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Use Of Fermented Tarum (Indigofera Zollingeriana) Leaf Flour From Aspergillus Niger On Growth Performance Of Jaya Sakti Carp Larvaes

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Abstract— Tarum leaves (Indigofera zollingeriana) are an alternative local raw material that can be used as fish feed. I. zollingeriana has a fairly good protein content, namely 29.06%, which is needed for fish growth. The use of I. zollingeriana is faced with the obstacle of a high fiber content of 15.25%, which reduces feed digestibility and inhibits fish growth. Efforts to overcome this problem are through a fermentation process, one of which uses Aspergillus niger. Research was conducted to determine the use of I. zollingeriana leaf meal fermented by A. niger in feed on the growth performance of Jaya Sakti goldfish (Cyprinus carpio, L). The design used in this research was a completely randomized design (CRD) consisting of 4 treatments, namely the use of I. zollingeriana leaf flour fermented by A. niger in feed at 0%, 15%, 30% and 45% and 4 treatments each. test. The test fish used were 7-8 cm long, weighed 8-9 grams, 20 fish/m3 in happa measuring 2x2x1 m3 and each equipped with aeration. The test fish were fed at a feeding rate of 7%/BW with a feeding frequency of 5 times a day. The results of the research showed that the best specific growth rate (SGR) value was the use of 0% fermented I. zollingeriana leaf flour (control) of 1.46%/day. Utilization of 15% fermented I. zollingeriana leaf flour gave the highest specific growth rate (SGR) value (1.09%/day) compared to 30% utilization (0.91%/day) and 45% utilization (0.65%/day). Business analysis is based specifically on feed costs using FCR calculations, where commercial feed provides higher profits (Rp. 5,320/kg). Utilization of 30% I. zollingeriana leaf flour fermented by A. niger can provide higher profits (Rp. 3,305/kg) compared to 15% (Rp. 2,579/kg) and 45% (Rp. 667/kg).

Keywords— Feed, fermentation, Aspergilus niger, growth performance, carp.

I. INTRODUCTION

Feed is the main component in the sustainability of a cultivation business. The biggest cost in fish farming comes from feed costs. Cultivating freshwater fish, including goldfish, costs 60-70% of the food costs of production, thus affecting the profits that fish farmers will obtain (Nurhayati and Nazlia, 2019); (Dossou et al., 2018).

Growth is a very important factor for successful cultivation. One factor that can influence growth is the quality of feed which has a nutritional composition according to the needs of goldfish, thus determining the level of feed efficiency and feed digestibility (Putranti et al., 2015). Protein is the main component in fish feed (Ediwarman et al., 2010). The source of protein in fish feed comes from animal and vegetable protein, most of which are imported products. Artificial feed in the form of pellets is very popular with fish, however the price of specific pellets is expensive, therefore expensive feed can be substituted with cheaper local ingredients. The selected raw materials should be economical, available in large quantities, not compete with humans and have nutritional content according to fish needs (Aida et al., 2020); (Yan et al., 2017).

Tarum leaves (Indigofera zollingeriana) are an alternative local raw material that can be used as feed ingredients. I. zollingeriana plants are often found in Indonesia, grow fast, are adaptive to low soil fertility (Abdullah, 2014), have high tolerance to the dry season , does not require special care (Arniaty et al., 2015), is available continuously, and is cheap (Basir, 2018).

I. zollingeriana has quite good nutritional content so it has great potential to be developed as a local feed raw material that can replace soybean meal (Mukti, 2019). I. zollingeriana contains 29.06% protein (Pangentasari et al., 2018); 25.17-26.44% (Kumalasari et al., 2017); 22-28%, crude fat or ether extract (EE) of 3.70% and crude fiber of 14.96% (Santi, 2017). Indigofera contains the amino acids histidine 0.67%, threonine 1.14%, arginine 1.67%, tyrosine 1.05%, methionine 0.43%, valine 1.56%, phenylalanine 1.60%, isoleucine 1.35 %, leucine 2.26%, and lysine 1.57 (Marzuqi et al., 2015), mineral content namely: Ca 1.16%, P 0.26%, Mg 0.46% (Abdullah, 2010). The content and composition of vitamin A in Indigofera sp is more complete than in soybean meal, namely 3828.79 IU/100g. The ß-carotene content of Indigofera sp leaves (507.6 mg/kg) has the potential as an antioxidant for livestock (Palupi et al., 2015).

The use of plant-based fish feed ingredients is faced with the constraints of high fiber content and anti-nutrient substances which have an impact on feed digestibility (Bu et al., 2018), fish digestibility (Hansen and Hemre, 2013); (Pandey, 2013) as well as limiting fish use of feed so that fish growth is hampered (Mayulu, 2014). The higher the crude fiber value, the lower the feed digestibility value (Suprayudi et al., 2011). Digestibility value has a positive correlation with fish growth. The higher the fish digestibility value, the better the feed digested by the fish as a source of energy and growth (Hassaan et al., 2019); (Bokau et al., 2018); (Azaza et al., 2020).

To improve the nutritional quality of feed ingredients by reducing crude fiber and fat levels, as well as increasing crude protein and feed digestibility, fermentation is carried out (Jakobsen et al., 2015); (Rostika and Safitri, 2012). The fermentation process produces enzymes that break down crude fiber and increase protein levels. A number of proteins, carbohydrates and fats are broken down into smaller fractions, thus facilitating digestion and absorption of nutrients (Liwe et al., 2014). Fermentation can minimize the risk of aflatoxins in feed ingredients (Mwihia et al., 2018), beneficial for the organism's digestive tract which helps improve feed digestibility (Xie et al., 2016) and thereby improves feed efficiency, growth performance, immunity and tolerance to various stress-causing stresses in fish (Jannathulla et al., 2019).

