The effect of various processed seaweed, *Kappaphycus alvarezii* products as gel diet thickener on the utilization of nutrition in Rabbitfish, *Siganus guttatus* cultivation in the floating net cage

E Saade, S H Fadhilah, U Kalsum, and N G Usman

Nutrition and Feed Technology Laboratory, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, Indonesia

Email: edison90245@yahoo.com

**Abstract.** Seaweed, *K. alvarezii* as a gel diet thickener. The quality of the thickener is determined by the processing method. The purpose of this study was to determine the type of processed seaweed, *K. alvarezii* product, which is the best thickener in the gel diet based on fish body nutrient contents, protein efficiency ratio (PER), and protein retention (PR). Experimental fishes used were rabbitfish with an average weight of 55.23±4.46 g/individual, which was cultivated in a small cage (hapa) measuring 100 x 70 x 100 cm and placed in floating net cages (FNC). An experimental diet is a gel diet. The frequency of feeding is done twice a day, 7:00 in the morning, and 16:00 in the afternoon by satiation. The experimental design used was a completely randomized design (CRD) with 4 treatments and 5 replications. The treatment in this study was a gel diet containing some processed seaweed products such as dried seaweed flour (treatment A), fermented seaweed flour (treatment B), carrageenan flour (treatment C), and seaweed soft (treatment D). Analysis of variance (ANOVA) was carried out, and the W Tukey test was continued for the treatment that had a significant effect on determining the effect of various processed seaweed products on the measured parameters. The results showed that processed seaweed products in the gel diet significantly affected changes in fish protein, lipid and carbohydrate contents, protein efficiency ratio, and protein retention in rabbitfish. The best nutritional content of fish, PER, and PR is found in treatment B (fermented seaweed flour). Based on the results of this study, it was concluded that the nutritional body content of fish, REP, and RP was best obtained in rabbitfish, which consumed a gel diet containing fermented seaweed.

1. **Introduction**

Rabbitfish, *Siganus guttatus*, is one of the fish species that have high commercial potential for intensive cultivation. Rabbitfish can live in a wide range of salinity, high density, responsive to artificial feed, have a relatively fast growth rate, and can be cultivated both in floating net cages and in ponds [1]. It was further stated that the rabbitfish had not yet been mass-cultivated. This is caused by the technology of cultivation that has not been socialized intensively, knowledge of feed formulations that can provide benefits have not been well socialized, and the availability of seeds is not enough.

Rabbitfish, *S. guttatus* in nature as herbivorous fish, are very fond of natural seaweed (without processed) as its main source of nutrition. In this regard, the use of seaweed as a source of nutrition in rabbitfish feed technology is very appropriate. Efforts to optimize the utilization of seaweed nutrition
by various processing techniques to increase the utilization of the nutrients it contains are very urgent. Processed seaweed products that have the potential to increase the utilization of nutrients are fermented seaweed flour, carrageenan flour, and seaweed moss.

Gel feed is one of the artificial feed types wet or moist formulated from quality ingredients, affordable and environmentally friendly and made with cooking, making all particles of raw materials making up the pellet dissolve into a homogeneous dough and between particles of feed raw material with particle material the thickener blends perfectly [2]. The utilization of various processed seaweed products as a source of nutrition and thickening agent in gel feed is expected to increase nutrient utilization by rabbitfish. Digested and properly utilized feed nutrients will increase the utilization of protein, lipids, and carbohydrates by aquatic organisms. The body's nutritional content, protein retention, protein efficiency ratio, hepatosomatic index, increased blood glucose, and liver glycogen levels for some time are indicators of good nutrition. However, information about the utilization of gel feed nutrients containing various processed seaweed products as a source of nutrition and pengalal in rabbitfish that are kept in floating net cages is still lacking.

2. Research methods

2.1. Experimental fish
Experimental fishes used were rabbitfish, S. guttatus from hatchery of the Brackish Aquaculture Fisheries Research Center, and Fisheries Counseling, Maros. The average body weight of the tested young fish was 55.23 ± 4.46 g/individual. Stocking density is 15 individuals in each small net (hapa) measuring 100 x 100 x 70 cm. Tested fishes were kept in a small net, which is placed in floating cages measuring 3 x 3 x 3 m size in the waters of Siddo, Barru Regency, South Sulawesi Province for 30 days of feeding.

