The effects of substitution of natural feed with artificial feed on the growth, survival rate and albumin content of snakehead fish (*Channa striata*)

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Abstract. The purpose of this study was to determine the level of substitution of natural feed with artificial feed that resulted in the best growth, survival rate, and albumin content of snakehead (*Channa striata*) fish. The experimental design used was a completely randomized design with five treatments and three replications, namely: A) 100% natural feed, B) 75% natural feed and 25% artificial feed, C) 50% natural feed and 50% artificial feed, D) 25% natural feed and 75% artificial feed, and E) 100% artificial feed. The natural feed used was Sardin fish (*Sardinella* sp.) while the artificial feed was the commercial feed. The parameters observed during the study were absolute biomass growth, specific growth rate, survival rate, albumin content of the snakehead fish, and the level of feed consumption. The feed quality was evaluated based on the results of proximate analysis and fatty acid composition. The results showed that substitution of natural feed with the artificial feed at any level had no significant effect (p > 0.05) to the absolute biomass growth, specific growth rate, survival rate, albumin content, and level of feed consumption of the snakehead fish. Based on the results of this study, the 100% artificial feed can be used in rearing the snakehead fish.

1. Introduction
Snakehead fish (*Channa striata*) is a freshwater fish that has high economic value [1]. This fish has very high albumin content, which is used as a raw material for the pharmaceutical industry [2]. Albumin as a biomedical material because it can accelerate the process of wound healing postoperation [3]. The albumin content in snakehead fish is around 62.24 g per kg, whereas eggs whites only contain 9.34 g per kg [1]. According to Mudjiharto (2007), snakehead albumin powder is useful to heal the wound of white Wistar (*Rattus norvegicus*) compared to powder obtained from goldfish (*Cyprinus carpio*) and milkfish (*Chanos chanos*) [4].

Usually, the feeds used by snakehead fish farmers are natural food; however, these food have several constraints. These range from unavailability in terms of continuity, inconsistent nutritional content, to inadequate supply, therefore it is necessary to replace with artificial feed. This feed has several advantages compared to the natural food, which includes guaranteed continuity and availability, shorter preparation time, formulation of nutritional content as needed, and having additional ingredients used when needed and free from disease [5]. Research on the substitution of natural feed with artificial feed on the reproductive potential of mangrove crabs has been carried out by [6]. The results showed that
there was no significant difference between both feed to the reproductive potential of the mangrove crabs. However Muliati et al., (2018) showed that snakehead fish (Channa striata) fed with golden snail (Pomacea canaliculatus) has better survival rate and absolute growth of biomass than that which was fed on commercial feed, but did not significantly affect the specific growth rate and feed conversion ratio [7].

Different types of feeds will affect the quality of feed and the level of feed consumption, which determine the growth and survival rate of fish. In rearing of snakehead fish, the type of feed used also affects albumin content. Therefore, this study is needed to determine the level of the substitution of natural by artificial feed on the growth, survival rates, and albumin content of snakehead fish.

2. Materials and methods
This study was conducted at Freshwater Fish Seed Center, Maros, South Sulawesi. Proximate analysis of feed conducted at the Animal Food Chemistry Laboratory, Faculty of Animal Science, Hasanuddin University. Fatty acids analysis of feed was conducted at Integrated Laboratory of the Agriculture Institute, Bogor, while analysis of albumin content of feed and snakehead were conducted at the Center of Health Laboratory, Makassar, South Sulawesi.

2.1. Tested fish
The fish used for this study was snakehead fish (Channa striata) weight ranging from 0.08 - 0.10 g. The fish previously adapted to artificial feed, and the study commenced immediately as the fish started to eat the feed.

2.2. Experimental diets
The natural feed used in this experiment was sardin fish (Sardinella sp.) and the artificial feed used was commercial feed. The snakehead fish was fed 10% per day (dry matter) of fish biomass at frequency of three times per day, at 07:00 AM, 12:00 PM, and 07:00 PM. Feeding rate was adjusted every 15 days.

2.3. Fish rearing container
Twelve cages made from a woven nylon plastic, with a size of 1 x 1 x 1 m were used for rearing experiment. The cages were placed in a pond. Measurement of feed consumption was conducted in black-plastic covered glass aquarium.

2.4. The experimental design
The experimental design used was a randomized design with five treatments and three replications. The treatments were as follows: A) 100% natural feed; B) 75% natural feed, 25% artificial feed; C) 50% natural feed, 50% artificial feed, D) 25% natural feed, 75% artificial feed and E) 100% artificial feed.

