohydrate content was obtained in formula A1. It can be seen in Table 1. that the percentage of fermented coconut pulp flour in formula A1 is the highest compared to other formulas. Meanwhile, formula A2 also had the lowest carbohydrate content due to a decrease in the percentage of fermented coconut pulp flour used in the feed. This can occur because coconut pulp flour's carbohydrate content is higher than cricket flours. In line with the research by Wulandari et al. (2018), coconut pulp has a higher protein content than cricket flour; coconut pulp has a reasonably low protein content of only 5.6% and a high carbohydrate content of 38.1%, while in the research of Gantner et al., (2024), the carbohydrate content of cricket flour in 100 g is around 9.83%.

The feed's higher carbohydrate content can correlate with the shorter fermentation period of 2 days. Fermentation that lasts shorter will produce higher carbohydrate levels, while fermentation that lasts longer will reduce carbohydrate levels (Kurniawan et al., 2022). The need for carbohydrates in each fish is different, so it needs to be adjusted based on the type of fish that will be consumed. Omnivorous and carnivorous fish require lower carbohydrate levels than herbivorous fish (Tambulango et al., 2023). Catfish (*P.*

hypophthalmus) fed a feed containing 32.51% carbohydrates produced the best growth (Tobuku, 2022), so the feed formula suitable for catfish is formula A1. Fish use a certain amount of carbohydrates to support the body's health so that the feed's protein can be used efficiently as an energy source in supporting fish growth ikan (Yanto et al., 2019).

It can be seen in Figure 1 that the level of fermented coconut pulp flour has a significant effect on increasing the carbohydrate content of the feed made. The high percentage of fermented coconut pulp flour is followed by increased carbohydrate content in organic fish feed.

Protein Content

Based on the ANOVA test results in Table 3, the highest protein content is found in formula A2, which is 20.88%. It can be seen in Figure 1 that the higher the percentage of cricket flour used and the lower the coconut pulp flour used, the higher the protein content; otherwise, the lower the percentage of cricket flour and the higher the coconut pulp flour used, the lower the protein content. In line with research (Hamsana, 2021), cricket flour contains a protein content of 56.02-61.58% in wet material. As in the study by Gantner et al. (2024), the addition of cricket flour will increase protein and fat levels but can reduce the carbohydrate content of the product. However, protein levels in feed are also adjusted based on the type of fish.

Table 3. shows that the protein content of commercial feed for herbivorous fish requires the least amount compared to omnivorous and carnivorous fish. Milkfish require feed with a protein content of 20-25% (Susanto, 2019), while tilapia requires 14-16% protein (Amalia, 2018). The protein content in goldfish feed is around 25.75%, showing a positive increase in growth rate and absolute weight growth (Makmur et al., 2023). Based on the study results, formula A1 is suitable for herbivorous fish, formula A2 for carnivorous fish, and formula A3 for omnivorous fish.

Protein levels that are too high or too low are also not good for the fish body. Suppose the level of protein absorbed exceeds the needs. In that case, the level of consumption will decrease so that the uptake of other nutrients, including protein, will decrease so that the right balance between carbohydrates and protein is needed to achieve the efficiency and effectiveness of feed utilization (Karimah et al., 2018). Growth retardation and even symptoms of malnutrition in fish can arise due to fish consuming feed with low protein (Ahriani et al., 2023).

Cricket flour levels have a significant effect in increasing protein levels in feed. Protein levels in organic fish feed can also be caused by the type of food consumed by crickets (Sorjonen et al., 2019) and the life stage of crickets during larval, pupa, prepupa, or imago stages (Nogales-Mérida et al., 2019).

Sensory Test

Feed Color

The color of the organic fish feed produced comes from coconut pulp flour, cricket flour, bran, and tapioca flour. In Table 4, different formulas significantly affect the organic fish feed produced, so it has a different color. Various coconut pulp flour and cricket flour levels influence the color difference produced. This can result in different consumer acceptance. The lowest level of liking was obtained by formula A1, which was pale in color, as shown in Figure 1. Using coconut pulp flour as a raw material creates an organic fish feed product that is pale, like the color of coconut pulp. The higher the level of coconut pulp flour used, the paler the color produced (Murniaty et al., 2023). Formula A2 obtained the highest level of liking, where the color produced in the formula was dark to very dark, similar to that of commercial feed. The dark pigments formed in the fish feed are obtained from the cricket flour ingredients used because cricket flour has a dark color value. After all, it shows a relatively low brightness level due to the oven (Mafu et al., 2022).

