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Availability of Fisheries By-Product Materials with Cadmium Removal Treatment as a Feed Ingredient for Fingerling Black Rockfish *Sebastes schlegeli*

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Abstract: Squid liver and scallop-mid gut glands, which are generated and discarded as waste from the Japanese common squid and Japanese scallop, are rich in amino acids and lipids. However, the squid liver and scallop mid-gut glands contain cadmium (Cd) which is generally known as a harmful heavy metal for human health. Hirama *et al.*[*4] recently studied a technique for removal of Cd from squid viscera and scallop mid-gut glands and confirmed the efficacy of the acid leaching and electrolysis method to produce the fisheries by-product materials (meal and extract) with Cd removal treatment as a feed ingredient for cultured fish.

So far we have evaluated the nutritional value of squid viscera meal with Cd removal treatment (dCSVM), which contained 1.5–2.0 mg/kg Cd, as an alternative protein source to sardine meal in diets for fingerling black rockfish *Sebastes schlegeli*. In our study, it was clearly demonstrated that dCSVM with good protein digestibility could be substituted for 60% of sardine meal in diets for fingerling black rockfish without growth retardation, poor palatability and the problem of Cd accumulation. We suggested that dCSVM was superior to commercial squid viscera meal without Cd removal treatment (CSVM) as a high-quality feed ingredient for black rockfish based on the heavy metal accumulation in fish tissues.

Recently, we are investigating availability of mid-gut glands extract with Cd removal treatment (dCSMGE) as a feed ingredient for fingerling black rockfish. In the recent study, we found that weight gain, specific growth rate, and feed efficiency of fish fed the diet containing dCSMGE at 2% were significantly higher than those of the control. Furthermore, we confirmed that test diets containing dCSMGE was safe in terms of accumulation of Cd.

These results demonstrate that proper inclusion of dCSVM and dCSMGE is effective for the improvement of feed quality in practical diets for fingerling black rockfish.

Key words: squid viscera, scallop mid-gut glands extract, cadmium, alternative ingredients for fish meal with Cd removal treatment, black rockfish

The increasing feed cost in aquaculture production due to the increasing price of fish meal has been a serious problem recently. Therefore, the importance of studies on alternative protein sources for fish meal, a major ingredient for aquaculture feed, in diets has been increasingly realized (Gatlin *et al.*, 2007). However, it is widely recognized that high inclusion of alternative protein source in diets may result in poor palatability, particularly at low temperatures.

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*4 Hirama M., WakasugiM., TomitaK., KamadaT., TakahashiT., NobutaS., AsoS., SatohN., and IshidaR., 2013: Studies on the technique for removal of Cadmium from scallop mid-gut glands to produce fisheries by-product materials with Cadmium removal treatment as a feed ingredient for fish farming (in Japanese). Abstracts of the Annual Meeting of the Japanese Society of Fisheries Science. Japanese Society of Fisheries Science, Mie, Japan, September, p.77.

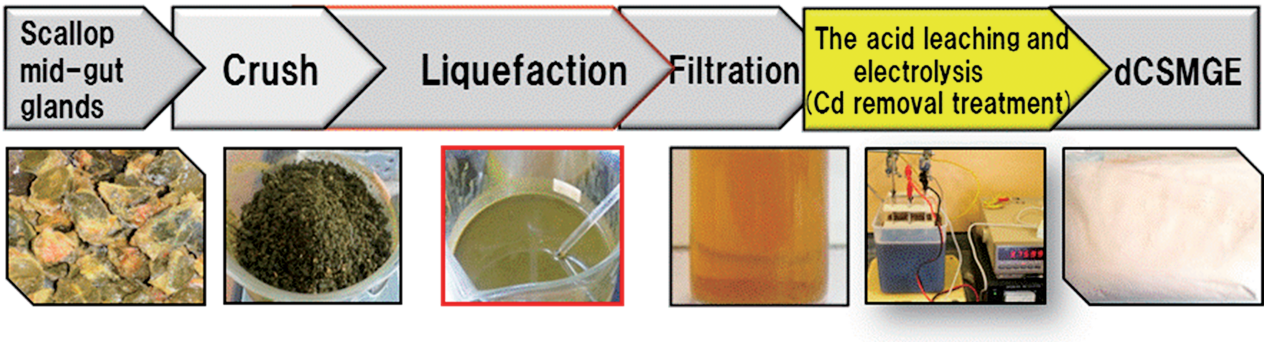

Fig. 1. Original production method of scallop mid-gut glands exract with Cd removal treatment (dCSMGE).

