which yield lower price than live or fresh fish, similar to salmon, tilapia, catfish and shrimp. Cobia and giant grouper are the candidates but it is necessary to lower the feed cost and to promote them in international markets, particularly in US and EU supermarkets and in restaurant chains. Meanwhile, governments and relevant authorities should also promote domestic consumption similar to the success of *Penaeus vannamei* in China and Thailand. Though the profit margin of the domestic market is smaller it is more s than export markets, which always encounter problems of competition in production and price fluctuations due to extraordinary events.

References

Kongkeo, H. 2009. Backyard Hatcheries and Small Scale Shrimp and Prawn Farming in Thailand, Success Stories in Asian Aquaculture (Editors: Sena De Silva and Brian Davy), Springer Sciences and Business, pp 69-86.

Chen, J., 2006. Marine Fish Cage Culture in China, Proceedings of FAO/NACA Workshop on the Future of Mariculture, 7-11 March 2006, Guangzhou, China, pp 308-325.

Xan, L. 2007. Present Status and Strategy Development of Mariculture in Vietnam, Proceedings of FAO/NACA Workshop on the Future of Mariculture, 7-11 March 2006, Guangzhou, China, pp 272-276.

Phillips, M. Marine Fish Hatchery Development in Asia, NACA Publication.

Rimmer, M. 2007. Regional Review on Existing Major Mariculture Species and Farming Technologies, Proceedings of FAO/NACA Workshop on the Future of Mariculture, 7-11 March 2006, Guangzhou, China, pp 105-118.

De Silva, S.S., Phillips, M.J. 2007. A Review of Cage Aquaculture: Asia (excluding China), FAO Fisheries Technical Paper No. 498, pp 18-48.

Sim, S.Y. 2006. Asia-Pacific Marine Finfish Aquaculture News, NACA Aquaculture Asia Magazine, 2006, pp8.

Pawiro, S. 2006. Live fish trade in Asia: Update, INFOFISH International 1/2006, pp 54-59.

Hong, W. 2001. The status of marine fish culture in China, World Aquaculture magazine, December 2001, pp 18-20

Sadovy, Y. 2000. Regional Survey of Fry/fingerling Supply and Current Practices for Grouper Mariculture, Final Report to the Collaborative APEC Grouper Research and Development Network, December 2000, NACA.

Effects of different trash fish with alginate binding on growth and body composition of juvenile cobia (*Rachycentron canadum*)

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The cobia (*Rachycentron canadum*) is a carnivorous fish. It can grow with good feed conversion efficiency in offshore net cage systems from fingerling to marketable size (4–6 kg) in one year with high survival and its white flesh is suitable for sashimi[1].

In cobia farming, trash fish are used as the main source feed for cobia grow-out. Farmers usually put trash fish direct into the cages. This causes a loss of nutrients out of the water environment leading to increased feed conversion ratio (6 – 8) and the risk of environmental pollution[7,8,13]. In addition, the difficulties in storing and variable nutritional quality are the main constraints for cobia culture[16]. In Vietnam, the pellet feeds has been developed and used in cobia culture, but due to difficulties in feed supplying and high prices so the farmers still tend to use trash fish in cobia farming because of stable supplies and low prices[13]. However, the low lipid content in trash fish can affect the lipid concentration of cobia thus reducing the quality of products and market acceptance.

Alginate has been used as binder in feeds for aquatic animals for a long time, when the use of wet or moist feed was common[10,11]. It has previously been shown that feed containing alginate stimulates the immune system resistance to diseases in red seabream, Pagrus major[9]. This study was carried out to determine effects of using trash fish with alginate binding on feed utilisation and body composition of juvenile cobia.

Materials and methods

Formulating moist diets

Three species of trash fish: A – anchovy; L – lizardfish; C - cardinalfish) and those combinations (50 % A + 50 % L; 50 % A + 50 % C and 50 % L + 50 % C) were formulated into six diets. Raw fish was ground and extruded by an extruder. Sodium alginate was used as a binder for all moist diets at a concentration of 3%. After extrusion, the moist diets were submersed in 10% $CaCl_2$ solution to gel through the strong binding of calcium and alginate for 10 minutes. Feeds was sealed in vacuum packed bags and stored frozen (-20°C) until feeding.

Fish rearing

Juvenile cobia were bought from a commercial farm in Nha Trang - Vietnam. Fish were acclimated with a commercial diet (45% crude protein, 16% lipid) for two weeks before starting of the trial, and then fish (mean weight 29 g) were randomly distributed to each of 18 tanks with 10 fish per tank. Fish were fed to satiation in 30 minutes, twice daily at 08:00 and 16:00. The feeding trial lasted for six weeks. Temperature and salinity in tanks were monitored daily, while pH and ammonia and oxygen were monitored once every three days. Animals were kept under natural photoperiod conditions. During the experimental period, temperature was 28 - 30°C, salinity was 28-30 ‰, pH: 7.5-8.5, ammonia was lower than 1 mg L^{-1} and dissolved oxygen was not less than 5.0 mg L^{-1}.