Fermentation is an effort to improve the quality of raw materials through the use of microbes (Sugiharto & Ranjitkar, 2019). One of the microorganisms used in fermentation is A. niger, which is a species of Aspergillus that can grow quickly, is easily available at a low price and does not produce mycotoxins (Maryanty et al., 2010). A. niger can grow at temperatures of 35ºC - 37ºC (optimum), 6ºC - 8ºC (minimum), 45ºC - 48ºC (maximum) and requires sufficient oxygen (Sinaga et al., 2012). A. niger is a mold species that has the ability to secrete the enzymes cellulase, chitinase, amylase, glucoamylase, catalase, pectinase, lipase, lactase, invertase, and acid protease (Purkan et al., 2016); (Djunaidi et al., 2020).

A. niger has been widely used in the fermentation of leaf material from bacteria for fish feed and provides the best results on fish growth performance. Fermentation of rice bran using A. niger as raw material for Tilapia fish feed showed the best results with dry matter digestibility values of 67.87 ± 2.44%, protein digestibility of 85.04 ± 3.28%, total feed consumption of 230 ± 4.08 g , final weight 11.81 ± 0.45 g, specific growth rate 1.65 ± 0.40 % and survival rate 75.00 ± 0.11 %. (Ikhwanuddin et al., 2018).

Furthermore, Nurhayati and Nazlia (2019) stated that fermentation of gamal leaf flour (Gliricidiasepium) with A. niger as raw material for tilapia fish feed was able to provide the best results with an SGR value of 0.7%, FCR 1.7 and protein retention of 14.99%. .

So far, research related to the use of I.zollingeriana leaf flour fermented using A. Niger in Carp Jaya Sakti fish feed has never been carried out. Based on this background, researchers conducted research related to "Utilization of Indigofera zollingeriana Leaf Flour Fermented with Aspergilus niger as a Larvae Ingredient for Jaya Sakti Goldfish (Cyprinus carpio, L)"

II. RESEARCH METHODS

Time and Location of Research

This research was carried out from March to June 2022. The rearing of Jaya Sakti goldfish was carried out in fish rearing ponds located at the Sungai Gelam Jambi Freshwater Aquaculture Fisheries Center (BPBAT). Meanwhile, proximate analysis of test feed and fish meat was carried out at the Fish Nutrition Chemistry Laboratory, Faculty of Fisheries and Marine Sciences, IPB, Bogor.

Research Tools and Materials

The tools used in this research were 16 units of 2x2x1 m3 hapa, hose and aeration stone, pellet molding machine with 3 mm dies, digital scales with an accuracy of 1 gram, basin, scoop, digital thermometer with an accuracy of 0.1^o, pH meter with an accuracy of 0, 1, DO meter with an accuracy of 0.1 mg/L, spectrophotometer with a wavelength of 640 nm, Sechi disk diameter 20 cm.

The materials used in this research were Carp Jaya Sakti fish larvaes with a length of 7-8 cm and a body weight of 8-9 grams, feed raw materials in the form of fermented I. zollingeriana leaf meal, local fish meal, soybean meal, copra meal, Tapioca flour, fine bran, fish oil, amino liquid, fish vitamin premix, phytase enzyme, vitamin E are available at the Sungai Gelam Jambi Freshwater Aquaculture Fisheries Center (BPBAT) and are commonly used by fish farmers.

Research design

The design used in this research was a completely randomized design (CRD) consisting of 4 treatments and 4 replications so that there were 16 experimental units. The treatment used was the addition of fermented I. zollingeriana leaf flour as in the digestibility test with various doses referring to research (Palupi et al., 2015); (Jefry et al., 2021).

Treatment 1 (P1) = I. zollingeriana leaf meal 0% (as control)

Treatment 2 (P2) = I. zollingeriana leaf meal 15%

Treatment 3 (P3) = I. zollingeriana leaf meal 30%

Treatment 4 (P4) = I. zollingeriana leaf meal 45%

Preparation of Containers, Media and Test Fish

A fish rearing container measuring 600 m2 is installed with 16 happa measuring 2x2x1m3 on 1/3 of the west side of the length of the pond and close to the incoming water source. The pool has a pool water depth of ±1.8 meters. Each happa is equipped with airation which is placed in the middle of the length of the happa and hung to a depth of 50 cm (Appendix 4). The test fish were stocked at a density of 20 fish/m3 obtained from the Sungai Gelam Jambi Freshwater Aquaculture Fisheries Center. The test fish were adapted first for 7 days, then their weight was weighed and their length was measured as initial weight and length. The next step is to fast the test fish for 1x24 hours to empty the fish's stomach. The test fish were fed according to the treatment with a feeding rate of 7% (Ediwarman, 2010) with a feeding frequency of 5 times a day, namely at: 07.30 WIB, 10.30 WIB, 13.30 WIB, 15.30 WIB and 17.30 WIB until they reached a size of 200% of their weight. beginning (Utomo, 2005).