2.2. Experimental diet
The experimental feed used was the gel diet. Gel diet is one of the wet feed with a water content of between 50-70% using seaweed, K. Alvarezii as a thickener made by cooking [2,3]. The main raw materials for the test feed are fish meal, shrimp head meal, cornmeal, copra meal, and carbohydrate mix. Carbohydrate mix is a mixture of sago flour, cassava flour, and fine bran in a ratio of 1:1:1. All processed raw materials for seaweed are produced by the research team itself except carrageenan, which is obtained from the seaweed industry, CV. Bantimurung Indah, Maros Regency. Seaweed flour is poured with hammer mill, seaweed flour is fermented by fermenter Rizhopus sp., and soft seaweed by cooking method. Ingredients and nutrients composition of the experimental diet are shown in Table 1.

| Ingredients (%) | Type of seaweed processed¹ |
|----------------|-----------------------------|
|                | SM  | SF  | SC  | SS  |
| Fish meal      | 40  | 40  | 40  | 40  |
| Shrimp head meal| 4   | 4   | 4   | 4   |
| Corn meal      | 6   | 6   | 6   | 6   |
| Carbohydrate mix.² | 15  | 15  | 15  | 15  |
| Copra meal     | 5   | 5   | 5   | 5   |
| Dry seaweed meal| 20  | -   | -   | -   |
| Fermented Seaweed meal | - | 20  | -   | -   |
| Carrageenan meal| -   | -   | 20  | -   |
| Soft seaweed   | -   | -   | -   | 20  |
| Fish oil       | 6   | 6   | 6   | 6   |
| Vitamin dan mineral mix.³ | 4   | 4   | 4   | 4   |
| Total          | 100 | 100 | 100 | 100 |

Nutrients content (%)
Moisture & 74.91 & 74.96 & 74.68 & 80.06 \\
Crude protein & 35.93 & 35.70 & 36.99 & 36.16 \\
Crude lipid & 7.67 & 8.96 & 4.99 & 3.00 \\
Nitrogen Free Extract & 29.78 & 28.91 & 32.85 & 34.81 \\
Crude fiber & 5.29 & 5.65 & 4.59 & 4.67 \\
Ash & 21.33 & 20.78 & 20.58 & 21.16 \\
Gross energy (kcal/g) & 417 & 426 & 408 & 393 \\
C/P ratio & 11.61 & 11.93 & 11.02 & 10.86 \\

1. SM: dry seaweed meal, SF: seaweed fermented, SC: seaweed carrageenan, SS: soft seaweed 
2. A mixture of sago flour, cassava flour and fine bran in a ratio of 1: 1: 1 
3. Vitamin A 900 IU, B1 2,400 mg, B2 4,350 mg, B6 900 mg, C 192,400 mg, D3 300,000 IU, E 2,250 mg, K3 360 mg. Ca pantothenate 1,350 mg, inositol 33,750 mg, lysin 36,000 mg, methionine 16,500 mg, folic acid 450 mg, biotin 300 mg, nicotinamide 6,000 mg, cholin chloride 4,500 mg, Co, Cu, I, Mn, Se, Zn, enzymes of protease, amylase dan cellulose + 1 kg lactose. 
4. Gross energy : 1 g protein : 5.6 kcal/g, 1 g lipid : 9.4 kcal/g, dan 1 g carbohydrate : 4.1 kcal/g [4].

Stages of making gel diet are a refinement of raw materials, mixing, adding 30% water, cooking, pouring the gutter to room temperature, storing in the refrigerator for at least one hour, forming feed in the form of cubes with a size corresponding to the size of the fish mouth, storing in the freezer to use [2].

2.3. Research procedure

2.3.1. Preparation. The initial preparation of this research was the manufacture of test feed using seaweed, K. alvarizii as a thickening material and a source of test feed nutrition in the form of dried seaweed flour, fermented seaweed flour, carrageenan flour, and soft seaweed.

A small net is a fish care net measuring of 100 x 70 x 100 cm installed in floating net cages measuring 3 x 3 x 3 m. Every corner of the small net on the bottom is equipped with ballast. This is so that a small net is always in the form of a square and is resistant to current shocks and sea waves. At the top, the small net is closed with a net to avoid the test fish jumping out.

2.3.2. Cultivation. The test fish is put into a small net for acclimation for a week to get accustomed to the test feed and research environment conditions. Everyday feeding is given twice a day, i.e., in the morning from 7:00 to 8:00 and in the afternoon at 16:00 to 17:00 by satiation for 30 days. In addition, water quality monitoring was also carried out in the form of temperature as measured by a rod thermometer, pH with litmus paper and dissolved oxygen measured at DO meters in the morning and afternoon, while water ammonia analysis was carried out twice during the research activities, namely the beginning and end of the study.

At the end of the study, analyzes of fish body nutrient content, protein retention, protein efficiency ratio, blood glucose, liver glycogen, and hepatosomatic index were carried out.

2.4. Measured parameters

2.4.1. Nutrition in the body. The nutritional content of the body of test fish in the form of crude protein, crude lipid, and carbohydrate using the AOAC method [5]. Protein analysis using the Kjeldahl method, lipids by the soxhlet method, and carbohydrates were calculated based on the formula 100 - (protein + lipid + ash).

