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Growth of Red Tilapia with the Addition of Seaweed (*Caulerpa* sp.) to Feed

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Abstract

Fish feed is influenced by several factors, including the raw ingredients used in the feed, the content of proteins, carbohydrates, and vitamins, the manufacturing process, and the way the feed is stored. Its impact on the fish's growth rate, which should continuously increase. *Caulerpa* sp. is rich in nutrients, providing vegetable protein, carbohydrates, minerals, and vitamins. This research aims to examine the effect of incorporating feed with additional *Caulerpa* sp. on the growth of red tilapia. One alternative is the addition of *C. racemosa* (sea grape seaweed flour) as a feed supplement in tilapia feed. This research used an experimental method with a completely randomized design with 4 treatments and 3 repetitions. The treatments were A (artificial feed + 10% *C. racemosa*), treatment B (artificial feed + 20% *C. racemosa*), treatment C (artificial feed + 30% *C. racemosa*), and treatment D (artificial feed without the addition of *C. racemosa*). The result of this study shows that tilapia growth in treatment A demonstrated the highest absolute growth of 37.27 g, a specific growth rate of 2.06%, a survival rate of 100%, a feed conversion ratio of 0.2 %, and a feed utilisation 37%. This study concludes that feeding with additional *C. racemosa* can affect the growth of Tilapia. The addition of 10% *C. racemosa* can improve the growth of Tilapia significantly.

Keywords: Aquaculture, Feed, Macroalgae, Seaweed, Tilapia, *Caulerpa* sp.

1. Introduction

Feed is the highest operational cost in fish farming, accounting for more than 60% of the total production cost [1]. To reduce production costs in aquaculture, fish feed can be made in-house [2]. The self-made fish feed has several advantages over buying it in the market. Among them is that the composition can be adjusted to the needs of the fish that will consume the feed because each type of fish has specific nutritional [3].

Good fish feed is influenced by several factors, among others: the raw or basic ingredients used in the feed, the content of protein, carbohydrates, and vitamins, the manufacturing process, and the way the feed is stored [4]. One indicator of good feed is its effect on the growth rate of fish, which will continue to increase. Growth is highly dependent on the protein content in the feed, but fish not only utilize protein for growth but also as a source of energy. Therefore, it is necessary to find ingredients that can meet these needs. Seaweed is an alga that lives in the sea and is a source of protein that contains a variety of amino acids and crude fiber, which is expected to increase growth in fish [5].

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Caulerpa sp. has nutritional content as a source of vegetable protein, carbohydrates, minerals, and vitamins [6]. *Caulerpa* sp. contains photosynthetic pigments chlorophyll a and β-carotene, xanthophyll, lutein, and polyphenols [7,8], stated that algae contain Insoluble Dietary Fiber (IDF, insoluble dietary fiber). This dietary fiber consists of cellulose and hemicellulose which play an important role in the process of food digestion in the body and can reduce blood cholesterol levels. *Caulerpa* sp. is traded internationally from the Philippines and Vietnam to Japan and may warrant commercialization as a new aquaculture product in Australia [9].

One alternative is the addition of *C. racemosa* (sea grape seaweed) flour as a feed supplement in tilapia feed. *C. racemosa* seaweed is a type of seaweed that can be used as a feed supplement for fish and contains immunostimulant substances that enhance the immune system of fish, thereby promoting growth [10]. The results of research by Putri *et al.,* stated that *C. lentillifera* sea grape flour can increase the growth of tilapia fish [11]. Furthermore, research by Magfiratun *et al.,* stated that *Caulerpa lentillifera* sea grape flour can increase growth and survival in milkfish [12]. According to Nurfah *et al.,* showed that the provision of *C. lentillifera* sea grape flour at different doses in fish feed affected growth, survival, and feed efficiency with the best treatment at a dose of 20 g / kg of fish feed [13]. According to Putri *et al.,* the digestibility of ingredients and protein digestibility of *Caulerpa lentilifera* sea grape flour amounted to 68.81% and 86.31%. The growth test showed that the use of *Caulerpa lentilifera* sea grape flour at 20% had a good effect on the final weight, survival, total feed consumption, protein efficiency ratio, protein retention, specific growth rate, and feed efficiency of tilapia. The purpose of this research is to analyze the effect of feed with additional *Caulerpa* sp. on the growth of red tilapia [14].

2. Material and Methods

2.1 Tools and Materials

The fish feed is made from fish meal, fine bran flour, corn flour (cornstarch), *C. racemosa* flour, vitamin premix, and fish oil.

2.1.1 Feed Formulation

Artificial feed formulations are prepared based on the nutritional needs of each type of aquatic biota. A good formulation means that it contains all the nutrients needed by fish and is economically cheap and easy to obtain to provide benefits. The formulation used in this study used the trial and error method where the amount of raw materials was calculated to reach 1 kg in each treatment and added with *C. racemosa* flour with the amount according to each treatment.