Making Test Feed

Making test feed in the form of a mixture of several raw materials and feed additives, so that it has certain nutritional value which is able to support the growth and reproduction of fish. The test feed used was artificial feed with an isoprotein content of ±28%. This food is made through a pellet molding process with a 3 mm die which is adjusted to the size of the goldfish's mouth opening with the physical properties of this food sinking. The test feed was made at the independent feed factory owned by BPBAT Sungai Gelam, Jambi. The molded feed is put in a plastic sack and stored in a clean place at room temperature. The test feed formulation can be seen in Table 1.

Table 1. Feed formulation for enlargement test on Carp fry

No	Feed raw materials	Composition of feed ingredients each treatment (%)			
		P1	P2	P3	P4
1	Local fish meal	30	30	30	30
2	Soybean meal	20	14	9	2
3	Fine bran	10,45	10,45	10,45	6,45
4	Cornstarch	20,5	15,2	9,75	3,7
5	Coconut cake/copra	12,5	9,8	5,25	6,3
6	Indigofera Leaf Flour	-	15	30	45
7	Tapioca	4	2,75	2	1
8	Fish oil	1	1,25	2	4
9	Aminoliquite	0,5	0,5	0,5	0,5
10	Vit. Fisha Premix	1	1	1	1
11	Phytase enzyme	0,03	0,03	0,03	0,03
12	Vitamin E (20 mg/100g)	0,02	0,02	0,02	0,02
Total		**100**	**100**	**100**	**100**

Information :

a per kg: Vit A 170,000.00 IU, Vit D3 50,000.00 IU, Vit E 3,000.00 IU, Vit K3 135.00 mg, Vit B1 200.00 mg, Vit B2 330.00 mg, Vit B6 335.00 mg, Vit B12 0.45 mg, Biotin 4 .00 mg, Folic Acid 65.00 mg, Calpan 1,000.00 mg, Nicoyinic Acid 2,000.00 mg, Iron 1,335.00 mg, Copper 100.00 mg, Zinc 3,350.00 mg

Observation of Test Parameters

The nutritional content of test feed was carried out by taking a 100 gram sample of feed/treatment, while the calculation of protein retention and fat retention was carried out by taking samples of fish meat before being given the treatment feed and fish meat at the end of rearing randomly as many as 10 fish/happa for each treatment and test. Next, the test feed and fish meat were subjected to proximate analysis including measuring water content, crude protein, crude fat, crude fiber and ash. Analysis of crude protein using the Kjeldahl method for water content and ash content was carried out using the Gravimetric method and crude fat using the Soxhlet method (AOAC, 2005).

Growth sampling of the test fish was carried out every 2 weeks by weighing the total weight of the fish, then a sample of 10 fish/happa was taken and each weight was weighed to determine the amount of feeding and calculate the FCR. Fish rearing water quality measurements include: temperature, pH, DO carried out every week in the morning (06.00 WIB) and afternoon (17.00 WIB) on the water surface. Measurement of ammonia levels by taking samples of fish rearing water and then observing in the laboratory. Brightness measurements are carried out by inserting a sechi disk that has been attached to a string into the maintenance container until the first time the disk is not visible. Data collection on ammonia levels and brightness was carried out at the beginning, middle and end of the maintenance period.

Data analysis

Data from research on various growth performance parameters were tabulated into Microsoft Excel in the form of tables and graphs and then processed using the SPPS 26.0 program with an ANOVA analysis of variance test at a 95% confidence interval. If there is a real effect of treatment, a further Duncan test is carried out. Meanwhile, water quality parameter data is presented in tabular form and analyzed descriptively. Calculation of fish growth performance parameters consists of:

1. Total Feed Consumption (JKP)

According to (Manganang and Mose, 2019), the amount of feed consumption (JKP) is calculated using the following formula:

$$\mathrm{JKP} = \frac{\mathrm{F}}{\frac{(\mathrm{Wo} + \mathrm{Wt})}{2}} \mathrm{x\ t}$$

Information :

JKP = Amount of feed consumption (grams/day)

F = Amount of feed consumed (grams)

t = Length of maintenance days (days)

Wo = Initial weight (grams)

Wt = Final weight (grams)

2. Specific Growth Rate (SGR)

The specific weight growth rate or what is often called the daily weight growth rate will use the formula according to Effendie (1997):

$$\mathrm{SGR}(\%/\mathrm{hari}) = \frac{\mathrm{LnWt} - \mathrm{LnWo}}{\mathrm{t}}$$

Information :

SGR: Specific weight growth rate (%/day) (grams)

Wt: Fish weight at the end of rearing (grams)

Wo: Fish weight at the start of rearing (grams)

t : Length of maintenance time (days)

3. Feed Conversion Ratio (FCR)

Feed conversion ratio (FCR) is the ratio of the amount of feed given to the weight of fish produced. The feed conversion ratio is calculated using the formula from Effendi (1997):

$$\mathrm{FCR}\ (\%) = \frac{\mathrm{F}}{\mathrm{Wt} - \mathrm{Wo}}$$

Information:

FCR = Feed Conversion Ratio (%)

F = amount of feed given during the rearing period (grams)

Wt = Final weight (grams)

Wo = Initial weight (grams)

4. Efficiency of Feed Utilization (EPP)

Feed utilization efficiency (EPP) is calculated using the Tacon (1987) formula:

$$\mathrm{EPP}\ (\%) = \frac{\mathrm{Wt} - \mathrm{W0}}{\mathrm{F}}$$

Information :

EPP = Feed Utilization Efficiency (%)