2.4.2. Protein efficiency ratio. According to Watanabe (1988), the ratio of protein efficiency (PER) can be calculated using the formula [6]:

\[
\text{Protein efficiency ratio (\%)} = \frac{\text{Final body weight (g)} - \text{Initial body weight (g)}}{\text{Amount of protein consumed (g)}} \times 100
\]  

(1)
2.4.3. **Protein retention.** Protein retention (PR) is measured using the formula [6].

\[
\text{Protein retention (\%)} = \left( \frac{\text{Final body protein (g)} - \text{Initial body protein (g)}}{\text{Amount of protein consumed (g)}} \right) \times 100
\]  

(2)

2.4.4. **Blood glucose.** Blood glucose analysis using NESCO Multi check made by Bioptic Technology, Inc. ... with a capacity range of 20-600 mg/dL. Blood samples were taken at the caudal of the test fish. To avoid the rebellion test fish were previously anesthetized with clove oil at a dose of 2\% [2]. Blood samples obtained are dropped into strips. Furthermore, automatically within a few seconds, the glucose content is read on the NESCO Multi check monitor in mg/dL units [7].

2.4.5. **Hepatosomatic index.** Test fishes were put in styrofoam, which contained seawater and mixed with clove oil at a dose of 2\% until fainting. Anesthetized test fish were weighed using analytical scales with a precision of 0.001 g. Furthermore, surgery is performed to take the liver of the test fish and weigh its weight. The hepatosomatic index was calculated, according to Ighwela et al. (2014) [8].

\[
\text{Hepatosomatic index (\%)} = \left( \frac{\text{Liver weight (g)}}{\text{Bodyweight (g)}} \right) \times 100
\]  

(3)

2.4.6. **Liver glycogen.** The fish liver test obtained in the hepatosomatic index analysis was followed by an analysis of the glycogen content with reference to the method at a wavelength of 635 nm [9].

2.5. **Experimental design and treatments**

This study used a completely randomized design with 4 treatments and 3 replications. The treatments in this research are:

- Treatment A: Dry seaweed flour
- Treatment B: Fermented seaweed flour
- Treatment C: Carrageenan flour
- Treatment D: Soft seaweed

2.6. **Data analysis**

The data obtained were processed by ANOVA to determine the effect of the treatment on the measured parameters. The treatment that significantly affected the measured parameters was followed by the analysis of the W-Tuckey test to determine the different treatments.

3. **Result research**

3.1. **Changes in body nutrient content**

Changes in nutrient content in the form of crude protein, lipid acid, and carbohydrate average test fish body after consuming gel feed containing various processed seaweed products, *K. Alverizii* for 30 days of cultivation can be seen in Table 2.

**Table 2.** Changes in the average nutrient content in rabbitfish, *S. guttatus* after being fed gel containing various processed seaweed, *K. alverizii* products for 30 days of cultivation.

| Seaweed processed products | Changes in the average nutrients content (%) |  |
|---------------------------|--------------------------------------------|--|
|                           | Crude protein                              | Crude lipid | Carbohydrate  |
| Dry seaweed flour (A)     | 41.75 ± 0.16b                              | 1,628.79±40.99a | 95.64 ±0.33ab |
| Fermented seaweed flour (B)| 43.52 ± 0.79c                              | 939.39±155.50b | 95.30 ± 0.71ab |
| Carrageenan flour (C)     | 43.63 ± 0.19b                              | 609.09 ± 95.45c | 93.30 ± 0.45b |
The different superscript letters in the same column show the significant difference between treatments (p<0.05).

The average PR of rabbitfish after being fed gel contains various processed products of seaweed as a source of nutrition and thickening material for 30 days of feeding between 63.55 ± 2.37 and 78.05 ± 4.39%, while protein PER between 0.30 ± 0.04 and 0.44 ± 0.01%

Analysis of variance showed that various processed seaweed products in gel feed significantly affected both PR and PER. Further tests using W Tukey showed that PR between treatments B and C was significantly different, whereas the two treatments were not significantly different from other treatments. In the PER parameters, it shows that the C feed significantly affected all treatments except treatment A, while between treatments A, B and C are the same (p> 0.05).

