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CHROMIUM-YEAST ENRICHED FEED FOR SALTWATER FISH: PHYSIOLOGICAL IMPLICATIONS AND TOXICITY CONSIDERATION

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ABSTRACT
Indonesia has a great potential in fisheries sector, especially aquaculture. With more than 70% ocean covered the whole country and favorable waters condition for various commercially fish, the economical prospect for mariculture in Indonesia is unquestionable. Various species have been successfully cultured in Indonesian Waters using floating net cages gaining a million tonnes of production each year. The main problem of this activity is the excessive cost resulting from the use of expensive commercial feed that contain high amount protein. To tackle this problem, an additional chromium-yeast enriched feed have been explored to increase the feed efficiency of several important marine fish commodities. Here we reviewed several physiological implication of chromium-yeast enriched feed to specific marine fish Silver Pompano (Trachinotus blochii, Lacepede) and Cantang Grouper (Epinephelus fuscoguttatus-lanceolatus) through its survival rate, Daily Growth rate (DGR) and Feed Utilization Efficiency (FUE). Overall the literature reported a beneficial and comparable performance of chromium-yeast enriched feed to the aforementioned fish without giving toxicity effect as the chromium contain in the fish flesh still below several standards. This give hopes to the new cost effective yet efficient feed in mariculture.

1. INTRODUCTION

The cultivation of fish in marine environment for food and other products or often called mariculture, has a tremendous potential to be developed in Indonesia. With more than 70% ocean covered the whole country and favorable waters condition for various commercially fish, the economical prospect for mariculture in Indonesia is unquestionable. In 2017, the total production for mariculture reached 9.884.669 tonnes, with average increament up to 12.57% from 2012 to 2017 [1]. This numbers came from several commodity including seaweed, grouper, silver pompano, snapper, clam or shell and many more. This was also relatively higher than the production obtained from capture fisheries. This signify the potential development of mariculture sector in Indonesia.

The high cost of feed is one of the problems for fishery cultivation business actors including the cultivation of star pomfret fish. The costs incurred for feed in fish farming reach 60% of the total production costs [2]. The high price of fish meal has an impact on the high price of fish feed. The increase in the price of feed ingredients (fish meal, fish oil and wheat flour) and production and transportation costs have led to higher feed prices [3]. Fish need feed in sufficient quantity, continually available, and quality to grow and develop properly. The protein content in marine fish feed ranges from 40-55% based on dry weight, while the protein content in other animal feed is only 15%. According to Rahmaningsih and Ari [4], marine fish feed, especially carnivores such as grouper which contains 40% - 50% protein, will provide maximum growth for the development of fish life, but protein is a fairly expensive feed nutrient.

The use of carbohydrates as an energy source can increase protein efficiency for the growth of fish body weight [5]. In general, fish are less able to utilize carbohydrates in feed. The ability to utilize carbohydrates in the diet of each fish species varies. Omnivorous and herbivorous fish are able to utilize carbohydrates by 30-40%, while carnivorous fish such as grouper fish are only able to utilize carbohydrates by 10-20%. This difference is caused by different eating habits, the ability of the fish digestive organs to digest feed carbohydrates, and the capacity of insulin performance in different fish [6].

The performance potential of insulin can be increased by chromodulin through increasing the sensitivity of insulin receptors. Economical sources of chromium are chromium chloride, chromium-yeast, chromium nicotinate, and chromium picolinate. Chromium (Cr) is an essential trace element which is required in very small concentrations. Chromium has a major role in the interaction between insulin and cell receptors that are present together as a complex compound called glucose tolerance factor (GTF) which can increase the activity of insulin function. Giving Cr in organic form will have a positive effect because it is easier to absorb [7].

Here we will review some of the reported study regarding the impact of chromium-yeast addition into feed of some commercial marine fish, in particular silver pompano (Trachinotus blochii, Lacepede) and (Epinephelus fuscoguttatus-lanceolatus). A toxicity study as well as future prospect analysis will also be explored to further enhance the discussion.

2. Chromium-Yeast Enriched Feed

Chromium or Cr is a metal mineral that is contained in the earth's layers. Chromium is an element that is naturally found in low concentrations in rocks, animals, plants, soil, volcanic dust, and also gases [8]. Chromium is a heavy metal that has a valence number of +2 to +6. Three-valent chromium (trivalent) is the most stable form and has physiological functions, however, chromium with triple valence is very difficult to be absorbed from the digestive tract [9].