Wt = Weight of test animal material at the end of the study (grams)

Wo = Weight of test animal material at the start of the study (grams)

F = Amount of fish feed consumed during the study (grams)

5. Protein Efficiency Ratio (PER)

The protein efficiency ratio is a comparison between the increase in fish weight and the amount of protein consumed based on Takeuchi (1988):

$$\mathrm{PER}(\%) = \frac{\mathrm{Wt} - \mathrm{W0}}{\mathrm{Pi}}$$

Information :

PER = Protein Efficiency Ratio (%)

Wt = Weight of test animal material at the end of the study (grams)

Wo = Weight of test animal material at the start of the study (grams)

Pi = Total protein content of feed consumed (%)

6. Protein Retention (RP)

The protein retention value will be calculated after going through the results of the proximate analysis of the body protein of the test fish at the beginning and end of rearing. Protein retention can be calculated based on the Watanabe (1988) equation, namely:

$$\mathrm{RP}(\%) = \frac{\mathrm{Pt} - \mathrm{Po}}{\mathrm{Pp}}$$

Information :

RP = Protein Retention (%)

Pt = Amount of fish body protein at the end of rearing (g)

P0 = Amount of fish body protein at the start of rearing (g)

Pp = Amount of feed protein consumed by fish (g)

7. Fat Retention (RL)

The fat retention value will be calculated after going through the results of the proximate analysis of body fat of the test fish at the beginning and end of rearing. Fat retention can be calculated based on the Watanabe (1988) equation:

$$RL\ (\%) = \frac{Lt - Lo}{Li}$$

Information :

RL = Fat Retention (%)

Lt = Amount of fish body fat at the end of rearing (g)

Lo = Amount of fish body fat at the start of rearing (g)

Li = Amount of feed fat consumed by fish (g)

8. Survival Rate (SR)

Survival rate (SR) is calculated using the Effendie (1997) formula:

$$SR\ (\%) = \frac{Nt}{No}$$

Keterangan :

SR = Survival Rate / Survival (%)

Nt = Number of fish alive at the end of the study (tails)

N0 = Number of fish at the start of the study (tails)

III. Results and Discussion

The use of fermented I. zollingeriana leaf flour in several doses (0%, 15%, 30% and 45%) in Carp Jaya Sakti fish rearing feed provides different nutritional content. Nutrient components that contribute to growth and reproduction include: energy, protein, fat and crude. The results of the proximate analysis of the Carp Jaya Sakti fish rearing feed for each treatment can be seen in Table 2.

Table 2. Proximate analysis of rearing test feed for Carp Jaya Sakti fish fry (% dry matter)

Nutrient Content (%)	Composition of ingredients for each treatment			
	P1	P2	P3	P4
Ash	20,46	19,66	19,70	17,45
Proteins	33,31	33,16	34,73	34,86
Fat	6,70	7,52	6,74	8,40
Crude Fiber	13,38	12,40	12,63	12,07
BETN*	26,14	27,26	26,20	27,22
Digestible Energy**	236,23	245,14	241,63	258,10
(kcal/g feed)	7,09	7,39	6,96	7,40

* extract ingredients without nitrogen are calculated using the formula: 100%-(protein content + fat + fiber + ash

** digestible energy: 1 g protein = 3.5 kcal, 1 g fat = 8.1 kcal, 1 g carbohydrate = 2.5 kcal (National Research Council, 1993)

Nutrient requirements for fish vary depending on species, age, size and physiological status such as growth and reproduction (Lochmann & Philips 2006) as well as food formulation (Santamaria & Santamaria 2011). Nutrient components for growth and reproduction in fish are obtained from the food they eat, including: protein, fat, crude fiber and energy (Carprizal, 2016).

Fish growth is closely related to the availability of protein in feed. Seeing the important role of protein in the fish's body, protein feed needs to be provided continuously with adequate quality and quantity. Protein requirements are influenced by water temperature, body size, stocking density, oxygen levels and the presence of toxins. Protein requirements in fish decrease as fish size increases (Pillay & Kutty, 2005). The crude protein content in fish feed ranges from 25% - 55%, depending on the age and type of species, where herbivorous and omnivorous fish require 15 - 30% protein while carnivorous fish require around 45% protein (Stacey, 2006).

The growth of goldfish can be increased if the fish use feed protein more efficiently to convert it into body protein deposits (Phimphilai et al., 2006). The protein content of test feed for enlarging goldfish larvaes in Jaya Sakti for each treatment ranged from 33.16 to 34.86% (>30%) (Table 3.2), which meets the quality requirements for goldfish enlargement feed with a minimum protein content of 25% (SNI , 2006). In line with this, Putranti et al., (2015) in their research explained that the protein content in cultivating goldfish (Cyprinus carpio) is recommended to be 30% with a protein energy value of 9 kcal to increase feed efficiency and growth.

The quality of feed protein is determined by its essential amino acid content. The lower the essential amino acid content, the lower the quality of feed protein (Johnson, 2002). Most animals, including fish, require 10 amino acids consisting of arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine (Gatlin, 2010). The need for essential amino acids in goldfish ranges from 0.5% to 6.0% (NRC, 1993). In line with this, the Heenemann Verlagsgesellschaft in (Pillay & Kutty, 2005) also explains that the amino acid requirements in carp are 16% arginine, 8% hestidine, 5% isoleucine, 13% leucine, 22% lysine, 12% methionine, phenylalanine 25%, thereonine 15%, tryptophan 3%, valine 14%.