3.2. The efficiency of protein utilization
The efficiency of protein utilization consists of protein retention (PR) and protein efficiency ratio (PER) in rabbitfish after being fed gel containing various processed seaweed products, *K. Alvarezii* as a source of nutrition and thickener for 30 days of cultivation can be seen in Table 3.

| Seaweed processed products | Protein retention (%) | Protein efficiency ratio (%) |
|----------------------------|-----------------------|-----------------------------|
| Dry seaweed flour (A)      | 68.59±8.30<sup>ab</sup> | 0.38±0.05<sup>ab</sup>      |
| Fermented seaweed flour (B)| 78.05±4.39<sup>a</sup>  | 0.44±0.01<sup>a</sup>       |
| Carrageenan flour (C)      | 63.55±2.37<sup>b</sup>  | 0.30±0.04<sup>b</sup>       |
| Soft seaweed (D)           | 74.78±2.35<sup>ab</sup>| 0.43±0.05<sup>a</sup>       |

The different superscript letters in the same column show the significant difference between treatments (p<0.05).
3.3. The efficiency of carbohydrates utilization

The efficiency of carbohydrate utilization measured as average the blood glucose and liver glycogen contents in rabbitfish, *S. guttatus*, which consumes gel feed containing various processed seaweed, *K. alvarezii* products for 30 days feeding seen in Table 4.

Table 4. Average blood glucose (BG) and liver glycogen (LG) in rabbitfish, *S. guttatus* after being fed gel containing various processed seaweed, *K. alvarezii* products for 30 days of cultivation.

| Seaweed processed products       | Average blood glucose (mg/dL) | Average liver glycogen (mg/g) |
|---------------------------------|------------------------------|------------------------------|
| Dry seaweed flour (A)           | 99.67 ± 29.02±               | 3.47 ± 0.24±                 |
| Fermented seaweed flour (B)     | 118.67 ± 47.37±              | 3.87 ± 0.09±                 |
| Carrageenan flour (C)           | 84.00 ± 8.72±                | 3.58 ± 0.10±                 |
| Soft seaweed (D)                | 106.33 ± 24.71±              | 3.81 ± 0.07±                 |

The different superscript letters in the same column show the real difference between treatments (p<0.05).

The average blood glucose content of rabbitfish, *S. guttatus*, which consumed gel fed containing various processed seaweed, *K. Alverezii* products as a source of nutrition and thickener for 30 days of cultivation between 84.00 ± 8.72 to 118.67 ± 47.37 mg/dL. ANOVA results show that various processed seaweed products in gel fed have no significant effect on average blood glucose content in enlargement of rabbitfish that are kept in floating net cages in the sea.

Furthermore, the highest and lowest average glycogen content of the liver was obtained in fermented seaweed processed products (treatment B) with a value of 3.87 ± 0.09 mg/g and dried seaweed flour (treatment A) with a value of 3.47 ± 0.24 mg/g. The results of the various analysis showed that various types of processed seaweed significantly affected the average liver glycogen. Based on the results of further tests, W Tukey confirmed that between treatments A and B were significantly different, while the two treatments, both treatments A and B, were not significantly different from other treatments.

3.4. Hepatosomatic index

The hepatosomatic index in rabbitfish, *S. guttatus*, which consumes gel feed containing various processed seaweed, *K. alvarezii* products for 30 days feeding seen in Table 5.

Table 5. Average hepatosomatic index (HI) in rabbitfish, *S. guttatus* after being fed gel containing various processed seaweed, *K. alvarezii* products for 30 days of cultivation.

| Seaweed processed products       | Average hepatosomatic index (%) |
|---------------------------------|--------------------------------|
| Dry seaweed flour (A)           | 1.33 ± 0.34±                  |
| Fermented seaweed flour (B)     | 1.41 ± 0.02±                  |
| Carrageenan flour (C)           | 0.87 ± 0.11±                  |
| Soft seaweed (D)                | 1.06 ± 0.11±                  |

The same superscript letters in the same column show the not different between treatments (p>0.05).

Rabbitfish which consume gel fed containing various processed seaweed products as thickening agent and source of nutrition for 30 days of feeding between 0.87 ± 0.11 to 1.41 ± 0.02%. The results of the ANOVA showed that the effect of various processed seaweed products on gel fed on the hepatosomatic index was not significantly different (p>0.05).
4. Discussion

4.1. Changes in the nutrient content of the fish body

The results showed that the various treatments of processed seaweed, *K. alvarezii* products as a thickening agent, and source of nutrition significantly affected the changes in the nutritional content of the test fish body during 30 days of cultivation, including crude protein levels, crude fat content, and carbohydrates.

Changes in the highest crude protein content were obtained in processed seaweed treatments of B and C. The processed seaweed products in treatment B, the fermentation process involved fermenter *Rhizopus* sp. so that there was an increase in the activity of microorganisms in binding N as a basic material for protein synthesis. Microorganism, as a fermenter, is able to produce protease enzymes that break down proteins into simple peptides and are later reorganized into amino acids. These amino acids are absorbed into the body of the test fish so that the body’s protein content increases [10]. While the processed seaweed products in treatment C are extracted through the cooking process during the carrageenan making process so that there is an overhaul of proteins into amino acids. These amino acids are easily absorbed in the metabolic process so that the protein increases in the body of the test fish. In the cooking process, the water content, which decreases, will cause the protein content in the material to increase. According to Sundari (2015), the use of heat in the processing of materials can reduce water content, which results in the presentation of elevated protein levels. Cooking results in loss of water content and dry matter that is different when evaporation occurs due to the presence of heat pressure so that it affects the nutrient content [11].