The use of organic minerals in feed is an alternative to increase efficiency in mineral use. The hexavalent Cr mineral (Cr + 6) can cause toxicity even though its absorption rate in the intestine is high. Chromium in the trivalent form (Cr + 3) is not toxic, but it is very difficult to absorb. A study on mice showed that organic Cr has the ability to survive in the body better than inorganic Cr, making it easier to absorb. Organic chromium can be in the form of Cr-chelate, high-Cr yeast (high-Cr yeast) and Cr-picolinate [10].

Yeast (Saccharomyces cerevisiae) is a source of GTF (Glucose Tolerance Factor) which plays a role in increasing the potential performance of insulin. Yeast is also capable of synthesizing a type of B vitamin, namely niacin (nicotinic acid) which is an important part of GTF. The formation of organic chromium can be carried out by incorporation of Cr into fungi. This is done through a biofermentation process that uses fungi as producers with a substrate enriched with inorganic Cr minerals [10]. The incorporation of trivalent chromium into yeast forms chromium-yeast which is a form of organic chromium complex.

Organic chromium is a mineral added to feed that can accelerate the digestibility and absorption of feed that enters the body [11]. The formation of organic chromium can be done through a biofermentation process using fungi. One of the fungi that can be used as a chromium substrate is yeast [10]. Organic chromium is stored in the blood in the form bound to transferrin, then Cr-transferrin is linked to the transferrin receptor and enters the cells [12].

Chromium (Cr) is an essential micro mineral that is beneficial for the body (Lewicki et al. 2014)[13]. The main role of Cr is related to glucose metabolism, which is to increase the potential for insulin activity through GTF (Glucose Tolerance Factor) where chromium will form a complex with insulin and insulin receptors. GTF facilitates the interaction of insulin receptors with their receptors, resulting in an increase in the effectiveness of insulin [12]. According to NRC [14] Cr in animal feed plays a role in glucose metabolism, fat metabolism, and protein metabolism in the body.

Research on giving organic chromium has been conducted by several researchers. Giri et. al., [15] gave organic chromium (Cr+3) in the form of chromium picolinate to juvenile Labeo rohita fish and produced the best growth rates in addition of chromium picolinate at a dose of 0.8 mg/kg. Provision of organic chromium in feed at 5 ppm is able to produce the best growth performance of snakehead fish [16]. Wahyudi [17] states that the dose of Cr2O3 of 3.9 ppm is the optimum dose that can be given to tiger grouper. Giving chromium-yeast 3.20 ppm can increase the value of the daily growth rate and the highest feed efficiency [18]. Meanwhile, gouramy, which is a herbivorous fish, with the addition of chromium-yeast in the feed as much as 1.5 ppm significantly increased the growth rate and highest feed efficiency compared to other treatments, namely 3.0 and 4.5 ppm [19].

3. Physiological Impact

The physiological impact of chromium-yeast enriched feed stock to several marine fish has been reported previously. The main observed parameter includes survival rate, daily growth rate (DGR), Feed Utilization Efficiency (FUE). The implication of chromium-yeast enriched feed have been studied to Two commercially important saltwater fish, silver pompano and cantang grouper, which production is economically important in Indonesia as well as in International Market.

3.2 Silver Pompano

Silver pompano (Trachinotus blochii, Lacepede) is one of the marine commodities cultivated in Indonesia . star pomfret fish is one of the marine cultivation commodities that have high economic value . Currently, this fish has a selling price of around Rp . 90,000.00–100,000.00 per kg. The maintenance of this fish is relatively fast compared to other marine fish commodities, easy to maintain, and can be sold in a dead condition, making the harvesting process easier [20].

The results of observations on the maintenance carried out by Rostika et. al., [21] pomfret for 42 days with the addition of feed containing chromium-yeast showed that treatments A (control) and C (3.20 ppm chromium-yeast) indicated the survival rate of each. 97% each (2 dead). Whereas in treatment B (1.49 ppm chromium-yeast), the survival rate was 93% (5 dead) and in treatment D (4.59 ppm chromium-yeast), the survival rate was 95% (4 individuals). die). This shows that the survival decreases with increasing maintenance time for 42 days, the survival rate of all treatments <100% [21].