Apart from being energy, fat is also a source of fatty acids which fish need for basic functions, namely growth, reproduction and tissue maintenance. The availability of essential fatty acids (EPA) in feed is very necessary for growth, normal development and helps the absorption of various types of fat-soluble vitamins (Sargent et al., 1995). The use of protein by fish is not optimal, so fat is needed as another energy source optimally for growth. In this study, the fat content of the test feed ranged from 6.70% -8.40% (Table 3.2), where the fat composition in the rearing feed for goldfish was a minimum of 5% (SNI, 2006). Furthermore, Kurniasih et al., (2015) in their research explained that goldfish require 1.0% linoleic fatty acid and 1% linolenic acid.

Energy is an important nutritional component in fish life, both for metabolic, swimming and reproductive functions. Fish's energy needs can be obtained from protein, fat and carbohydrates in the feed they eat. As an energy source, the function of protein can be replaced by fat and carbohydrates. Increasing the availability of carbohydrates and fats can reduce protein oxidation to produce energy so that it can increase the utilization of feed protein for growth and reproduction. Furuichi (1988) in (Handayani, 2006). The level of energy requirements in fish is usually associated with the optimal level of protein requirements in the feed. In the world of aquaculture, this is usually called the protein energy ratio (E/P). This value is obtained from the calculation between the protein content in the feed and the amount of energy obtained in the feed formulation at the digestible energy (DE) level. The protein energy ratio value of the test feed for each treatment in this study ranged from 6.96% - 7.40% (Table 3.2). The protein energy ratio (E/P) value in consumption fish should be in the range of 8 – 10 (Frikardo, 2009) in (Putranti et al., 2015).

Crude fiber is plant material that is difficult to digest and affects the physical form of feed. The crude fiber content in the test feed for each treatment in this study ranged from 12.07% - 13.38%. (Table 3.2). The maximum crude fiber content of goldfish rearing feed is 8% (SNI, 2006). Generally, fish can tolerate crude fiber content in their feed, namely up to 8%, if it exceeds 8% it will affect the quality of the fish feed (pellets) and can suppress the growth of the fish (Gatlin, 2010).

Growth is a very important factor in the success of fish farming, where this growth can be interpreted as an increase in the length or weight of fish during a period of cultivation. Growth in fish can occur if the food consumed is used by the body for metabolism, movement, production of sexual organs and replacing unused cells. The increase in cells in body tissue is responsible for the increase in fish weight (Effendi, 1997). The increase in bioCarps weight of Carp Jaya Sakti fish in this study increased with increasing time of fish rearing, this shows that the feed provided can support the growth of Carp Jaya Sakti fish.

The amount of increase in fish weight for each treatment is as follows: P1 (utilization of 0% fermented I. zollingeriana leaf meal) 31.07 grams, P2 (utilization of 15% fermented I. zollingeriana leaf meal) 22.48 grams, P3 (utilization 30 % fermented I. zollingeriana leaf flour) 19.39 grams and P4 (utilization of 45% fermented I. zollingeriana leaf flour) 15.54 grams. This increase in fish weight is related to the level of feed consumption, where higher feed consumption by fish tends to result in higher weight gain compared to lower feed consumption levels. The higher the addition of fermented I. zollingeriana leaf flour in the fish feed formulation, the lower the amount of feed consumed by the fish, which in turn has an impact on reducing fish weight gain (Table 3). The higher the level of feed consumption by fish causes the higher the possibility for fish to meet their nutritional needs, which then influences the increase in body weight of the fish (Abidin et al., 2015).

In this study, the higher the addition of fermented I. zollingeriana leaf flour in the feed had an effect on the color, taste and aroma of the fish feed (Appendix 6). This is supported by the opinion of Olaniyi and Oladunjoye (2012) who say that a higher level of replacement of feed ingredients causes changes in the texture and taste of the feed so that the feed is less attractive to fish. In line with this, Suprayudi et al., (2012) in their research explained that changes in the aroma and taste of the feed are thought to influence the fish's acceptance of the feed and the amount of feed consumed which then has an impact on the increase in fish weight. In line with this, Suprayudi et al., (2015) in their research explained that this is related to the presence of attractants contained in the feed (Suprayudi et al., 2015). The protein or amino acid content contained in feed is not only a source of energy that can stimulate growth but also as an attractant (Khasani, 2013).

Quality feed is feed that has good protein quality, with a high digestibility value and can provide all essential amino acids (Erfanto et al., 2013). Deficiency of essential amino acids such as tryptophan, lysine and sulfur-containing amino acids when using certain amounts of vegetable raw materials can also reduce growth performance in some types of fish (Zhang et al. 2017). Furthermore, Jefry et al., (2021) in their research explained that the amino acid content of I. zolligeriana leaf meal in the form of arginine is 1.67% lower than soybean meal at 3.48%, so it is thought to cause amino acid deficiency which has an impact on growth. gourami fish larvaes and this may also apply to goldfish. The lowest increase in fish weight in this study is also thought to be due to the presence of anti-nutritional compounds (Samtiya et al., 2020), where phytic acid and trypsin inhibitors, common anti-nutritional compounds can affect the taste of feed, intake and absorption of nutrients, resulting in reduced fish growth (Haghbayan & Mehrgan, 2015).