The highest residential fat content was obtained in treatment A, namely dried seaweed flour compared to other treatments. Seaweed processed products in treatment A, the fat is well utilized by the test fish. The process of heating or drying seaweed in the process of making dried seaweed with sunlight does not change the chemical structure of the fat so that the metabolic process is more efficient in the body of the fish compared to treatment B, C, and D.

The degree of fat damage varies greatly depending on the temperature used and the length of time the processing material. The higher the temperature used, the more intense the damage to fat. The decrease in fat content after cooking is due to the nature of the fat that cannot stand the heat. During the cooking process, the fat melts and even evaporates into other components such as flavor. Fats can tolerate hot temperatures higher than other nutrients, but when fat meets the smoke point of heating, the cooking process so that there is an overhaul of fats into amino acids. These amino acids are easily absorbed in the metabolic process so that the protein increases in the body of the test fish.

General fat absorption in fish can be in the form of fatty acid units and glycerol. Fatty acids, when joined with bile salts, are easily soluble in water, then they will be directly absorbed by the intestinal mucosa. After the process of absorption by the intestine, the combination will split again. Bile salts will go to the liver to then be secreted into the gall bladder, then glycerol, which is easily soluble in water, will be absorbed directly by the intestinal mucosa. In the intestinal mucosa, when the fatty acids recombine with glycerol, they will form new fats. This new fat distribution includes the spleen and blood vessels. Then fat will be stored in living tissue [6].

According to Parakkasi (1999), carbohydrates are divided into two groups, crude fiber and non-nitrogenous extracts, including carbohydrates, which are ingredients that contain starch and sugar. Changes in carbohydrate content in treatment C, carrageenan flour, were higher than treatments A, B, and D. Carbohydrates present in the body of the test fish were utilized as an energy source and growth process so that the carbohydrates present in the fish's body were reduced during 30 days of cultivation. This is supported by rabbitfish as herbivorous fish that very efficiently utilize carbohydrates [12]. Carrageenan is a linear polysaccharide and is a galactan molecule, and its main units are galactose, and a large molecule consisting of galactose residues, so the main composition in carrageenan is its carbohydrate content [13]. Next, polysaccharides consist of monosaccharides that are chipped into polymer chains with glycosidic bonds. Polysaccharides will form gelatin or bond-forming, so the granules formed will become granules and on the surface will form dietary fiber, which will be very useful for digestion (metabolism). Polysaccharides in food function besides as a texture enhancer.
(cellulose, hemicellulose, pectin, lignin), as well as energy sources (starch, dextrin, glycogen). These texture enhancing polysaccharides cannot be digested by the body but are dietary fibers that can.

4.2. The efficiency of protein utilization

The efficiency of protein utilization by rabbitfish measured consisted of protein retention (PR) and protein efficiency ratio (PER). PR is a comparison between the amount of protein stored in the form of tissue in the body of a fish and the amount of protein consumed in feed [14]. The efficiency of protein utilization is influenced by several factors, including fish species and size, physiological functions of the fish, digestibility, feed quality, feed consumption, and enzyme activity [15]. Furthermore, it is stated that PER is a comparison between body weight and the amount of protein consumed, which basically calculates the efficiency of using protein feed ingredients for use in body protein synthesis.

According to Soedibya (2013), protein retention is a parameter to show the amount of contribution of protein consumed in feed to the increase in body protein, or the amount of additional body protein from feed protein consumed, or the amount of protein that can be absorbed and utilized to build or repair cells which are damaged, and provides protein for daily metabolism, as well as for maintenance and growth [16].

The high RP and PER of rabbitfish that consume gel fed containing fermented seaweed flour (treatment B) indicate that seaweed fermentation is the most effective processed seaweed in remodeling proteins into amino acids, even though RP and PER treatment B are the same as treatments A and D. Amino acids are the simplest form of protein that is readily absorbed by the digestive organs of aquaculture organisms. Although rabbitfish are herbivorous fish that are very efficient in utilizing carbohydrates, it turns out that by fermenting feed ingredients, it can also be very efficient using protein. This means that herbivorous fish are greatly helped in the process of protein metabolism when the amino acids are readily available in the feed.

4.3. The efficiency of carbohydrates utilization

The parameters of blood glucose and liver glycogen are parameters that can be seen to determine the efficiency of feed carbohydrates utilization by aquaculture organisms. Glucose in the blood is the result of carbohydrate metabolism, while glycogen is a form of carbohydrate stored in the liver and muscles [17].