Sample collection and analysis methods

At the end of the six week feeding trial, fish in each tank were individually weighed and sampled for muscle analysis 24 hours after the last feeding. Three fish from each tank were randomly sampled and frozen at -30°C for whole body composition analysis. Crude protein was determined using the Kjeldahl nitrogen method and calculated as N x 6.25. Lipid content was determined gravimetrically following ether extraction. Total ash contents were calculated gravimetrically following ignition of samples in a muffle furnace at 550°C until constant weight. Dry matter was calculated by oven drying at 105°C until constant weight.

The parameters were calculated as follows:

- Weight gain (WG %) = 100 × (final body weight − initial body weight)/initial body weight
- Survival (%) = 100 × (final amount of fish)/(initial amount of fish)
- Specific growth rate (SGR) =100 × ln(final weight/ initial weight)/days of the experiment
- Feed conversion ratio (FCR) = feed consumed (g, DW)/ body weight gain (g)

Results were expressed as mean ± standard of deviation (SD) and group mean difference were compared using one–way ANOVA. When there were differences, the group means were further compared with Duncan's multiple range test. All computations were performed with SPSS 17.0. A significant level of $P < 0.05$ was employed at all cases.

Results

Results of growth and feed conversion ratio of the juvenile cobia fed different trash fish are shown in Table 1. The different diets had significant differences on weight gain; specific growth rate; feed conversion ratio and survival

of juvenile cobia ($P < 0.05$). The weight gain and specific growth rate were highest when using the C diet and had significant difference with other diets. The results showed that cardinalfish was most suitable for cobia farming in Vietnam.

Whole body proximate composition of cobia was presented in Table 2. Different trash fish significantly affected on crude protein, crude lipid and moisture of cobia ($P < 0.05$). There was no difference in ash concentration of cobia among groups. Compared with body composition of cobia at beginning trial, crude protein, lipid and ash concentration of cobia decreased while moisture concentration increased at the end of experiment.

Discussion

A recent study in Viet Nam concluded that there is rapidly increasing demand for trash fish for aquaculture. In 2003, there were over 175,790 tonnes of trash fish that was used in aquaculture[13]. In cobia farming, trash fish was used as main feed for cobia farming. Farmers usually put trash fish direct to the cages. This causes a loss of nutrients out of the water environment leading to increased feed conversion ratio (6 – 8)

Table 1. Weight gain, specific growth rate (SGR), feed conversion ratio (FCR) and survival of the cobia fed experimental diets

Diet	Initial weight (g)	Weight gain (%)	SGR (%/day)	FCR	Survival (%)
C	29.93 ± 0.81	421.67 ± 44.89b	3.93 ± 0.21b	3.17 ± 0.06a	83.33 ± 20.82b
L	30.73 ± 0.64	222.32 ± 24.03a	2.78 ± 0.18a	3.27 ± 0.30a	76.67 ± 5.77ab
A	30.00 ± 2.00	216.69 ± 7.95a	2.74 ± 0.06a	4.87 ± 0.25c	83.33 ± 5.77b
A:C	29.83 ± 1.66	226.81 ± 23.81a	2.82 ± 0.18a	3.36 ± 0.11a	73.33 ± 15.28ab
L:C	29.71 ± 2.15	243.30 ± 29.71a	2.93 ± 0.21a	4.18 ± 0.07b	56.67 ± 11.55a
A:L	28.41 ± 1.23	215.83 ± 27.93a	2.73 ± 0.21a	4.33 ± 0.28b	73.33 ± 5.77ab

Data in the same row with different superscripts differ at P < 0.05.

Table 2 Whole body proximate composition of the cobia fed experimental diets

Diet	Crude protein (%)	Crude lipid (%)	Ash (%)	Moisture (%)
Initial	22.42 ± 0.82	8.44 ± 1.06	4.93 ± 0.42	65.52 ± 0.77
C	16.76 ± 0.57b	4.43 ± 0.37bc	3.80 ± 0.64	73.24 ± 1.00b
L	16.06 ± 0.48b	3.57 ± 0.47abc	4.05 ± 0.54	75.12 ± 0.40 bc
A	16.10 ± 1.14b	3.25 ± 0.77ab	3.92 ± 0.28	74.07 ± 1.79 bc
A:C	16.66 ± 1.09b	3.04 ± 0.33a	4.04 ± 0.23	75.85 ± 0.49c
L:C	16.46 ± 0.64b	4.54 ± 0.05c	4.49 ± 0.30	70.10 ± 1.22a
A:L	11.34 ± 1.17a	4.28 ± 1.22abc	4.44 ± 0.05	75.23 ± 1.37bc

Data in the same row with different superscripts differ at P < 0.05.