2.5. Experimental parameters:
2.5.1. Absolute biomass growth (W)

\[ W = B_t - B_o \]

Where \( B_t \) is measured gross biomass (g) of all the surviving fishes at the time of final harvesting, and \( B_o \) is the initially measured biomass (g) of all the stocked fishes.

2.5.2. The specific growth rate of individual weight (SGR)

\[ SGR = 100 \times \frac{\ln W_t - \ln W_o}{t} \]
Where $W_t$ is the mean weight of fish at the time of final harvesting (g), $W_o$ is the mean weight of fish at the beginning (g) of the study and $t$ is duration or rearing (days).

2.5.3. Survival rate (%)

The survival rate (SR) = \( \frac{N_t}{N_0} \times 100 \)

Where $N_t$ is the number of fish at the end of the study, and $N_0$ is the number of the fish beginning of the study.

2.5.4. The content of albumin (%). Analysis of snakehead fish albumin content was carried out at the beginning and end of the study. Besides, it also carried out an analysis of albumin content in artificial feed and *Sardinella* sp.fish, which is a natural food used in this study. Measurement of albumin content using a spectrophotometer.

2.5.5. The level of feed consumption (g). The level of feed consumption is calculated based on the amount of feed given minus of feed that was not consumed. Since the feed water content was not the same, the amount of feed consumed calculated as dry weight.

2.5.6. Proximate and fatty acid analysis of feed. Crude protein was analyzed using the micro-Kjeldahl method, while lipid, crude fiber, ash, and moisture were analyzed using the gravimetric method. The fatty acid analysis was analyzed using Gas Chromatography (GC).

2.6. Data analysis. To evaluate the effect of treatment on the growth, survival rate, albumin content of larvae and the level of feed consumption was carried out by analysis of variance. To determine best response among the treatments W-Tukey test was employed. Additionally, the quality of the feed was analyzed descriptively based on the need for growth and survival of snakehead fish.

3. Results

3.1. Growth

Total biomass growth and specific growth rate of the individual weight of the snakehead fish, are presented in Table 1. The results of analysis of variance shows differences in the level of substitution of natural with artificial feed had no significant effect ($p>0.05$), on the absolute biomass growth and specific growth rate as shown in Table 1.

| Treatments | Absolute biomass growth (g) | Specific growth rate (%) |
|------------|----------------------------|--------------------------|
| A          | 13.41±2.72a                | 3.53±0.22a               |
| B          | 14.11±4.88a                | 3.17±0.38a               |
| C          | 12.88±2.55a                | 3.40±0.13a               |
| D          | 9.05±0.68a                 | 3.57±0.38a               |
| E          | 9.39±1.57a                 | 3.50±0.20a               |

Description: - The average value ± standard deviation
- The same letter in the same column shows no significant difference at $p>0.05$
3.2. Survival rate
The survival rates of snakehead fish are presented in Table 2. The results also showed that differences in the level of substitution of natural with artificial feed had no significant effect at $p > 0.05$, on the survival rate.

| Treatments | Survival rate (%) |
|------------|-------------------|
| A          | 55.00±6.67        |
| B          | 57.50±8.33        |
| C          | 53.33±7.77        |
| D          | 40.83±4.44        |
| E          | 43.33±4.16        |

Description: - The average value ± standard deviation
- The same letter in the same column shows no significant difference at $p > 0.05$

3.3. Albumin content of snakehead fish
The albumin content of snakehead fish in the treatment A, B, C, D and E ranged between 19.71 - 21.48; 20.95 - 42.11; 23.22 - 26.94; 23.49 - 25.69 and 23.03 - 33.16 mg per g of fish. The average albumin content is presented in Table 3. The results showed that differences in the level of substitution of natural with artificial feed had no significant effect at $p > 0.05$, on the albumin content of snakehead fish.

| Treatment | Albumin content (mg per g) |
|-----------|---------------------------|
| A         | 26.87± 4.20              |
| B         | 24.35± 0.90              |
| C         | 25.27± 1.37              |
| D         | 29.66± 8.30              |
| E         | 20.20± 0.85              |

Description: - The average value ± standard deviation
- The same letter in the same column shows no significant difference at $p > 0.05$

3.4. The level of feed consumption
The level of feed consumed during the study is present in Table 4. Based on the analysis of variance results, differences in the degree of substitution of natural feed with the artificial had no significant effect ($p > 0.05$) on the amount of feed consumed.
Table 4. Average level of feed consumed in dry weight (g)

| Treatments | Amount of feed consumed (g) |
|------------|-----------------------------|
| A          | 21.37 ± 7.46^a              |
| B          | 34.80 ± 15.04^a             |
| C          | 40.08 ± 22.44^a             |
| D          | 32.98 ± 21.92^a             |
| E          | 25.27 ± 4.88^a              |

Description: - The average value ± standard deviation
   - The same letter in the same column shows no significant difference at p>0.05

3.5. Feed proximate composition

The result of proximate analysis of the natural feed and artificial feed is shown in Table 5.