The ability of rabbitfish to absorb metabolic glucose from carbohydrates contained in gel fed containing dried seaweed flour, fermented seaweed flour, carrageenan flour, and soft seaweed are the same. It is assumed that the type and composition of carbohydrates in all test feeds are the same. The difference in nutrient content in the test feed does not affect blood glucose levels in the test fish. This is due to the help of enzymes in increasing blood glucose. According to Furuichi and Yone (1982), in the body of the fish, there is the catecholamine hormone. This hormone will suppress the secretion of the hormone insulin, which serves to help supply glucose into cells, thereby causing glucose levels to enter the blood to increase. This hormone will also activate the enzymes involved in the catabolism of liver and muscle glycogen stores [4].

Blood glucose in the fish's body is the main energy source, so glucose entering the fish's body will be metabolized to meet energy needs. This depends on the amount of glucose entering, the source of glucose supply, and the substrate essential for cell metabolism. Glucose absorbed from the digestive process of feed nutrients is carried by blood vessels to produce energy to all cells in the body. Glucose will undergo glycolysis in the cytoplasm, which is the process of breaking down sugar into ATP [18].

According to Furuichi and Yone (1982), one of the roles of the hormone cortisol is to encourage enzymes involved in the process of gluconeogenesis to increase blood glucose from non-carbohydrate sources [4]. The occurrence of protein catabolism forming glucose also produces amino acids, so that amino acids in the blood have increased. Increased amino acids in the blood will reactivate insulin so that it can carry out glucose transport, so glucose in the blood will decrease again. The amount of glycogen reserves in fish is very limited. If needed, glycogen will experience decomposition through the process of glycogenolysis, to produce glucose as an energy source. Carbohydrates contained in the
test feed which will enter the body and be converted into glucose and then enter the blood. Glucose that comes from a feed, if not utilized as an energy source, will be stored in the liver as glycogen. Through the process of glycogenesis, the formation of glucose as a monosaccharide will undergo a metabolic process, and glycogen is produced. Glycogen is what functions as an energy reserve. Increased glycogen levels indicate the presence of blood glucose after energy for metabolism has been fulfilled, which will be converted to glycogen stored in the liver and meat of baronang fish [17].

Nextly, in the process of carbohydrate metabolism, carbohydrates are composed of glucose molecules. Carbohydrates are the main source of energy and body heat. Carbohydrates are mostly in the form of glucose (around 80%), others are in the form of fructose and galactose. This can happen in the liver because the liver has both enzymes that play a role in catabolism and carbohydrate anabolism. Insulin plays a role in increasing glycogen synthesis. Insulin functions to speed up and facilitate the entry of glucose into cells. After being in a cell, by the hormone insulin, Glucose will be stored or synthesized into glycogen both in the liver, muscles, or other tissues.

The liver glycogen content in fermented seaweed, namely treatment B, increased higher compared to other treatments. As for the benefits of fermentation in feed can increase the nutritional value and storability of the feed itself, the nutritional value of feed increases due to the process of breaking down complex compounds into simple compounds so that they are easily absorbed by the cultivating body. The content of glycogen in fermented seaweed processed products, namely treatment B, ranges from 3.87%. The high glycogen content of the liver is processed, fermented seaweed is caused by carbohydrate feed, which is very effectively utilized by rabbit fish. This is supported by rabbit fish as herbivorous fish that very efficiently utilize carbohydrates. Fish that feed with high carbohydrates produces high body fat, which will cause increased fat accumulation and liver glycogen [4].

Liver glycogen content in processed dried seaweed that is treatment A ranged from 3.47 mg / g is relatively low, this is allegedly due to some deficiencies of processed dried seaweed, namely the rough fiber content of seaweed is difficult to digest, the growth of cultivating consuming is not optimal and has a texture that is a mushy and very difficult manufacturing process. Glycogen is a reserve of carbohydrates in the body that is stored in the liver and muscles. The amount of glycogen reserves is very limited. When needed by the body, it is converted back into glucose. Cellulose is a polysaccharide that cannot be digested by the body but is useful in the mechanism of digestion [17].

4.4. Hepatosomatic index
One of the organs that functions to store glycogen as a source of energy in cultivated organisms is the liver. The liver is used to maintain the development and growth of fish. The liver functions in addition to fatty acid synthesis and detoxification as well as nutrient storage so that fish do not quickly mobilize glycogen reserves. Food intake stored in the form of lipids, proteins, and carbohydrates in the liver will be converted into energy used when entering the metabolic process. The hepatosomatic index will decrease along with the increase in feed protein so that liver weight will decrease in maternal fat storage [8].