Calculation of growth performance indicators for Carp Jaya Sakti fish fed fermented I. zollingeriana A. niger leaf meal during the research included: amount of feed consumption, specific growth rate, feed conversion ratio, feed utilization efficiency, protein efficiency ratio, protein retention, fat retention and Survival rates are presented in Table 3.

Table 3. Growth performance indicators of Carp Jaya Sakti fish larvaes fed with fermented I. zollingeriana leaf flour during the research.

Parameter	Utilization of fermented Indigofera zollingeriana leaf flour (%)			
	0	15	30	45
JKP (gr)	7.221,31±362,87^{c}	6.101,10±385,81^{b}	5.876,55±209,08^{b}	5.082,58±276,88^{a}
SGR (%/day)	1,46±0,08^{d}	1,09±0,05^{c}	0,91±0,13^{b}	0,65±0,03^{a}
FCR (%)	2,92±0,15^{a}	3,40±0,08^{b}	3,47±0,15^{b}	4,09±0,06^{c}
EPP (%)	34,38±1,82^{c}	29,46±0,71^{b}	28,89±1,25^{b}	24,48±0,39^{a}
PER (%)	73,24±5,51^{c}	53,13±2,81^{b}	47,84±4,23^{b}	29,56±1,10^{a}
RP (%)	57,58 ±4,47^{c}	41,22 ±2,31^{b}	37,39 ±3,49^{b}	23,45 ±0,95^{a}
RL (%)	35,61 ±2,05^{c}	20,44 ±0,64^{b}	19,76 ±1,09^{b}	11,50 ±0,17^{a}
SR (%)	95,31±1,88^{a}	94,59±3,29^{a}	95,31±0,63^{a}	91,88±6,50^{a}

Note: the same letter on the same line indicates that it is not significantly different at the 95% confidence interval

Total Feed Consumption (JKP)

Based on the results of research that has been carried out, the amount of fermented I. zollingeriana leaf meal consumption in Jaya Sakti goldfish ranges from 5,082.58 - 7,221.31 grams. The highest feed consumption value was found in P1 (0% fermented I. zollingeriana leaf meal) amounting to 7,221.31 ± 362.87 grams, while the lowest amount of feed consumption was in P4 (45% fermented I. zollingeriana leaf meal) amounting to 5,082.58 ± 276 grams. .88 grams (Table 3.3).

The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf meal had a significantly different effect (P<0.05) on the amount of Carp Jaya Sakti fish feed consumed. Based on further tests, it is known that P1 (0% fermented I. zollingeriana leaf flour) is significantly different (P<0.05) from P2 (15% fermented I. zollingeriana leaf flour, P3 (30% fermented I. zollingeriana leaf flour) and P4 (45% fermented I. zollingeriana leaf flour), P2 (15% fermented I. zollingeriana leaf flour) and P3 (30% fermented I. zollingeriana leaf flour) are not significantly different (P>0.05) but are significantly different (P<0.05) with P4 (45% fermented I. zollingeriana leaf flour).

In this study, it was seen that the amount of feed consumed by fish decreased with the increasing addition of fermented I. zollingeriana leaf meal in the test feed formulation (Figure 3.2). In the test feed used in this research, it was seen that the more fermented I. zollingeriana leaf flour added to the test feed formulation affected the color, taste and aroma of the feed (Appendix 6), which in turn had an impact on decreasing the palatability (acceptability of the feed) by the fish. This is supported by the opinion of Han et al., (2014), namely, fish palatability to feed is influenced by feed performance conditions which include physical properties in the form of shape, color, texture and size, as well as chemicals that form taste and aroma.

***Specific Growth Rate* (*SGR*)**

Based on the results of research that has been carried out, the specific growth rate value for the use of I. zollingeriana leaf meal fermented by A. niger in this study ranged from 0.65-1.46%/day. The highest specific growth rate was found in P1 (0% fermented I. zollingeriana leaf meal) at 0.65%/day while the lowest specific growth rate value was found in P4 (45% fermented I. zollingeriana leaf meal) at 1.46%/day (Table 3.3). The specific growth rate value in this study is lower than the research results of Ikhwanuddin et al. (2018) with values ranging from 1.21-1.51%/day and research results by Putra et al. (2018) with values ranging from 2.53-3.47%/day.

The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf flour had a significantly different effect (P < 0.05) on the specific growth rate. Further test results showed that the specific growth rate of Carp Jaya Sakti P1 (0% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% fermented I. zollingeriana leaf meal). fermented I. zollingeriana leaves) and P4 (45% fermented I. zollingeriana leaf flour). P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) were not significantly different (P>0.05) but the two treatments were significantly different (P<0.05) from P1 (0% fermented I. zollingeriana leaf flour) and significantly different (P<0.05) from P4 (45% fermented I. zollingeriana leaf flour).

In this study, it was seen that the highest fish growth rate value was found in P1 (0% fermented I. zollingeriana leaf meal) followed by P2 (15% fermented I. zollingeriana leaf meal). This is thought to be because the feed has a high level of palatability so that the amount of feed consumed in this treatment is better. The growth rate of fish can be increased if the fish consume feed efficiently, where in more efficient use of feed, only a small amount of food substances are broken down to meet energy needs and the rest is used for growth (Carpitoh et al., 2015).