Feed Aroma

The aroma produced by organic fish feed comes from coconut pulp and crickets. Crickets that have been processed into flour have a distinctive fishy aroma. Applying coconut pulp as a raw material for organic fish feed produces a coconut-like aroma. The highest favorable rating was achieved by formulating A2 with the highest cricket flour content, 70 g, as it had the closest aroma to commercial feed. This aligns with research by Haetami et al. (2023); the feed formulation has a more pleasant aroma because it resembles commercial feed, so fish are interested in consuming it.

Formula A1 resulted in the lowest favorability rating. Some panelists mentioned that formula A1, which has the highest coconut pulp flour content, has an aroma that is not very similar to commercial feed because it does not have a fishy aroma. Some panelists mentioned a musty or rancid aroma. These assessments significantly affect fish acceptance, as in the case of Mokoginta et al. (2022), which states that a decrease in fish response to feed can occur due to the rancid aroma that arises in the feed. The aroma of feed from vegetable ingredients is not so attractive to fish (Zahra, 2023), so the levels of vegetable ingredients that are too high result in a low level of liking. As in research by Samudera et al. (2022), ration consumption increased at fermented coconut pulp levels, which tended to be lower than the ration formula, which had higher levels of fermented coconut pulp. This is due to the rancid or pungent aroma that arises along with increasing levels of coconut pulp in the ration so that consumption power decreases. This aroma produced by the feed significantly affects the control of fish consumption (Ahriani et al., 2023). So, the best feed for fish is not only determined by nutritional content but also influenced by the aroma because the aroma can stimulate fish appetite (Sulasi et al., 2018).

Feed Texture

The sensory test results obtained by different formulas significantly affect the organic fish feed produced, causing different textures and levels of liking. The highest level of liking for the texture of the feed is in formula A2. This is because fish feed formula A2 has a rugged, dense, and smooth texture on its surface. This texture is similar to commercial feed, which is thick and soft on the surface. In addition, during kneading, formula A2 also has the most dense and chewy texture compared to other formulas. This occurs because the protein absorbs water, allowing it to flex into gluten (Mafu et al., 2022). The texture produced in the feed can also be influenced by tapioca flour, which affects the density because it is used as an adhesive. The adhesive material functions to glue the feed parts together to form a strong, compact, and unified feed structure (Irawati et al., 2023).

The lowest level of liking was obtained by formula A1, which indicated a fine, crumbly, fibrous feed texture. The crumbly and fibrous texture is thought to be due to the high percentage of fermented coconut pulp flour in the formulation. Some panelists mentioned that the fish feed in Formula A1 was still textured like coconut pulp and looked like compacted coconut pulp. Feed with the addition of fermented coconut pulp has unfavorable characteristics, such as feed not lasting long floating on the water's surface, so goldfish are less optimal in consuming feed (Putri et al., 2023). The heating process also affects the texture, adhesive factor, and the percentage of raw materials used. The heating process will affect the texture of fish feed. Heating using oben produces a denser and more unified texture of fish feed than drying under the hot sun (Akerina et al., 2022).

Conclusions

The level of fermented coconut pulp flour significantly increases the carbohydrate content of the feed, resulting in an average of 30.51%. The cricket flour level significantly increases the protein content in the feed, resulting in an average of 20.88%. The combination of formula A2 showed the highest level of color, aroma, and texture preference with dark to very dark color ratings similar to commercial feed, fishy smell, and closest to commercial feed, and had a hard, dense, and smooth texture. Suggestions for further research are that the study be carried out with variable heating to obtain the best results at optimum operating conditions. The analysis can be added to the analysis of crude fiber, fat, ash, and water content.

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