Based on the results of this study, rabbitfish have the ability to convert test feed containing various processed seaweed products, namely dried seaweed flour, fermented seaweed flour, carrageenan flour, and soft seaweed by becoming energy in the metabolic process. Rabbitfish absorbs nutrient content from gel feed, and energy storage takes place in the form of a hepatosomatic index so that various types of processed seaweed, K. alvarezii, provide the same effect. This is due to the amount of 20% (seaweed) given equally so that the hepatosomatic index is the same for all types of processed seaweed.

In the type of processed dried seaweed flour, namely treatment A, the hepatosomatic index is 1.33% through the drying process. Drying is an important processing step because it is related to the moisture content of the material as a factor that influences the appearance, texture, taste, nutritional value of food, and especially the activity of microorganisms. The purpose of drying is to reduce the moisture content of the material to the extent that the development of microorganisms that can cause
decay stops, as well as changes due to enzyme activity, making the material not perishable so that it has longer durability and facilitates further processing so that young people are digested by cultivation and increase body weight [19]. In the type of processed, fermented seaweed flour, namely treatment B, the hepatosomatic index is 1.41%. Fermentation is the process of breaking down complex compounds (macronutrients) into simple compounds (micronutrients). The reshuffle of complex compounds into simple compounds makes food more easily digested by fish. In fermentation, the anaerobic breakdown of carbohydrates and proteins. The breakdown of complex nutrients becomes simple with the help of microorganisms producing energy. Fermentation can also be interpreted as a gradual change by the enzymes of some bacteria, yeast, and fungi [15,20]. According to Wandansari et al.,(2013), fermented seaweed can reduce the content of crude fiber so that cultivation can easily digest feed. The purpose of the fermentation process is to hydrolyze the seaweed cell walls in the fermentation process, and enzymes are needed [21].

In the type of processed carrageenan seaweed flour, namely treatment C, the hepatosomatic index is 0.87%. In general, seaweed, K. alvarezii (carrageenan) can interact with macromolecules that are charged, for example, protein, thereby affecting the increase in viscosity, gel formation, and deposition [22]. The seaweed is soaked with a strong alkaline, KOH solution. The addition of an alkaline solution to the sample can help the polysaccharide extraction become perfect and accelerate the elimination of 6 sulfates from the monomer unit to 3,6-anhydro-D-galactose so that it can increase the gel strength and reactivity of the product to protein [8].

The average hepatosomatic index in rabbitfish, which consumed gel fed containing seaweed luminous (treatment D), was 1.06%. Seaweed is processed into luminous with a cooking process so that it becomes soft. Cooking is done by using boiling water with a temperature of ±70 °C. The cooking process can deactivate the anti-nutrient content, increase digestibility, attractants, and palatability for diet [23–25].

Ighwela et al. (2014) state that the liver is the center of metabolism in the body and the liver has been commonly used as an indicator of growth [8]. In treatment B fermented seaweed flour, that can be seen in Table 1 with a high value of the protein-energy ratio (11.93 kcal/g) compared to other processed seaweed treatments. This is caused by the high protein energy ratio, which will reduce the amount of protein consumed because the metabolic energy needs are immediately met and will increase the accumulation of fat in the body. The accumulation of fat in the body of the fish will affect the metabolism of amino acids, which are not used for protein synthesis, thus causing low protein storage in the body, which can further reduce the growth rate and increase bodyweight of fish [15]. This is consistent with research conducted by Yandes et al. (2003), which states that the hepatosomatic index decreases with increasing protein feed. An increase in the hepatosomatic index indicates an increase in the number of nutrients absorbed and accumulates in the liver [26].

5. Conclusion and suggestion

5.1. Conclusion
Based on the results of this study, it was concluded that rabbitfish were able to optimize the utilization of nutritional gel fed containing fermented seaweed as a source of nutrition and thickening material.

5.2. Suggestion
Although processed products of the best-fermented seaweed, in terms of efficient supply of raw materials, soft seaweed is most effective.

References
[1] Purba R 2004 Pengaruh kadar protein terhadap pertumbuhan dan efisiensi pakan ikan baronang, Siganus conliculatus Aquac. Indones. 5 123–7
[2] Saade E and Trijuno D D 2014 Growth response of koi fish fed on the diet containing Euchema cottoni J. Akuakultur Indones. 13 140–5
[3] Pribadi R, Saade E and Tandipayuk H 2016 Pengaruh Metode Pengerasan Terhadap Kualitas
Fisik dan Kimiawi Pakan Gel Ikan Koi Cyprinus carpio haematopterus Menggunakan Tepung Rumput Laut Kappaphycus alvarezii sebagai Pengental

Furuichi M and Yone Y 1982 Availability carbohydrate in nutrition of carp and red sea bream Bull Japan. Soc. Sci. Fish 32 502–6

AOAC [Association of Official Analytical Chemist] 1990 Official methods of analysis (Mayland. USA: Association of Official Analytical Chemist Inc)