Table 5. Proximate analysis of natural and artificial feed (% dry weight)

|                      | Natural feed | Artificial feed |
|----------------------|--------------|-----------------|
| Moisture             | 79.54        | 9.32            |
| Protein              | 78.35        | 59.00           |
| Lipid                | 8.27         | 5.90            |
| Fiber                | 0.39         | 2.73            |
| NFE                  | 0.56         | 22.75           |
| Ash                  | 12.43        | 9.61            |

Description: 1. Except for moisture, all fractions are stating in dry matter
   2. NFE: Nitrogen-free Extrac

Based on Table 5, the nutritional composition of each treatment is shown in Table 6

Table 6. Results of proximate analysis at various levels of substitution natural feed with artificial feed (% dry feed)

| Composition (%) | A      | B      | C      | D      | E      |
|-----------------|--------|--------|--------|--------|--------|
| Protein         | 78.35  | 73.51  | 68.68  | 63.83  | 59.00  |
| Lipid           | 8.27   | 7.68   | 7.09   | 6.49   | 5.90   |
| Fiber           | 0.39   | 0.98   | 1.56   | 2.15   | 2.73   |
| NFE             | 0.56   | 5.83   | 11.66  | 17.20  | 22.75  |
| Ash             | 12.43  | 11.73  | 11.02  | 10.32  | 9.61   |

Description: Dry matter

3.6. Fatty acid composition in the natural and artificial feeds

The analysis results of fatty acids in the natural and artificial feed are presented in Table 7.
Table 7. Composition of fatty acids in the natural and artificial feeds

| Fatty Acids          | Natural Feed | Artificial Feed |
|----------------------|--------------|-----------------|
| Fat content          | 8.54         | 5.49            |
| Fatty acid           |              |                 |
| Capric Acid.C10:0    |              | 0.02            |
| Lauric Acid C12:0    | 0.16         | 0.22            |
| Myristic Acid. C14:  | 2.41         | 1.54            |
| Myristoleic Acid. C14:1 | 0.02     | 0.02            |
| Pentadecanoic Acid. C15:0 | 0.55 | 0.12            |
| Palmitic Acid. C16:0 | 17.81        | 11.93           |
| Palmitoleic Acid. C16: 1 | 2.76   | 1.76            |
| Heptadecanoic Acid. C17:0 | 0.59  | 0.13            |
| Cis-10-Heptadecanoic Acid, C17:1 | 0.14 | 0.09            |
| Stearic Acid, C18:0  | 7.14         | 2.87            |
| Elaidic Acid, C18:1n9 | 0.12     | 0.13            |
| Oleic Acid, C18:1n9  | 9.47         | 27.79           |
| Linoleic Acid, C:18n6 | 3.95     | 10.88           |
| Arachidic Acid, C20:1 | 0.35     | 0.25            |
| y-Linolenic Acid, C18:2n6 | 0.28   | 0.07            |
| Cis-11-Eicosenoic Acid, C:20:1 | 0.52 | 2.10            |
| Linolenic Acid, C18:3n3 | 0.64     | 2.57            |
| Heneicosanoic Acid, C21:0 | 0.07   | 0.02            |
| Cis-11,14-Eicosadienoic Acid, C20:2 | 0.23 | 0.47            |
| Behenic Acid, C22:0  | 0.22         | 0.12            |
| Cis-8,11,14-EicosatrienoicAcid, C20:3n6 | 0.26 | 0.11            |
| Pyruvic Acid Methyl Ester, C22:1n9 | 0.06 | 0.28            |
| Cis-11,14,17-Eicosatrienoic Acid Methyl Ester C20:3n3 | 0.07 | 0.13            |
| Arachidonic Acid, C20:4n6 | 0.76     | 0.11            |
| Tricosanoic Acid, C23:0 | 0.08     | 0.02            |
| Cis-13,16-Docosadienoic Acid, C22:2 | -      | 0.04            |
| Lignoceric Acid, C24:0 | 0.26     | 0.08            |
| Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3 | 1.02 | 0.63            |
| Nervonic Acid, C24:1  | 0.60         | 0.22            |
| Cis-4,7,120,13,16,19-Docosahexaenoic Acid, C22:6n3 | 6.39 | 0.87            |
| Fatty Acid Total     | 56.93        | 65.58           |

Based on Table 7, the composition of fatty acids in each treatment is shown in Table 8.