2.1.2 Feed Preparation and Molding

Feed ingredients that have been calculated based on the formulation were; 550 g of fishmeal, *C. racemosa* flour according to the treatment (10%, 20%, 30%), 370 g of fine bran flour, 50 g of corn flour (cornstarch), 10 g of vitamins and 20 ml of fish oil. Before mixing the feed ingredients, the ingredients were first weighed according to the results of the formulation calculation. Feed molding using a meat grinder, then cut into pieces according to the amount of fish mouth openings drying using an electric oven at 60° C for approximately 8 hours. After drying, it is packed using an airtight container with the aim that the feed is not moist and not easily moldy.

2.1.3 Fish Rearing Process

The fish used in this study were 120 red tilapia fish. Each container is filled with 10 fish with an average weight of 5 grams per fish and uses a container with a volume of 15 liters. Before maintenance, fish are first acclimatized with the aim of not being stressed in their new environment. The acclimatization process is carried out for ± 20 minutes. Feed is given after the fish can adjust to its new environment. Feeding is done 3 times a day with the amount of feed given amounting to 3% of fish biomass.

2.1.4 Water Quality Management

Water quality measured in this study were temperature, pH, and dissolved oxygen. Water changes are carried out every 3 days, not by replacing the water as a whole but by flushing every 2 days to remove food debris and dirt that settles at the bottom of the container so that the quality of the media water is well maintained.

2.2 Research Design

This study used a complete randomized design with 4 treatments and 3 repetitions:

a. **Treatment A**: Artificial feed + 10% *C. racemosa*
b. **Treatment B**: Artificial feed + 20% *C. racemosa*
c. **Treatment C**: Artificial feed + 30% *C. racemosa*
d. **Treatment D**: Control

2.3 Research Variables

2.3.1 Feed Nutritional Analysis

To determine the nutritional content of the feed, a nutritional test (proximate) is carried out. The proximate test will be carried out at the Fishery Product Processing Technology Laboratory of the Jakarta Fisheries University.

2.3.2 Specific Growth Rate (SGR)

The specific growth rate is the percentage of fish that increases every day during the study.

$$SGR = \frac{LnWt - LnW0}{t} \times 100\%$$

The daily growth rate of fish was calculated using the formula of [15] as follows:

Description
SGR: Survival Growth Rate (%)/day
Wt: End of rearing fish biomass (gr)
W0: Initial fish biomass (gr)
T: Length of rearing time (days)

2.3.3 Absolute Growth

To calculate absolute weight growth using the formula of Dawes *et al*., [16].
Description
W: Absolute weight growth (gr)

$$W = Wt - Wo$$

Wt: Fish biomass at the end of the study (gr)
Wo: Fish biomass at the beginning of the study (gr)

2.3.4 Feed Conversion Ratio (FCR)

$$FCR = F / Wt - Wo$$

The Feed Conversion Ratio (FCR) is the amount of feed given to produce fish biomass. FCR was calculated using the Effendi formula [16]
Description
FCR: Feed Conversion Ratio,
F: Weight of feed given (gr)
Wt: Fish biomass at the end of the study (gr)

Wo: Fish biomass at the beginning of the study (gr)

2.3.5 Survival Rate (SR)

Survival rate is the percentage of the number of fish alive and the number of fish stocked during maintenance. Survival is calculated using the formula from Effendie [16] as follows:
Description
SR: Survival rate (%)

$$SR=\frac{Nt}{No}x100\%$$

Nt: Number of fish alive at the end of the study (fish)
No: Number of fish at the beginning of the study (fish)

2.3.6 Feed Efficiency

Feed efficiency is calculated from the increase in fish biomass, which is already known, divided by the total feed consumption multiplied by 100%. by using the formula as stated by Watanabe [17], namely:

$$\mathbf{EP}=\frac{(\mathbf{Wt}+\mathbf{D})-\mathbf{Wo}}{\mathbf{F}}\ \mathbf{x}\ \mathbf{100\%}$$

Description
EP: Feed Efficiency (%)
Wt: Fish biomass at time t (gr)
Wo: Fish biomass at the beginning of the experiment (gr)
D: Biomass of fish that died during rearing (gr)
F: Amount of feed given (gr)

2.3.7 Water Quality

Water quality parameters measured include temperature, pH, and dissolved oxygen measured periodically every week, from the beginning of the study until the end of the study

2.4 Data analysis

Before the analysis of variance, the data was first tested for normality and homogeneity; this test aims to determine whether the data is normally distributed or not. To see the differences between treatments, the analysis of variance was used with the F test at the 95% confidence level with the help of the statistical application. Then proceed with the Least Significant Difference (BNT) test if the treatment is different. Water quality parameters were analyzed descriptively and presented in tabular form.