Squid liver, squid viscera and scallop mid-gut glands, which are generated and discarded as waste from the Japanese common squid *Todarodes pacificus* and Japanese scallop *Mizuhopecten yessoensis*, are rich in amino acids and lipids (Sakuta and Shimakage, 2004). Particularly, by-products of squid processing are important feed ingredients in aquaculture shrimps diets, since the diets contain squid by-products are effective for the improvement of growth performances and feed utilization in prawn species (Hertramp and Piedad-Pascual, 2000). In Hokkaido, Japan, these fisheries wastes are generated and wasted every year, and the volumes of squid viscera and scallop mid-gut glands were 9,324 and 30,533 metric ton in the 2010 fiscal year.

However, the squid liver and scallop mid-gut glands contain cadmium (Cd) at 19 and 39 mg per kg wet weight on average, respectively (Wakasugi *et al*., 2005; Kruzynski, 2004). Cd is generally known as a harmful heavy metal for human health (Mai *et al*., 2006). Wakasugi *et al*. (2009) recentlystudied a technique (Fig. 1) for removal of Cd from squid viscera and scallop mid-gut glands[*5] and confirmed the efficacy of acid leaching and electrolysis to produce fisheries by product materials (meal and extract) with Cd removal.This material was evaluated as a feed ingredient for cultured fish (Wakasugi, 2009). Consequently, they have developed squid viscera mealand scallop mid-gut glands exract with Cd removal treatment, dCSVM and dCSMGE, respectively.

Black rockfish, *Sebastes schlegeli is* an important species in Japan (Nakagawa *et al*., 2007) and Korea (Bai, 2009) that is cultured for stock enhancement and aquaculture. However, information on the alternative protein sources of fish meal in diets for aquaculture is still limited. Aso *et al*. (1999) reported that scallop viscera meal with Cd removal treatment could substitute 10 % of brown fish meal in the diets for fingerling black rockfish.Lim *et a*l. (2004) showed that dehulled soybean meal could replace fish meal up to 20% withoutsupplementation of methionine and lysine and 30% with these amino acids being supplemented in fingerling and growing black rockfish. Therefore, we studied availability of dCSVM and dCSMGE as a feed ingredient for fingerling black rockfish.The present article reviews information on the feed values of dCSVM and dCSMGE for black rockfish.

Availability of squid viscera as a feed ingredient for cultured-fish

Availability of various by-products in fisheries as a feed ingredient for aquaculture fish species was studied recentlyby many researchers, because by-products fromfisheries hold promise as potential protein substitutes for fish meal (Li *et al*., 2004).

It has been reported that extrudeddiets containing 20–30 % raw squid liver could be used for rainbow trout *Oncorhynchus mykiss*, yellowtail *Seriola quinqueradiata*, and red seabream *Pagrus major* (Mastuda *et al*., 2001a, b). Feeding studies have shown that the commercial squid viscera meal

[*5] Hirama M., WakasugiM., TomitaK., KamadaT., TakahashiT., NobutaS., AsoS., SatohN., and IshidaR., 2013: Studies on the technique for removal of Cadmium from scallop mid-gut glands to produce fisheries by-product materials with Cadmium removal treatment as a feed ingredient for fish farming (in Japanese). Abstracts of the Annual Meeting of the Japanese Society of Fisheries Science. Japanese Society of Fisheries Science, Mie, Japan, September, p.77.

without Cd removal treatment (CSVM) can be used as an alternative protein source in diets for various fish species; In fingerling black rockfish, Satoh *et al.* (2006) showed that CSVM could be substituted for 30% of sardine meal in a diet when growth performance was used as the dependent variable, while substitution of only 10% of sardine meal could be recommendedin terms of the heavy metal accumulation in the liver. Mai *et al.* (2006) evaluated the effects of dietary CSVM on the growth and Cd accumulation in tissues of Japanese seabass, *Lateolabrax japonicus*. They demonstrated that growth rates in fish fed diets contained 50 and 100g CSVM per kg diet were significantly higher than that in control fish, and that Japanese seabass did not accumulate Cd in the muscle (edible portion), although Cd concentrations in fish kidneys, livers and gills were at high levels (0.4–5.9 mg per kg dry weight). In the paper, they also pronounced that a long-term feeding trial was necessary to investigate Cd accumulation in cultured Japanese seabass. More recently, Wang *et al.* (2012) reviewed that several fish diets supplemented with CSVM contained high Cd levels, 51–116 mg/kg diet.