The growth rates of each treatment were, A (Control, 0 ppm Chromium-yeast) 0.23 grams/day, B (1.47 ppm Chromium-yeast) 0.27 grams/day, C (3.20 ppm Chromium- yeast) 0.32 grams/day and D (4.59 ppm chromium-yeast) 0.26 grams/day. The results of the daily average growth rate were continued by using analysis of variance (ANOVA) because it showed that the daily average growth rate of the addition of different chromium-yeast concentrations gave significantly different results and was continued using Duncan's multiple range test with a confidence level of 95 %. Based on the results of the Duncan multiple distance test, treatment C showed the highest average daily growth rate results and stated significantly different results to the control.

According to Vincent [22] Cr+3 is an important part of the organic metal component known as glucose tolerance factor (GTF). This glucose tolerance factor is known as chromodulin, an oligopeptide that binds to chromium and has low molecular weight. The chromodulin plays a role in increasing the performance potential of insulin by increasing the sensitivity of insulin receptor sites. Subandiyono [19] states that an increase in insulin in the blood accelerates the entry of blood glucose into cells so that the decrease in blood glucose levels occurs more quickly. According to Anderson [23], this process is associated with increased insulin activity in the presence of chromium. This indicates that blood glucose can be immediately utilized by cells as a source of metabolic energy.

Efficiency of feed utilization of each treatment, namely, A (Control, 0 ppm Chromium-yeast) 68%, B (1.47 ppm Chromium-yeast) 76%, C (3.20 ppm Chromium-yeast) 85% and D (4.59 ppm Chromium-yeast) 73%. The results of the calculation of feed utilization efficiency were continued using analysis of variance (ANOVA) because it showed different feed utilization efficiencies by giving significantly different results and continued using Duncan's multiple range test with a 95% confidence level. Based on the results of the Duncan multiple distance test, treatment C showed the highest average daily growth rate results and stated significantly different results to the control.

According to Andriani [24], the value of feeding efficiency is directly proportional to the resulting growth, meaning that growth will change in line with changes in feeding efficiency if the amount of feed given does not change. The greater the value of feeding efficiency, the better the fish use the feed given so that the greater the body weight of the fish produced. The value of feed utilization efficiency in the provision of Cr + 3 which was higher than control showed that the use of glucose as metabolic energy gave the body cells the opportunity to use protein and fat efficiently as support for growth. Therefore, the increase in body protein and lipids is also due to the metabolism of amino acids and lipids related to insulin activity in the body. The insulin hormone is also called the "abundance hormone" which means the insulin hormone leads directly to the accumulation of excess carbohydrates, fats, and proteins [25]. Therefore, chromium as an insulin cofactor must be optimized in the diet to maximize insulin function physiologically. Watanabe et. al., [26] and Gatlin [27] state that microminerals in the form of Cr + 3 play an important role in carbohydrate metabolism, especially for the utilization and regulation of glucose. Transferring blood glucose into cells cannot be separated from the role of insulin influenced by chromium as a cofactor [26-28], and chromium has an optimal range of scores for performing optimal function [29].

3.1 Cantang Grouper

Grouper fish is an Indonesian export fishery commodity that is superior and has a high economic value in both local and international markets. Grouper has several species including humpback or mouse grouper, sunu grouper, tiger grouper, kertang grouper and hybridized grouper [30]. One of the hybrid grouper fish that is of interest is the black grouper (Epinephelus fuscoguttatus-lanceolatus). Cantang grouper is a hybrid grouper produced from a cross between tiger grouper (Epinephelus fuscoguttatus) and giant grouper (Epinephelus lanceolatus) [31].

Cantang grouper fish is a type of fish that has a high selling price. The price of live grouper in Pangandaran Regency in 2019 is a consumption measure such as reaching IDR 95,000 / kg. The development of the grouper market encourages people to meet the market demand for grouper fish through cultivation. This has made Cantang grouper cultivation continue to increase and become a promising business opportunity.

An observation was carried out by Rostika et. al., [32] for 42 days on grouper larvae with 4 treatments, namely control (A), feed with the addition of chromium-yeast 3.1 mg/kg (B), feed with the addition of chromium-yeast. 3.9 mg/kg (C), feed with the addition of chromium-yeast 4.6 mg/kg (D). The results showed that the survival rate of Cantang grouper seeds did not show any differences between treatments. This is because the chromium content in the feed during the study was in the range that the fish could still tolerate. The high value of the survival rate of Cantang grouper seeds is thought to be due to the influence of the chromium content in the feed which can increase the body resistance of Cantang grouper seeds. This is in line with the research of Rahkmawati et. al., [33] where giving 2 mg / kg of chromium-yeast in feed gave the best results in increasing the immune response of red tilapia (Oreochromis sp.).