3. Results and discussion

Table 1: Proximate of feed

Feed	Water Content (%)	Ash Content (%)	Protein Content (%)	Fat content (%)	Carbohydrate (%)
Feed A	9.07 ± 0.09	7.71 ± 0.12	39.85 ± 0.37	2.06 ± 0.01	31.65 ± 0.21
Feed B	8.66 ± 0.19	23.23 ± 0.30	29.35 ± 0.44	4.28 ± 0.12	34.48 ± 0.67
Feed C	8.30 ± 0.06	25.00 ± 0.01	28.61 ± 0.09	2.38 ± 0.04	35.71 ± 0.20
Feed D	7.71 ± 0.12	14.45 ± 0.09	33.97 ± 0.28	0.95 ± 0.22	42.93 ± 0.15
Method	Oven	Tanur	Kjedhal	Soxhlet	By Different

3.1 Water Content

The feed containing *C. racemosa* exhibited high water content in treatment A, with a value of 9.07 ± 0.09%. In treatment B, the water content was 8.66 ± 0.19%, and in treatment C, it was 8.30 ± 0.06%. In contrast, treatment D (which did not contain *C. racemosa*) had a water content of 7.71 ± 0.12%. The feed containing *C. racemosa* exhibited high water content in treatment A, with a 9.07 ± 0.09% value. In treatment B, the water content was 8.66 ± 0.19%, and in treatment C, it was 8.30 ± 0.06%. In contrast, treatment D (which did not contain *C. racemosa*) had a water content of 7.71 ± 0.12%.

The water content in artificial feed added with *C. racemosa* is an important parameter in determining the quality and shelf life of feed. Moisture content reflects the amount of water in the feed ingredients and impacts the feed's texture, stability, and susceptibility to microbial growth. In artificial feeds, moisture content is typically controlled to maintain quality and prevent spoilage *C. racemosa* is a type of marine algae that has a fairly high water content, as algae generally grow in a watery environment. When added to artificial feed, the water content of *C. racemosa* can increase the total water content of the feed, depending on how the feed is processed and dried. If *C. racemosa* is not dried properly before mixing into the feed, this will increase the total moisture content, which can affect the quality of the feed in the long run.

Artificial feed generally has a low moisture content (usually below 10%) to ensure good shelf life and prevent the growth of microorganisms such as mold and bacteria. However, as stated in [18], moisture content exceeding 12% can lead to spoilage, rot, and reduce its nutritional content. So it is important to keep the moisture content within a safe range.

C. racemosa contains naturally high water content, so its addition to the feed can increase the total moisture content of the feed if it is not processed properly. Therefore, in feed formulation, *C. racemosa* is usually dried first to reduce its water content before mixing it in. According to Peerakjetkhajom *et al*., feed with high moisture content tends to have a shorter shelf life due to the greater risk of microorganism growth. This can lead to spoilage and a decrease in the nutritional quality of the feed, such as a decrease in protein or vitamins. High moisture content can also affect the texture and density of the feed. Feed that is too wet or mushy may be less stable in water and break down quickly before being consumed by the farmed animals [19]

According to Novianti *et al.*, a way to control the moisture content in *Caulerpa*-added feed is through proper drying, either using an oven, solar dryer, or other method that can reduce the water content before mixing. In some cases, additives such as binders can be used to stabilize the moisture content of the feed, making it less affected by the addition of wet ingredients such as algae [20]. Keeping the moisture content of the feed at an optimum level will help increase its storability, maintain its nutritional content, and ensure that it does not spoil easily. In addition, the addition of well-dried *Caulerpa* can still provide its nutritional benefits without excessively increasing the moisture content [21].

3.2 Ash Content

Ash content refers to the minerals contained in a material and includes pollutants or impurities. The amount or level of ash in a feed material is important only to determine the varied combination of mineral elements in the feed; however, ash is not used as an index to determine the amount of specific mineral elements. The ash content of a feed material is determined by burning the material at high temperatures (500-600°C). The organic matter burns off at these temperatures, and the remaining ash is left behind [22].

Ash content can be determined by conducting a proximate analysis of the feed material. The ash content in the feed containing the addition of green algae (*C. racemosa*) exhibited high values in treatment C, with 25.00 ± 0.01%. In treatment B, the ash content value was 23.23 ± 0.30%. In treatment D (which did not contain *C. racemosa*), the ash content was 14.45 ± 0.09%. In treatment A, the ash content value obtained was 7.71 ± 0.12%.

Caulerpa racemosa is a type of marine macroalgae that has a fairly high mineral content. This includes calcium, magnesium, and other microelements that are beneficial for the growth of fish or other aquatic animals. By adding *C. racemosa* to artificial feed, it is expected that the ash content will also increase due to the addition of natural minerals from the algae. A good ash content in feed indicates that the feed contains enough minerals that are important for various physiological functions, such as bone formation, enzyme regulation, and electrolyte balance in fish [23]. Ash levels that are too high or too low can be an indicator of raw material quality. Unusually high ash levels may indicate the presence of contaminants or unwanted inorganic materials [24].

With the addition of *C. racemosa* to artificial feed, the ash content may increase as marine algae are rich in minerals. This can provide additional benefits for fish that require micronutrients, but too high ash levels may indicate an unbalanced feed. Ideally, the ash content of fish feed ranges from 22.2-48.9%, depending on the type of fish being farmed [25]. If the addition of *C. racemosa* causes the ash content to increase above this range, it is necessary to adjust or change the formulation so that the feed still meets balanced nutritional needs.

The implication of excessive ash content in the feed can affect the energy value of the feed because most minerals cannot be metabolized into energy by fish. If the ash content is too high, especially from non-essential mineral components or impurities, it can inhibit growth rate or cause metabolic disorders in fish or aquatic animals [24].