Availability of dCSVM as a feed ingredient for fingerling black rockfish

We have evaluated the nutritional value of dCSVM, which contained 1.5–2.0 mg/kg Cd, as an alternative protein source to sardine meal in diets for fingerling black rockfish (Satoh *et al.*, 2013a). The Cd level of dCSVM was less than 3.0 mg/kg, which is the allowable level of Cd in livestock feed ingredients according to the Law Concerning Safety Assurance and Quality Improvement of Feeds in Japan. In this study, it was demonstrated that dCSVMwith good protein digestibility could be substituted for 60% of sardine meal in diets for juvenile black rockfish without growth retardation, poor palatability and the Cd accumulation, although feed efficiency gradually decreased with the increase of dCSVM inclusion. In that paper, we suggested that dCSVM was superior to CSVM as a high-quality feed ingredient for black rockfish based on the heavy metal accumulation in fish tissues. Furthermore, we found that appropriate replacement (30–60%) of sardine meal by dCSVM was effective for stimulation of feeding in fingerling black rockfish, and that supplementation of methionine and lysine was not necessary with the inclusion of dCSVM. From these results, we concluded that dCSVMwas safe and useful as an alternative protein source in fingerling black rockfish diets.

Availability of dCSMGE as a feed ingredient for fingerling black rockfish

We also investigated availability of dCSMGE, which contains about 0.5 mg/kg Cd, as a feed ingredient for fingerling black rockfish[*4]. The total free amino acids content (mg/kg dry matter) of dCSMGE is about 30,000, while that of fish meal is about 800. dCSMGE contain amino acids effective for feeding stimulants and growth enhancement in various fish species (Mackie and Mitchell, 1985, Shimizu *et al.*, 1999, Ikeda *et al.*, 2012). In the recent feeding trial for 65 days, we found that weight gain, specific growth rate, and feed efficiency of fish fed the diet containing dCSMGE at 2% of the diet were significantly higher than those of the control[*6]. Moreover, we confirmed that test diets containing dCSMGE was safe in terms of accumulation of Cd[*6].

Kumai *et al.* (1989) found that commercial scallop extract as a flavor in the diet for ocelate puffer *Takifugu rubripes* promoted feed intake and digestive and absorptive functions in the ocelate puffer. Kikuchi and Furuta (2009) reported that blue mussel extract in diets based on fish and soybean meals for tiger puffer would be an effective feeding stimulant. We observed that dCSMGE improved feeding activity of barfin flounder *Veraspermoseri* in the short-term feeding experiment at low temperatures[2*7]. dCSMGE may be also an effective

*6 Satoh N., IshidaR., NobutaS., AsoS., WakasugiM., TomitaK., HiramaM., and TakahashiT., 2013: Availability of scallop mid-guts extract with cadmium removal treatment as a feed ingredient for fingerling black rockfish (in Japanese). Abstracts of the Annual Meeting of the Japanese Society of Fisheries Science.Japanese Society of Fisheries Science, Mie, Japan, September, p.42.

*7 Satoh N., IshidaR., NobutaS., AsoS., WakasugiM., TomitaK., HiramaM., and TakahashiT., 2013: Availability of scallop mid-guts extract with cadmium removal treatment as a feed ingredient for juvenile barfin flounder (in Japanese). Abstracts of the Annual Meeting of the Japanese Society of Fisheries Science. Japanese Society of Fisheries Science, Tokyo, Japan, March, p.135.

feed ingredient for the improvement of growth performance, feed utilization, and feeding activity in fish.

Krill extract and meal are often added to aquaculture feed to improve of platability (Shimizu, 1999) and digestibility (Satoh, 2003), but the supplementation in the diets is mostly limited for larval and juvenile fish because of the high price. To date, we estimate the cost of producing dCSMGE (semi-liquid form) will be below half of cost of krill ingredients. On the other hand, the producing cost of dCSMGE in powder form is higher than that in semi-liquid form, since producing of dCSMGE powder requires energy to dry. Interestingly, Kader *et al.* (2012) found that fermented soybean meal and squid by-product blend (1:1) could be substituted for about 40% of fish meal protein in the diet of Japanese flounder. Likewise, fermented soybean meal and scallop by-product blend (1:1) was able to replace at least 30% fish meal protein in red seabream diet (Kader *et al.*, 2011). These blends are effective for producing low-cost and healthy aquaculture feed, and the fermentation technique may be an effective measure of producing dCSMGE powder.

Conclusion

Our results demonstrate that proper inclusion of dCSVM and dCSMGE is effective for the improvement of feed quality in practical diets for fingerling black rockfish. Future research is needed to clarify the nutritional value of dCSVM and dCSMGE as a feed ingredient for aquaculture fish species other than black rockfish.

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