Table 8. Fatty acids composition at at various levels of substitution natural feed with artificial feed

| Fatty Acids          | A  | B  | C  | D  | E  |
|----------------------|----|----|----|----|----|
| Fat content          | 8.54 | 6.25 | 7.02 | 3.51 | 5.49 |
| Fatty acid           |    |    |    |    |    |
| Capric Acid.C10:0    | -  | 0.015 | 0.01 | 0.005 | 0.02 |
| Lauric Acid C12:0    | 0.16 | 0.21 | 0.19 | 0.18 | 0.22 |
| Myristic Acid. C14:  | 2.41 | 2.19 | 1.98 | 1.76 | 1.54 |
| Myristoleic Acid. C14:1 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Pentadecanoic Acid. C15:0 | 0.55 | 0.44 | 0.34 | 0.23 | 0.12 |
| Palmitic Acid. C16:0 | 17.81 | 16.34 | 14.87 | 13.40 | 11.93 |
| Palmitoleic Acid. C16: 1 | 2.76 | 2.51 | 2.26 | 2.01 | 1.76 |
4. Discussion

The growth and survival rates, and the albumin content of the snakehead fish, were influenced by the level of feed consumption and quality of feed. The differences in the level of substitution natural with the artificial feed provided the same response to the level of feed consumption, meaning that nutrients and energy needed by fish for growth, survival, and albumin synthesis are not different.

The research of Muliti et al., (2012) showed that snakehead fish (Channa striata) fed with golden snails (Pomacea canaliculatus), the survival rate and absolute growth of biomass were better than that which was fed commercial feed, but did not significantly affect the specific growth rate and feed conversion ratio [7]. The lower of absolute growth of biomass in artificial feed treatment was due to insufficient nutrient content and energy needs for growth. Besides snakehead in the study consumed more golden snails than commercial feed.

According to Craig (2002), snakehead fish is a predatory fish, and protein requirements range between 40 - 60%, while according by Trushenski et al., (2006) it ranged between 60 – 70% [8,9]. The results of the study conducted Raizada et al., (2012) on giant snakehead (Channa marulius) showed that feed with a protein content of 52.86% and 58.6% produced biomass growth not significantly different but higher and significantly different than a protein content of 29.4%, 34.9%, 40.29%, and 47.57% [10]. Additionally, the results of Kpogue et al., (2013) study on fingerling snakehead (Prachanna obscura) showed that the fish fed with 50% protein content produced the best growth and utilization of nutrients compared to those fed with 30%, 40% and 60% protein content [11]. Also, the results of the research conducted by Sagada et al., (2017) on juvenile northern snakehead (Channa argus) showed that feed with 45% protein content and 9% fat produced the lowest growth response [12]. However, the feed with 45% protein content and 12% fat, 48% protein and 15% fat, 51% protein and 9% fat and 51% protein and 12% fat, all produced higher growth. Based on these research results, the protein content in the treatment A and B were higher than the fish protein requirement.