3.3 Protein Content

Protein levels can be determined by analyzing or conducting proximate tests on feed ingredients added with *C. racemosa* extract. The protein content in the feed that contains the addition of green algae (*C. racemosa*) showed a high content value in treatment A, namely 39.85 ± 0.37%. In treatment D (not given *C. racemosa*), the protein content value was 33.97 ± 0.28%. In treatment B, the protein content was 29.35 ± 0.44%. While in treatment C, the protein content obtained was 28.61 ± 0.09%.

The content of protein levels in artificial feed added with *C. racemosa* is an important aspect. This is because protein is the main component in supporting the growth, tissue repair, and metabolic functions of aquatic animals such as fish. *C. racemosa*, as a marine alga, is known to have significant protein content, so its addition to artificial feed can affect the overall protein content in the feed. *Caulerpa* is a type of marine macroalgae that contains moderate to high amounts of protein, depending on the species. The protein in these algae generally contains essential amino acids that are important for the growth of farmed animals, especially fish. The protein content in *Caulerpa* sp. ranges from 12.88-30.03%, and this is also very dependent on the species and environmental conditions where the algae or seaweed grows [21].

One important aspect of the protein in *C. racemosa* is the composition of essential amino acids that are beneficial for fish growth [26]. According to Matanjun *et al*., amino acids such as lysine, methionine, and threonine are often a major concern in fish feed, and the addition of *C. racemosa* can help improve the composition of the necessary amino acids. Proteins from marine algae are generally well digested by fish, although there is some variation depending on the type of fish and the algae processing method [27].

If the addition of *C. racemosa* is too high, it may cause an imbalance of protein compared to other feed components, such as fat or carbohydrates. Thus, the amount of *C. racemosa* added needs to be adjusted to the feed formula to keep the nutrition balanced. *C. racemosa* must be properly processed, such as dried before mixing into the feed, so that the protein remains stable and is easily digested by the farmed animals.

3.4 Fat content

Fat content can be determined by conducting proximate analysis or tests on feed ingredients added with *C. racemosa* extract. The fat content in the feed that contains the addition of green algae (*C. racemosa*) showed a high content value in treatment B, namely 4.28 ± 0.12%. In treatment C, the fat content value was 2.38 ± 0.04%. In treatment A, the fat content was 2.06 ± 0.01%. While in treatment D (not given *C. racemosa*), the fat content obtained was 0.95 ± 0.22%.

C. racemosa generally has a relatively low-fat content compared to other feed mixtures, such as fishmeal. The average fat content in *C. racemosa* ranges from 1-3%, and this also depends on the species of *Caulerpa* or seaweed used and the habitat environment [28]. Despite its low-fat content, *Caulerpa* contains beneficial essential fatty acids, such as omega-3 and omega-6 fatty acids. These fatty acids are important for healthy metabolic function in fish or other aquatic animals [27]. The addition of *C. racemosa* in artificial feed is unlikely to increase the fat content significantly, as the natural fat content in *C. racemosa* is relatively low. However, the addition of this algae may enrich the fat profile of the feed with essential fatty acids that are important for fish health and growth. As the fat content in *C. racemosa* is very low, its use will not unduly disturb the general nutritional balance of the feed. If the main fat source comes from other ingredients such as fishmeal, fish oil, or vegetable oil, the addition of *C. racemosa* will only make a small contribution to the total fat.

The addition of *C. racemosa* as a source of essential fatty acids could be an environmentally friendly alternative to fish oil, the use of which is increasingly being controlled to maintain wild fish populations. In addition, fat in the diet helps maintain the body condition of the fish, including the formation of fatty tissues that are essential for survival, especially in colder environments [29]. *C. racemosa* has a low-fat content, so there is no risk of excessive fat increase in artificial feeds due to the addition of this algae. However, if the total fat content needs to be increased, fat sources from other ingredients, such as fish oil or vegetable oil, can be added to the feed to meet the energy requirements and essential fatty acids that are good for fish.

3.5 Carbohydrates

Carbohydrate content can be determined by analyzing or conducting proximate tests on feed ingredients added with *C. racemosa*. The carbohydrate content with a high content value in treatment D (not given *C. racemosa*) was 42.93 ± 0.15%. In treatment C, the carbohydrate content was 35.71 ± 0.20%. In treatment B, the carbohydrate content was 34.48 ± 0.67%. While in treatment A, the carbohydrate content obtained was 31.65 ± 0.21%.

The carbohydrate content in artificial feed added with *C. racemosa* is an important component that plays a role in providing energy sources for cultured fish. Carbohydrates are one of the macronutrients required in feed formulations, although aquatic animals, especially carnivorous fish, do not require them in large quantities, such as fat and protein. *C. racemosa*, as a type of marine algae, has a high carbohydrate content, especially in the form of polysaccharides such as agar, carrageenan, and alginate. According to Liftanto *et al*., the carbohydrate content in this marineral algae varies but can reach 27.20-48.10%, depending on the species and growth conditions. As a green alga, *C. racemosa* contains complex sugars, such as soluble and insoluble fibers, that provide additional value to feed formulations [21]. The carbohydrates contained in *C. racemosa* play a role in balancing the feed so that it is not overly dependent on protein as an energy source. This is important to optimize the use of protein for growth rather than as an energy fuel.