Juvenile cobia.

and the risk of environmental pollution[7]. According to Tacon[12], the alginates with low soluble calcium could be used as effective and low-cost binding agents for raw trash fish or moist combination. In the present study, trash fish is bound by alginate before feeding. This reduces the amount of nutrients lost to the environment and improves the feed conversion ratio of juvenile cobia (3.17 – 4.87). Similar results were also noted by some other authors[5,6].

Lipid is an important nutrient in diet as the source of energy and essential fatty acids[15]. The diets has high lipid content can lead to decrease feed consumption and reduce the utilisation of other nutrients resulting to reduced growth[4,14,15]. However majority of culturing cobia is consumed as sashimi1 so it is desirable to increase the lipid content in muscle through feeding high lipid diets. This was reported by some authors[2,14]. In present study, the lipid concentration in cobia at the end of experiment are 3.04 - 5.84 %, it is lower than lipid content of cobia before experiment (8.44 %). According to Huy[7] using trash fish that had low lipid content in cobia farming caused lipid reducing in muscle of cobia, thereby reduced quality and price of products. The growth performance of juvenile cobia in present study was better than cobia that used pellets feed but the results of body proximate composition of cobia indicated that trash fish could be suitable for cobia farming but its lipid content need to be improved before feeding for cobia.

This study shows that using trash fish with alginate as binder could have excellent opportunity to improve the utilisation of the resources and feed costs in places where natural conditions are suitable. It would be interesting to examine the effects of these diets on growth, intestine morphology and body composition of cobia for longer period of time.

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References

Chou, R.L., Su, M.S., Chen, H.Y., 2001. Optimal dietary protein and lipid levels for juvenile cobia (*Rachycentron canadum*). Aquaculture, 193, 81– 89.

Craig, S.R., Schwarz, M.H., McLean, E., 2006. Juvenile cobia (*Rachycentron canadum*) can utilize a wide range of protein and lipid levels without impacts on production characteristics. Aquaculture, 261, 384-391.

D.T.N. Mach, M.D. Nguyen, R. Nortvedt., 2010. Effects on digestibility and growth of juvenile cobia (*Rachycentron canadum*) fed fish or crab silage protein. Aquaculture Nutrition, 16, 305-312.

Ellis, S.C., Reigh, R.C., 1991. Effects of dietary lipid and carbohydrate levels on the growth and body composition of juvenile red drum *Sciaenops ocellstus*. Aquaculture, 97, 383- 394.

Feng, L., Oinghui, A., Kangsen, M., Beiping, T., Hongming, M., Wei, X., Wenbing, Z., Zhiguo, L., 2008. Effects of dietary binders on survival and growth performances of postlarval tongue sole, *Cynoglossus semilaevis* (Gunther). Journal of the world aquaculture society, 39, 500-509.

Gabrielsen, B.O., Austreng, E., 1998. Growth, product quality and immune status of Atlantic salmon, *Salmo salar* L., fed wed feed with alginate. Aquaculture Research, 29, 397-401.

Huy. N.Q., 2002. Status of cobia (*Rachycentron canadum*) reproduction and culturing in Vietnam. Journal of Fisheries (In Vietnamese with English abstract), 7, 14-16.

New, M.B., 1996. Responsible use of aquaculture feeds. Aquaculture Asia, 1: 3-15.

Satoh. K., Nakagawa, H., Kasahara, S., 1987. Effects of Ulva meal supplementation on disease resistance of red seabream, Nippon Suisan Gakkaishi, 53, 1115- 1120.

Storebakken, T., 1985. Binders in fish feeds. I. Effect of alginate andguargumon growth, digestibility, feed intake and passage through the gastrointestinal tract of rainbow trout. Aquaculture, 47, 11–26.

Storebakken, T., Austreng, E., 1986. Binders in Fish Feeds. II. Effect of different alginates on the digestibility of macronutrients in rainbow trout. Aquaculture, 60, 121–131.

Tacon, A.G.J., 1987. The nutrition and feeding of farmed fish and shrimp. A training manual (2. The nutrients sources and composition. FAO Trust Fund GCP/RLA/075/ITA Project report.

Tuan, L.A., 2005. Trash fish resources in Vietnam marine: Composition, production and sustainable usage as feed in aquaculture: National proceedings in Environmental protection and fisheries resources. Ha Noi Agricultural Publishing House, 379-387.

Wang, J.T., Liu, Y.J., Tian, L.X., Mai, K.S., Du, Z.Y., Wang, Y., Yang, H.J., 2005. Effects of dietary lipid level on growth performance, lipid deposition, hepatic lipogenesis in juvenile cobia (*Rachycentron canadum*). Aquaculture, 249, 439-447.

Watanabe, T., 1982. Lipid nutrition in fish. Comp. Biochem. Physiol. 73B, 3–15.

Zhou, Q.C., Mai, K.S., Tan, B.P., Liu, Y.J., 2005. Partial replacement of fish meal by soybean meal in diets for juvenile cobia (*Rachycentron canadum*). Aquaculture Nutrition, 11, 175–182.