***Feed Convertion Rasio* (*FCR*)**

The research results showed that the feed conversion ratio (FCR) value for each treatment ranged from 2.92 - 3.47%. The highest FCR value was found in treatment P1 (0% fermented I. zollingeriana leaf meal) of 2.92 ± 0.15%, while the lowest feed conversion ratio (FCR) value was found in P1 (0% fermented I. zollingeriana leaf meal) of 2.92±0.15% (Table 3.3). The FCR value in this study is higher than the FCR value from research (Putra et al., 2018) of 2.38-1.55%.

The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf flour had a significantly different effect (P>0.05) on the feed conversion ratio value. Further test results showed that the conversion ratio of Carp Jaya Sakti fish feed P1 (0% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% flour fermented I. zollingeriana leaves) and P4 (45% fermented I. zollingeriana leaf flour). P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) were not significantly different (P>0.05) but the two treatments were significantly different (P<0.05) from P4 (45% fermented I. zollingeriana leaf meal). P4 (45% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P1 (0% fermented I. zollingeriana leaf meal), P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal fermented I. zollingeriana leaves).

In this study, it was seen that the lowest FCR value was found in P1 (0% fermented I. zollingeriana leaf meal), namely 2.92%, meaning that to produce 1 kg of fish meat, 2.92 kg of feed was needed. The low FCR value in P1 (0% fermented I. zollingeriana leaf meal) indicates that the feed has better quality than other treated feeds. High feed conversion indicates that the feed is of low quality. Feed that is of good quality and can be digested well by fish has a high efficiency value and a low conversion value. The value of the daily weight gain rate of fish is closely related to the feed efficiency value. If the daily weight gain rate increases, the feed provided can be used as efficiently as possible for fish growth, so that the efficiency value also increases. This will be followed by the feed conversion value (Satpathy et al, 2003).

Feed Utilization Efficiency (EPP)

The results of the research showed that the efficiency value of fermented I. zollingeriana leaf meal utilization for each treatment ranged from 24.48 to 34.38%. The highest feed utilization efficiency value was found in P1 (0% fermented I. zollingeriana leaf meal) of 34.38 ± 1.42%, while the lowest feed efficiency value was found in P4 (45% fermented I. zollingeriana leaf meal) of 24.48 ±0.39% (Table 3).

The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf meal had a significantly different effect (P<0.05) on the efficiency of feed utilization. Further test results showed that the utilization efficiency of Carp Jaya Sakti fish feed at P1 (0% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% fermented I. zollingeriana leaf flour) and P4 (45% fermented I. zollingeriana leaf flour). P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) were not significantly different (P>0.05) but the two treatments were significantly different (P<0.05) from P1 (0% fermented I. zollingeriana leaf flour) and P4 (45% fermented I. zollingeriana leaf flour). P4 (45% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P1 (0% fermented I. zollingeriana leaf meal), P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal fermented I. zollingeriana leaves).

Protein Efficiency Ratio (PER)

The research results showed that the protein efficiency ratio in this study ranged from 29.56 to 73.24%. The highest protein efficiency ratio value was found in P1 (0% fermented I. zollingeriana leaf meal) of 73.24 ± 5.51, while the lowest protein efficiency ratio value was found in P4 (45% fermented I. zollingeriana leaf meal) of 29.56 ±1.10 (Table 3).

The results of analysis of variance (ANOVA) with a confidence level of 95%, showed that the use of I. zollingeriana leaf meal fermented by A. niger in feed had a significantly different effect (P>0.05) on the protein efficiency ratio (PER) value. on Jaya Sakti goldfish. The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf flour had a significantly different effect on feed utilization efficiency (P<0.05). Further test results showed that the utilization efficiency of Carp Jaya Sakti P1 fish feed (0% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% fermented I. zollingeriana leaf meal). fermented I. zollingeriana leaves) and P4 (45% fermented I. zollingeriana leaf flour). The feed utilization efficiency of P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) was not significantly different (P>0.05) however the two treatments were significantly different (P<0.05) with P1 (0% fermented I. zollingeriana leaf flour) and significantly different (P<0.05) with P4 (45% fermented I. zollingeriana leaf flour). The feed utilization efficiency of P4 (45% fermented I. zollingeriana leaf meal) was significantly different (P<0.05) from P1 (0% fermented I. zollingeriana leaf meal), P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal).

The high value of the protein efficiency ratio in P1 is thought to be due to the feed in this treatment approaching the protein requirements of goldfish larvaes. The higher the PER value indicates the higher the fish weight value (Figure 3.1). Higher protein content in food can cause protein consumption to increase and make it more digestible and the subsequent effect is an increase in fish body weight (Nurhayati et al., 2019).

Protein Retention

Protein retention is a comparison between the amount of protein stored by fish in the body and the amount of protein provided through feed. According to Webster and Lim, (2002) in (Haerudin et al., 2017), the protein retention value of feed is determined by the protein source used in the feed which is closely related to the quality of the protein which is determined by the amino acid composition and the fish's need for these amino acids. . The research results showed that the protein retention value in this study ranged from 23.45 - 57.58%. The highest protein retention value was found in P1 (0% fermented I. zollingeriana leaf meal) of 57.58 ± 4.47, while the lowest protein retention value was found in P4 (45% fermented I. zollingeriana leaf meal) of 23.45 ± 0 .95 (Table 3).