Polysaccharides present in *C. racemosa*, such as agar, alginate, and carrageenan, are types of carbohydrates that are not fully digested by fish but have important roles in feed structure, digestive regulation and can even serve as feed binders to improve the stability of feed pellets in water. Polysaccharides from algae also have the potential to enhance fish immunity and provide antioxidant effects, which can improve the overall health of fish [22]. Carnivorous fish such as snapper or grouper generally have lower carbohydrate requirements, as they do not have the efficient ability to digest large amounts of carbohydrates (Amin *et al*., 2020). In contrast, omnivorous or herbivorous fish, such as tilapia or milkfish, can utilize carbohydrates better and require them in feed for energy. A balanced carbohydrate content can help support growth and energy metabolism in fish, but excessive amounts, especially in carnivorous fish, can lead to metabolic disorders or fat accumulation in the fish body [30].

3.6 Absolute Growth

Red tilapia (*Oreochromis niloticus*) is one of the freshwater fish that is widely cultivated because it can adapt well to the environment and can grow quickly in various environmental conditions. Feed is an important aspect in the success of fish farming, as 60-70% of aquaculture operational costs are allocated to feed. The type of feed given to fish will greatly affect the growth and efficiency of aquaculture.

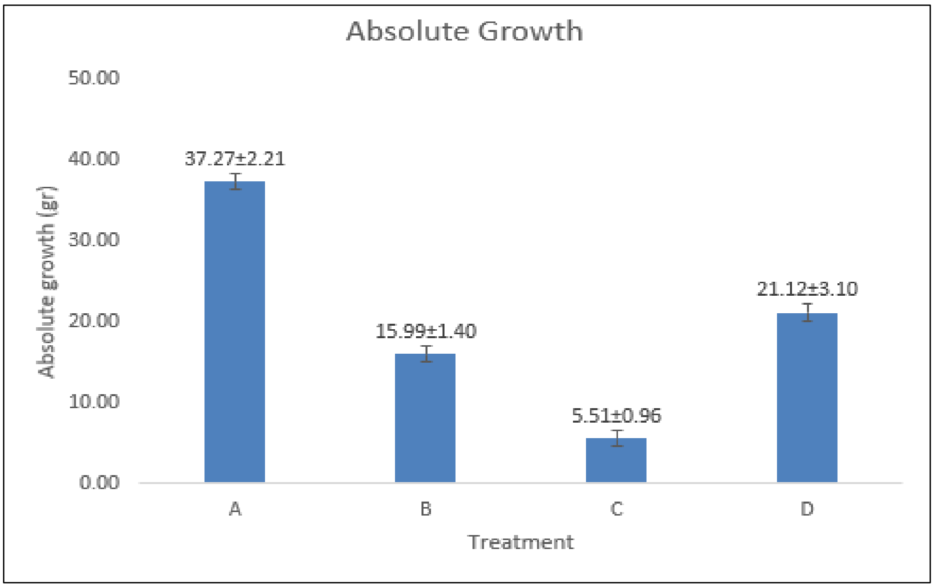

Figure 1: Absolute growth of red tilapia (*O. niloticus*)

Based on the data, the growth of red tilapia (*O. niloticus*) was measured by weighing the weight of the fish every week for eight weeks. The results showed that tilapia growth in treatment A (artificial feed + 10% *C. racemosa*) showed the highest growth rate compared to other treatments, then D (artificial feed without the addition of *C. racemosa*), then treatment B (artificial feed + 20% *C. racemosa*) and while the lowest growth was in treatment C (artificial feed + 30% *C. racemosa*).

Feed has a very big influence on the growth of tilapia (*O. niloticus*). Factors such as feed quality, frequency of feeding, and nutrient content in feed play an important role in determining growth rate, energy utilization efficiency, and fish health. Based on the data obtained, the highest tilapia growth was found in treatment A with artificial feeding given 10% C racemose. This is because the addition of *C. racemosa* in tilapia feed can increase the nutritional content of the feed, especially if used as a supplement or mixed ingredient with commercial feed. According to Ashour *et al*., *C. racemose* can also support improved immunity, digestion, and growth of tilapia if used at the right dose. However, excessive use can reduce feed efficiency due to higher fiber content [31]. The use of *Caulerpa* sp. in fish feed can provide nutritional and growth benefits to tilapia, but the effect will depend on the nutrient content of *Caulerpa* sp. and the proportion used. *Caulerpa* is high in protein for algae, although it is still lower than conventional protein sources such as fishmeal. According to Arisa *et al*.,.The protein in *Caulerpa* remains beneficial for supporting the growth and tissue repair of tilapia. *Caulerpa* contains omega-3 and omega-6 fatty acids, which are important for supporting fish health [32]. This is what influences treatment A's optimal growth value, especially for improving immune system function and tilapia growth [33] *Caulerpa* is rich in essential minerals such as calcium, magnesium, and potassium, which are essential for fish metabolism. According to Suryaningrum *et al*., *Caulerpa* contains minerals that can aid in the physiological processes of fish and support bone strength and enzymatic systems. *Caulerpa* contains vitamins such as vitamins A, C, and E, which function as antioxidants, boost the immune system of fish, and help maintain healthy skin and scales [34]. The content of natural pigments such as chlorophyll and carotenoids in *Caulerpa* can help improve the color of fish, which is an added value to the aesthetics of tilapia, especially if marketed in live conditions. Feed is a key factor in tilapia growth. Providing quality feed, with the right amount, frequency, and nutritional content will maximize growth, improve fish health, and optimize farming efficiency. Good feed management can reduce production costs and increase yields.