Watanabe T 1988 Fish Nutrition and Mariculture. Kanagawa International Fisheries Training Center (Japan International Corporation Agency (JICA), Tokyo)

Saili T, Aka R, Auza F A, Salido W L and Sari A M 2019 Kolesterol, Asam Urat, dan Glukosa Darah Ayam Buras yang Diberi Pakan dengan Ramuan Herbal dan Ekstrak Kerang Bakau (Polymesoda erosa) J. Ilmu dan Teknol. Peternak. Trop. 6 225–31

Ighwela K A, Ahmad A Bin and Abol-Munafi A B 2014 The selection of viscerosomatic and hepatosomatic indices for the measurement and analysis of Oreochromis niloticus niloticus condition fed with varying dietary maltose levels Int. J. Fauna Biol. Stud. 1 18–20

Wedemeyer G A and Yasutake W 1977 Clinical methods for the assessment of the effects of environmental stress on fish health vol 89 (Department of the Interior, Fish and Wildlife Service)

Abdel-Aziz M F A, Mohammed R A, Abou-Zied R M and Allam S M 2016 Effect of feeding frequency and feeding time on growth performance, feed utilization efficiency and body chemical composition on Rabbitfish Siganus rivulatus fry and juvenile under laboratory condition Egypt. J. Aquat. Biol. Fish. 20 35–52

Sundari D 2015 Pengaruh proses pemasakan terhadap komposisi zat gizi bahan pangan sumber protein Media Litbangkes 25 235–42

Parakkasi A 1999 Ilmu nutrisi dan makanan ternak ruminansia (Yogyakarta: Gadjah Mada University Press)

Karyani S 2013 Analisis kandungan food grade pada carrageenan dari ekstrak rumput laut hasil budidaya nelayan Seram Bagian Barat J. Tek. Mesin Politek. Negeri Ambon 4 499–506

Barrows F T and Hardy R W 2001 Nutrition and feeding in: Wedemeyer G (Eds). Fish hatchery management. (Bethesda, Maryland: American Fisheries Society)

Alamsjah M A, Christiana R F and Subekti S 2011 Pengaruh Fermentasi Limbah Rumput Laut Gracilaria sp. dengan Bacillus subtilis Terhadap Populasi Plankton Chlorophyceae [Effect Of Waste Seaweed Fermentation Of Gracilaria sp. With Bacillus subtilis Against On Plankton Populations Of Chlorophyceae] J. Ilm. Perikan. dan Kelaut. 3 203–14

Soedibya P H T 2013 Retensi protein pada ikan nila GIFT (Oreochromis niloticus) yang diberi pakan Azolla pinnata dengan diperkaya mikroba probiotik J. Akuakultur Indones. 12 109–13

Furuichi M and Yone Y 1980 Effect of dietary dextrin levels on the growth and food efficiency, the chemical composition of liver and dorsal muscle, and the absorption of dietary protein and dextrin in fishes. Japan. Soc. Sci. Fish 46 225–9

Mokoginta H E and Subandiyono 2003 Respon glukosa darah ikan gurami, Osphronemus Gouramy, Lac. terhadap stress perubahan suhu lingkungan J. Akuakultur Indones. 19 73–7

Wirakartakusumah M A, Abdullah K and Syarif A M 1992 Sifat fisik pangan PAU Pangan dan Gizi (IPB-Bogor)

Pamungkas W 2011 Teknologi fermentasi, alternatif solusi dalam upaya pemanfaatan bahan pakan lokal Media Akuakultur 6 43–8

Wandansari B D 2013 Fermentasi rumput laut Eucheuma cottonii oleh Lactobacillus plantarum Chem Info J. 1 64–9

Winarno F G 2004 Kimia pangan dan gizi (Jakarta: PT.Gramedia Pustaka Utama)

Saade E and Aslamyah S 2009 Uji fisik dan kimiawi pakan buatan untuk udang windu penaeus Monodon fab. yang menggunakan berbagai jenis rumput laut sebagai bahan perekat Torani (Jurnal Ilmu Kelaut. dan Perikanan) 19 107–15

Saade E, Aslamyah S and Salam N I 2011 Kualitas pakan buatan udang windu yang
menggunakan berbagai dosis tepung rumput laut (Gracilaria gigas) sebagai bahan perekat J. Akuakultur Indones. 10 59–66
[25] Saade E 2011 Kandungan nutrisi, atraktanitas dan palatabilitas pakan ikan nila GIFT, Oreochromis niloticus yang menggunakan berbagai sumber tepung rumput laut, Euchema cottoni sebagai binder Aquac. Indones. 12 33–41
[26] Yandes Z and Affandi R 2017 Pengaruh pemberian sellulosa dalam pakan terhadap kondisi biologis ikan gurame Osphrenomus goyrame Lac J. Iktiologi Indones. 3 27–33