| Fatty Acid                      | ∑n3 | ∑n6 | ∑n3/HUFA | ∑n3/∑n6 |
|--------------------------------|-----|-----|----------|---------|
| Heptadecanoic Acid, C17:0      | 0.59| 0.48| 0.36     | 0.25    |
| Cis-10-Heptadecanoic Acid, C17:1| 0.14| 0.13| 0.12     | 0.10    |
| Stearic Acid, C18:0             | 7.14| 6.07| 5.00     | 3.94    |
| Elaidic Acid, C18:1n9           | 0.12| 0.12| 0.13     | 0.13    |
| Oleic Acid, C18:1n9             | 9.47| 9.31| 8.63     | 22.96   |
| Linoleic Acid, C:18n6           | 3.95| 5.68| 7.42     | 9.15    |
| Arachidic Acid, C20:1           | 0.35| 0.33| 0.30     | 0.28    |
| y-Linolenic Acid, C18:2n6       | 0.28| 0.23| 0.18     | 0.12    |
| Cis-11-Eicosenoic Acid, C:20:1  | 0.52| 0.92| 1.31     | 1.70    |
| Linolenic Acid, C18:3n3         | 0.64| 1.12| 1.61     | 2.09    |
| Heneicosanoic Acid, C21:0       | 0.07| 0.06| 0.05     | 0.06    |
| Cis-11,14-Eicosadienoic Acid, C20:2| 0.23| 0.29| 0.35     | 0.41    |
| Behenic Acid, C22:0             | 0.22| 0.20| 0.17     | 0.15    |
| Cis-8,11,14-Eicosatrienoic Acid, C20:3n6 | 0.26| 0.22| 0.19     | 0.15    |
| Pyruvic Acid Methyl Ester, C22:1n9 | 0.06| 0.12| 0.17     | 0.23    |
| Cis-11,14,17-Eicosatrienoic Acid Methyl Ester, C20:3n3 | 0.07| 0.09| 0.10     | 0.12    |
| Arachidonie Acid, C20:4n6       | 0.76| 0.60| 0.44     | 0.27    |
| Tricosanoic Acid, C23:0         | 0.08| 0.07| 0.05     | 0.04    |
| Cis-13,16-Docosadienoic Acid, C22:2 | -   | 0.01| 0.02     | 0.03    |
| Lignoceric Acid, C24:0          | 0.26| 0.22| 0.17     | 0.13    |
| Cis-5,8,11,14,17-Eicosapentaenoic Acid, C20:5n3 | 1.02| 0.92| 0.83     | 0.73    |
| Nervonic Acid, C24:1            | 0.60| 0.51| 0.41     | 0.32    |
| Cis-4,7,12,10,13,16,19-Docosahexaenoic Acid, C22:6n3 | 6.39| 5.01| 3.63     | 2.25    |
| ∑n3                            | 8.12| 7.14| 6.17     | 5.19    |
| ∑n6                            | 5.25| 6.73| 8.23     | 9.64    |
| ∑n3/HUFA                      | 7.48| 6.02| 4.56     | 2.52    |
| ∑n3/∑n6                       | 1.55| 1.06| 0.75     | 0.54    |
| 4.20                           | 11.17| 1.63| 0.38    |
The lipid content of feed ranges from 5.9 - 8.27%. According to Sagada et al., (2017), the lipid requirement of snakehead fish (Channa striatus) ranges between 4.0 -18.0% [12]. Based on this finding, the lipid content of the feed in this study is in the range of the normal lipid requirement for snakedhead fish.

The maximum carbohydrate requirement of carnivorous fish is only 20% [13]. According to Dayal et al., (2016), the carbohydrate requirement of snakehead fish is 24.74 % [14]. Based on this finding, the carbohydrate content (NFE) in the natural feed was too low. According to Wang et al., (2005) at low carbohydrate content, some of the protein will be catabolized to energy [15].

Furthermore, the requirement for essential fatty acids is different for various fish species, and there are three fish groups in terms of necessary fatty acid requirements. The first group requires more linoleic (n-6) fatty acids; the second group requires linolenic (n-3) fatty acids, and the third group requires both of these fatty acids. According to Mokoginta et al., (2000), freshwater fish need n-3 and n-6 fatty acids of 1.55 - 1.56% and 0.6 - 0.73% respectively and snakehead is a freshwater fish [16]. The results of this study showed that the n-3 content of the artificial feed was 4.2% while in natural feed was 8.12%. The content of n-6 in artificial feed was 11.17%, while in natural feed was 5.25%. Based on this finding, the content of n-3 and n-6 fatty acids in both the natural and artificial feeds are higher than the fish needed.

In addition, the results showed that the albumin content of snakehead fish at the beginning of the study was 16.36 mg per g fish, and ranged between 19.41 to 42.11 mg per g of fish at the end of the study. The albumin content in artificial feed was 6.2 mg per g, while in the natural feed (Sardinella sp) was 11.3 mg per g fish. This increased albumin content at the end of the study was due to the presence of albumin in the feed. The results of this study indicated that the difference in the level of substitution of natural by artificial feed gives the same response to the snakehead fish albumin content. Due to the amount of feed consumed that is not different and the albumin content in the feed. Manggabarani et al., (2018) suggested that the albumin content was influenced by the environment, especially food consumption and differences in fish weight [17]. The results of the Alamsjah et al., (2014) study showed that snakehead fish fed with commercially feed with 32% protein content produced highest average albumin content of 17.3 mg per g fish body weight, at a protein content of 29% produced an average albumin of 16.9 mg per g fish body weight while the 26% protein content produced the lowest albumin level which was 15.9 mg per g fish body weight [18]. This result was similar to Yuniarti et al., (2013), that albumin content ranged between 37.9 - 47.1 mg per g of fish [19].

5. Conclusion
Based on the results of this study, it can conclude that the difference in the level of substitution of natural feed with artificial feed resulted in the same response on the level of feed consumption, absolute growth of biomass, specific growth rate, survival rate, and snakehead fish albumin content. In rearing of snakehead fish 100% artificial feed can be applied.

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