3.7 Specific Growth Rate

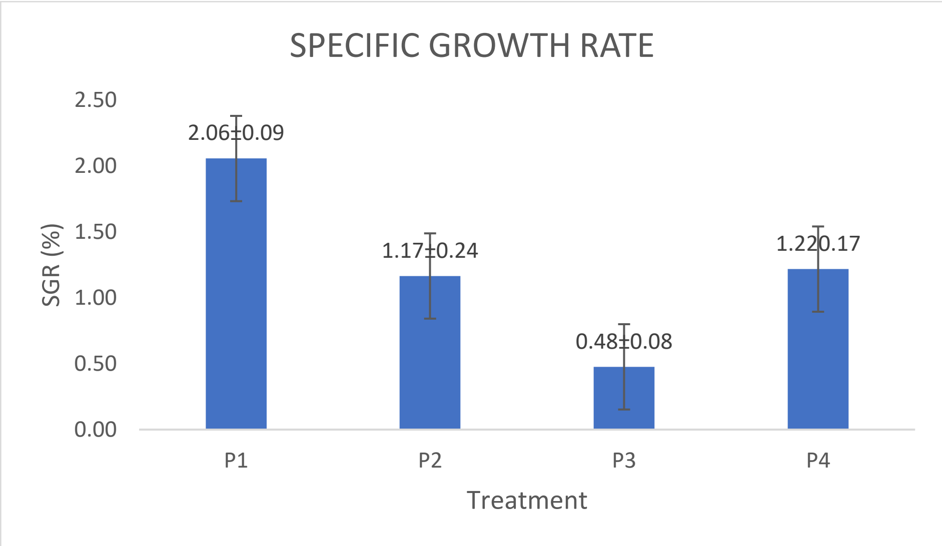

Figure 2: Specific Growth Rate of red tilapia (*O. niloticus*)

Based on the results of the study, the data obtained can be seen in the figure above shows that the highest average specific growth rate of tilapia is found in P1 (treatment A) as much as 2.06% / day, followed by P4 (treatment D) 1.22% / day, followed by P2 (treatment B) 1.17% / day and the lowest growth practice is found in P3 (treatment C) as much as 0.48% / day. The high specific growth rate given feed with the addition of *Caulerpa* sp. flour is believed to be because the feed meets its nutritional needs to stimulate tilapia growth. In addition to protein, carbohydrate, and fat requirements, fish feed also requires minerals and micronutrient vitamins. Most cultivated algae, including *Caulerpa* sp., are known for their high mineral content. In line with Darmawati *et al*., calcium and iron are the micro minerals with high content in seaweed [35] . Calcium is needed for bone formation and strengthening, while iron is a component of blood formation [32] *.aulerpa lentillifera* in feed can meet the needs of the fish body. Furthermore, the higher the percentage of *Caulerpa* sp. flour addition, the lower the SGR obtained. This is thought to be due to the high crude fiber content and ash content in the test feed, it affects the process of feed digestibility, and nutrient absorption becomes not optimal [36]. In line with research Darmawati *et al*., the Specific Growth Rate of milkfish seeds decreased in feeding with the addition of *Caulerpa* sp. flour by as much as 30% [35], . Research shows that the high crude fiber content in the feed will make the feed pass directly through the intestines without going through the process of protein absorption and nutrient digestion [37]. The higher the feed utilization efficiency value, the higher the fish growth rate. According to Nurfah *et al*., the statement states that the use of protein depends on the availability of non-protein energy sources in feed, which will affect the efficiency of nutrient retention [13]. The higher the use of *Caulerpa* sp. flour in feed, the lower the lipid retention.