The results of the observation on the weight growth of Cantang grouper fish during the study showed that the results of the observations on the weight growth of Cantang grouper fry showed an increase in weight during the maintenance period. The average individual weight of grouper seeds at the beginning of the rearing period ranged from 6.03 - 6.08 grams, while at the end of the study ranged from 16.53 - 19.27 grams. The results showed that the weight of grouper seeds in treatment C, namely feed with the addition of chromium-yeast of 3.9 mg/kg, resulted in the highest average weight of 19.27 grams.

Organic chromium (Cr^{+3}) content in feed gave different results to the average daily growth rate. This phenomenon is related to the ability of organic chromium to increase the performance potential of insulin [34]. The chromium in feed increases insulin performance through GTF. Increased activity of insulin in the blood accelerates the entry of blood glucose into target cells. Glucose in the blood can be immediately used as an energy source to meet the energy needs of metabolism, thus saving feed protein. Feed protein will be used for body protein synthesis, thereby increasing the growth rate of fish [15].

Based on the results of the FUE value during maintenance, it was found that the average feed efficiency value in each treatment was in the range of 58.33% - 68.65%. This shows that the fish can use feed of 58.33% - 68.65% for growth. The average FUE value in each treatment is quite good, according to the statement of Puspasari et. al., [35], namely the value of good feed utilization efficiency is more than 50% or even close to 100%. According to Maulidin et. al., [36], a good FUE value shows that the feed consumed is of good quality, so it can be easily digested and used efficiently by fish.

The highest FUE value was found in the C treatment (chromium-yeast 3.9 mg/kg) which was 69.93%. According to Susanto et. al., [37] the efficiency of feed utilization increases with chromium feeding due to an increase in the interaction between insulin and receptor cells (GTF). The use of feed carbohydrates as an energy source will suppress the portion of feed protein that is catabolized into energy, so that more protein is synthesized for growth [38].

4. Toxicity Study

The chromium content in the feed consumed by grouper fry accumulates in the fish's body. Heavy metals such as chromium accumulate in fish body tissues, namely in the gills, liver and fish meat [39]. The fish body tissue tested for chromium content in this study was the meat. The results of testing the chromium content in fish meat are used to determine whether or not the research fish is fit for human consumption. Fish that contain heavy metals exceeding the human consumption threshold if consumed will have the potential to cause various diseases both in the short and long term [40].

The highest chromium content in star pomfret fish with the provision of chromium-yeast concentration of 4.59 ppm showed that the chromium content in star pomfret fish was 1.031 mg/kg. The chromium content of the star pomfret fish with the addition of 1.47 ppm chromium-yeast is 0.6208 mg/kg, and the addition of 3.20 ppm chromium-yeast produces 0.653 mg/kg chromium in fish meat. Meanwhile, the lowest chromium content in grouper meat was found in the addition of 3.1 mg / kg, namely 0.2871 mg/kg and the highest in the addition of 4.6 mg/kg, namely 0.4412 mg/kg. The higher the amount of chromium added to the feed, the higher the amount of chromium accumulated in fish meat. This is in line with the research of Yanto et. al., [41] namely that the chromium content in the stalk fish meat continues to increase along with the increasing number of chromium additions to the feed given.

The maximum limit of metal contamination in food is based on the Directorate General of National Agency of Drug and Food Control Indonesia No. 03725/B/SK/89 is 2.5 mg/kg. The amount of chromium content in fish meat has not exceeded the human consumption threshold. This is also similar to the Food and Drug Administration's stipulation regarding metal contamination in food where the maximum allowable chromium metal content is 1 mg/kg. Based on these two provisions, it can be concluded that the fish from the research results in each treatment are still below the threshold

and safe for human consumption. The chromium contained in feed is already in organic form so it is safe for human consumption. Astuti [10] states that threevalent chromium (Cr^{+3}) is not toxic when consumed within reasonable limits.

5. Conclusion

The addition of chromium-yeast to feed for mariculture activity proved to give a beneficial advantage in terms of cost effectivity by reducing the protein content of the feed and instead using carbohydrate based feed which are more less expensive without downgrading the survival rate, feed utilization efficiency and daily growth rate. By this means, the mariculture sector can be further optimized and produce more benefits. Further study still needed to enlighten the whole theoretical framework of chromium-yeast enriched feed, particularly to commercially important marine commodity.

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