The results of analysis of variance (ANOVA) with a confidence level of 95%, showed that the use of I. zollingeriana leaf flour fermented with A. niger in Jaya Sakti goldfish had a significantly different effect ($P>0.05$) on protein retention values. on Jaya Sakti goldfish. Further test results showed that the protein retention of Carp Jaya Sakti fish in P1 (0% fermented I. zollingeriana leaf meal) was significantly different ($P<0.05$) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% fermented I. zollingeriana leaf meal). fermented I. zollingeriana leaves) and P4 (45% fermented I. zollingeriana leaf flour). Protein retention using feed P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) was not significantly different ($P>0.05$) but the two treatments were significantly different ($P<0.05$) with P1 (0% fermented I. zollingeriana leaf meal) and significantly different ($P<0.05$) with P4 (45% fermented I. zollingeriana leaf meal). Protein retention in feed utilization P4 (45% fermented I. zollingeriana leaf meal) was significantly different ($P<0.05$) from P1 (0% fermented I. zollingeriana leaf meal), P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf flour).

The high value of protein retention in P1 (0% fermented I. zollingeriana leaf meal) is because the feed provided has a protein content that suits the fish's needs compared to other treated feeds. The high value of protein retention is also influenced by the protein that enters the body (protein intake) and the protein that is lost at the metabolic level. Therefore, it is suspected that goldfish in this treatment use less protein in the form of energy for metabolic processes compared to other fish, so that the protein retained is higher. This is supported by the opinion of Satpathy et al, (2003), namely that protein retention is a reflection of the amount of protein provided, which can be absorbed and used to build or repair damaged body cells, as well as being used by the body for daily metabolism. Protein retention itself is the result of protein consumption minus the excretion of protein and endogenous protein. Meanwhile, endogenous protein is protein contained in excreta that comes from other than ration materials consisting of the decay of intestinal mucosal cells, bile and the decay of digestive tract cells. Andriani et al., (2018) in their research stated that, the higher the protein digestibility, the greater the protein that can be utilized by fish for growth.

Fat Retention

The results showed that the fat retention value in this study ranged from 35.61 – 11.50%. The highest fat retention value was found in P1 (0% fermented I. zollingeriana leaf meal) at 35.61 ± 2.05%, while the lowest fat retention value was found at P4 (45% fermented I. zollingeriana leaf meal) at 11.50 ± 0.17% (Table 3).

The results of analysis of variance (ANOVA) with a confidence level of 95%, showed that the use of I. zollingeriana leaf meal fermented by A. niger in feed had a significantly different effect ($P>0.05$) on the fat retention value of Jaya Sakti goldfish. Further test results showed that the fat retention of Carp Jaya Sakti fish in P1 (0% fermented I. zollingeriana leaf meal) was significantly different ($P<0.05$) from P2 (15% fermented I. zollingeriana leaf meal), P3 (30% fermented I. zollingeriana leaf meal). fermented I. zollingeriana leaves) and P4 (45% fermented I. zollingeriana leaf flour). Fat retention in the use of feed P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf meal) was not significantly different ($P>0.05$) but the two treatments were significantly different ($P<0.05$) with P1 (0% fermented I. zollingeriana leaf meal) and significantly different ($P<0.05$) with P4 (45% fermented I. zollingeriana leaf meal). Fat retention in feed utilization P4 (45% fermented I. zollingeriana leaf meal) was significantly different ($P<0.05$) from P1 (0% fermented I. zollingeriana leaf meal), P2 (15% fermented I. zollingeriana leaf meal) and P3 (30% fermented I. zollingeriana leaf flour).

The high value of fat retention in the treatment is because the feed provided has a balanced nutritional content and is in accordance with the fish's needs so that the fish can make better use of the fat in the feed or can be retained (absorbed) into the fish's body more. Apart from that, the high value of fat retention is due to the ability of fish to utilize energy sources other than protein, namely carbohydrates and fat. Freshwater fish, including goldfish, use carbohydrates and fat as an energy source, while seawater fish use protein as an energy source. One of the reasons for this is a different digestive tract system. (Suprayudi et al., 2012).

Survival Rate (SR)

The research results showed that the survival rate (SR) value in this study ranged from 91.88 - 95.31% and was classified as good (Table 3.3). A survival rate of ≥ 50% is considered good, survival of 30 – 50% is moderate and less than 30% is not good (Mulyani et al., 2014).

The results of analysis of variance (ANOVA) with a confidence level of 95% showed that the use of fermented I. zollingeriana leaf meal in Carp Jaya Sakti fish rearing feed formulations in all treatments had no significantly different effect ($P<0.05$) on the value the life of the Jaya Sakti goldfish. The use of I. zollingeriana leaf meal with A. niger did not have a negative effect on the survival rate of Jaya Sakti goldfish.

Viewed from the perspective of biotic factors, in this study fish deaths occurred due to the presence of predators, where the research was carried out in an open field with lots of dense trees and close to a reservoir so there were still many predators such as monitor lizards, birds and wild cats. Meanwhile, in terms of abiotic factors, namely food availability, in this study the food needs of goldfish to defend themselves is well available and in accordance with the needs of goldfish larvaes, making it easier for fish in the metabolic process of living creatures to grow. A high survival rate indicates that the quality and quantity of feed provided is quite good, so it can have a positive effect on survival (Erfanto et al. 2013). In line with this, Setyono et al., (2020) explained that the survival value of fish will be maximum if the test feed provided has nutrients that suit the fish's needs and can be tolerated by the fish's body. Apart from that, the feed given does not cause toxicity to the fish. fish so that the fish are able to survive until the end of the study. The use of I. zollingeriana leaf meal with A. niger did not have a negative effect on the survival rate of goldfish (Nurhayati and Nazlia, 2019).

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