3.8 Survival Rate

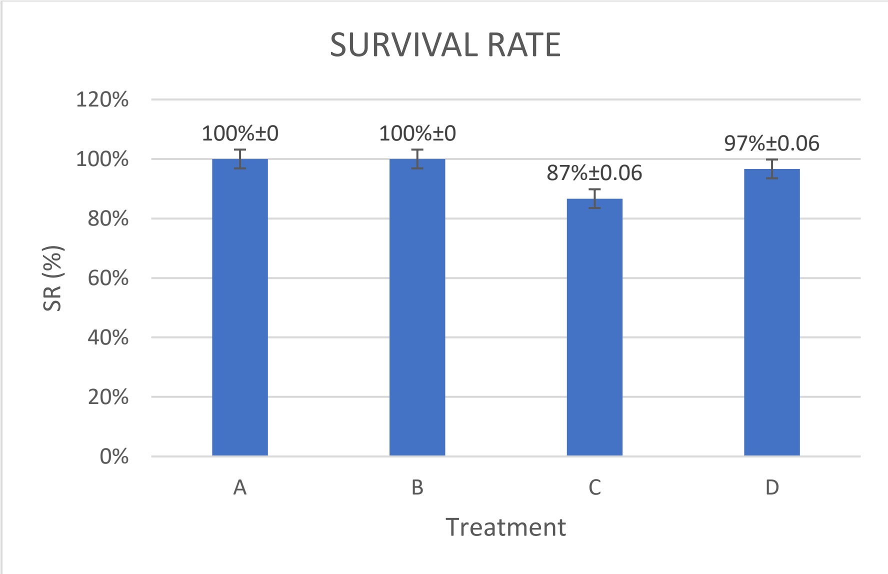

Figure 3: Survival Rate of red tilapia (*O. niloticus*)

Based on the data obtained, tilapia fish that died were found in treatment C, namely in weeks 3, 5, 6, and 8, with the number of deaths per week of 1 fish. In treatment D there was 1 red tilapia that died. The occurrence of death in tilapia can be caused by several factors, namely environmental factors, density, and lack of nutrition. Water quality is the most important factor in fish farming. Poor water conditions can cause stress, disease, and death in fish. Water quality, such as low oxygen, can cause fish to have difficulty breathing, which eventually leads to death. According to Ribeiro *et al*., poor water qualit includes low dissolved oxygen, high fish density, excessive feed, and dead algae. Then the acidity level (pH) of water that is too high or too low can interfere with the body functions of tilapia [38]. According to Mustapha *et al*., tilapia can generally live at a neutral or slightly alkaline pH ranging from 6.5 - 9. In addition, ammonia also affects the death of tilapia, and high ammonia is often produced by waste leftover fish feed and fish feces [39]. According to Yuan *et al*., high levels of ammonia and nitrite, often produced from fish waste or feed residues, are toxic and can cause poisoning in fish. This can cause tilapia to experience stress or poisoning so that tilapia experience death. In addition to water quality, stress in fish can also affect fish mortality [40]. Stress in fish can be caused by sudden environmental changes and poor water quality. According to El-Hack *et al*., overcrowding, rough handling, and lack of shelter. Sustained stress weakens the immune system of fish, making them more susceptible to disease and death [41].

3.9 Feed Conversion Ratio (FCR)

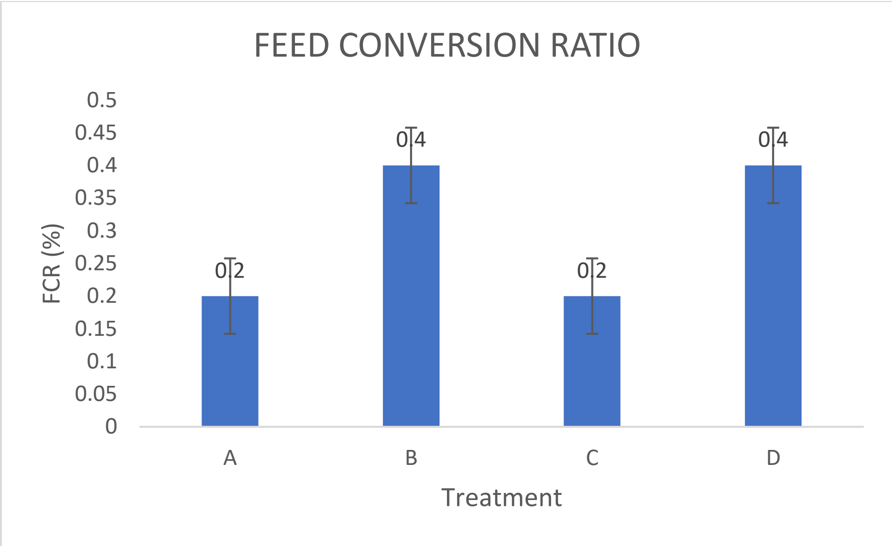

Figure 4: Feed Conversion Ratio of red tilapia (*O. niloticus*)

Feed conversion is the ratio of the amount of feed consumed by the fish to the weight gain of the fish being reared [42]. The data obtained showed that the lowest average FCR of tilapia was found in the treatment of the addition of *Caulerpa* sp. seaweed flour as much as 10% and 30% (A and C), and the highest was in the addition of Caulerpa sp. seaweed flour as much as 20% and control (B and D) of 0.4%. The feed conversion value in this study was classified as good, and it ranged from 0.2% to 0.4%. The range of FCR values is quite low, indicating that tilapia can utilize feed well in all treatments. According to Listiowati *et al*., the value of feed conversion is still considered efficient if it is less than 3. The low value of feed conversion indicates that fish can utilize the nutritional content of the feed properly [43]. According to Endraswari *et al*., the conversion value in feed can show how much feed is consumed by fish to become biomass in the fish body. If the high feed conversion value is influenced by poor feed quality. In addition, the feed conversion value also shows the efficiency of the utilization of fish feed nutrients, where the lower the feed conversion value produced, the more efficient the use of the feed [44].

3.10 Feed Efficiency

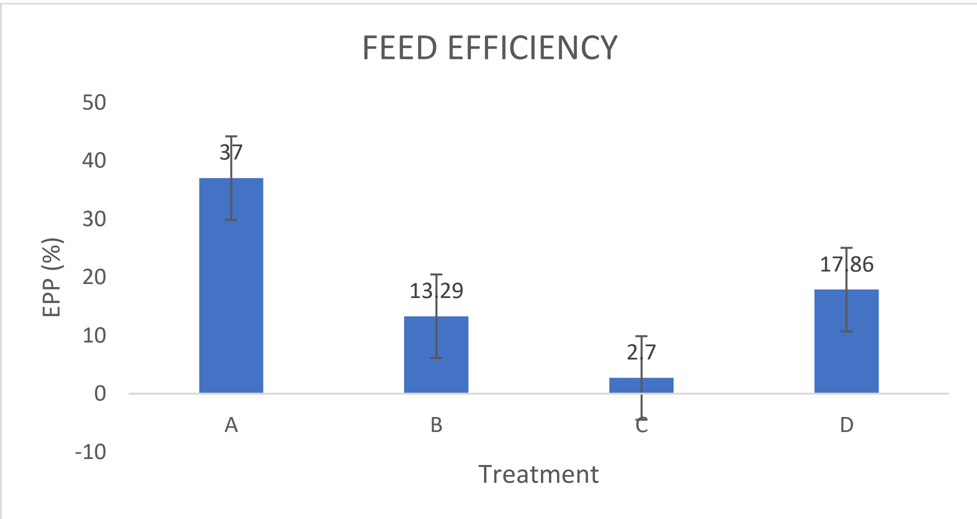

Figure 5: Feed Efficiency

Feed utilization efficiency is the ratio between body weight and the amount of feed given during maintenance. The feed conversion ratio is a condition that shows the effect of feeding on growth performance [23]. Feed efficiency is closely related to feed conversion. The lower the feed conversion value, the more feed efficiency increases. Based on the results obtained, the highest feed efficiency was found in treatment A with a value of 37%, followed by treatment D with a value of 17.86%, then treatment B with 13.29%, and the lowest was found in treatment C, which was 2.75%. This shows that the efficiency of tilapia feed utilization with the addition of *Caulerpa* sp. flour can only occur when given up to a concentration of 10%. In contrast to the research of Lemba *et al*.,. The results showed that the addition of *C. lentillifera* in the feed influenced the EPP value with an average value of 11.27%-20.59%. The high value of Feed Efficiency in the treatment with the addition of 10% *Caulerpa* sp. flour in feed is also due to the feed consumed having a high enough protein content, which is 39.85% [18]. In line with Kusuma *et al*., feed with a high feed utilization efficiency value, the feed content will be better. The higher the feed efficiency value indicates the more efficient use of feed by fish. A good Feed Efficiency value indicates that the feed consumed has good quality so that it can be easily digested and utilized efficiently by fish [45]. According to Craig *et al*., . The feed utilization efficiency value is said to be good if it is more than 30% [46].

3.11 Water Quality

Table 2: Water quality of media cultivation

Treatment	Parameters		
	pH	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**
A	6 – 8	29 – 31.34	5.7 – 8.7
B	6 – 8	28.8 – 31.2	6.2 – 8.6
C	6 – 8	28.4 - 31	5.7 – 8.6
D	6 – 8	28.8 – 30.7	6 – 8.6

The pH value obtained during the maintenance of red tilapia ranged from 6 to 8. This pH value is still within the optimal range and can be tolerated for the growth and survival of tilapia. This is supported by Mohammady *et al*., which states that the optimum pH for tilapia growth and survival ranges from 6.56 to 8.27 [47]. According to El-Sherif *et al*., the appropriate pH range for tilapia growth is 7 to 8; values outside this range can interfere with the growth process and cause stress to the fish [48].

Temperature values during tilapia rearing ranged from 28.4 to 31.34°C. This temperature range is optimal and suitable for the growth and survival of tilapia. According to Pandir *et al*., the optimal water temperature around the tilapia rearing site ranges from 27 - 32℃ [49]. According to Khater et al.,[3]. Temperature has a very direct effect on the life of tilapia, especially in the growth process. In addition, temperatures that are too high can make the tilapia become stressed, thus affecting its growth rate.

The dissolved oxygen content obtained during tilapia rearing ranged from 5.7 - 8.7 mg/l. The concentration of dissolved oxygen in this study is classified as an optimal condition. This statement is reinforced by El-Hack *et al*., [41], which states that the optimal dissolved oxygen content to support the growth and survival of tilapia ranges from 5 - 7 mg/l. Optimal dissolved oxygen levels can reduce stress in fish. Stress caused by lack of oxygen can affect the immune system of fish and inhibit the growth of tilapia. In addition, low dissolved oxygen levels often cause tilapia to develop respiratory problems, which can be fatal. Conversely, high dissolved oxygen can reduce the risk of death because fish can breathe more easily.

4. Conclusion

This study concludes that feed supplemented with *Caulerpa racemosa* can influence the growth of tilapia. The addition of 10% *C. racemosa* resulted in significantly higher growth rates in can tilapia.

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Conflict of interest needs to be added.

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