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An Evaluation of Traditional Coconut Oil as an Alternative Lipid Ingredient in the Diet on the Growth and Carcass Composition of Spiny Lobster, Panulirus Ornatus

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Abstract: *To looking for the alternative lipid source for replacement of fish oil in the lobster formulated diet, the present study was conducted to evaluate the effects of feeding varying substitution level of fish oil (FO) by traditional coconut oil (TCO) in the formulated diet on the growth, specific growth rate (SGR), feed conversion ratio (FCR), protein retention (PER), lipid retention (LR), survival rate and carcass composition of juvenile spiny lobster. Four experimental diets were formulated based on different composition of FOand TCO, containing 0% FO : 12% TCO (Diet A), 6% FO : 6% TCO (Diet B), 8% FO : 4% TCO (Diet C) and 10% FO : 2% TCO (Diet D). A total of 36 juveniles lobster (initial weight : 2.1 ± 0.5 g) was distributed in twelve net cages (three juvenile lobsters per net cage, size net cage : 70 × 70× 100 cm). The lobster were fed in two times a day (08.00 am and 05.00 pm) for 90 days of feeding trial. Results demonstrated that different substitution FO by using TCO in the diet were not significantly different in the absolutely growth, SGR, FCR, PER, LR and survival rate of juvenile lobster. The values of absolutely growth, SGR and FCR were ranged between 2.63 – 4.02 g, 1.67 – 2.29%, and 2.52 – 2.91,respectively. While, PER, LR and SR values were ranged between 3.56 – 4.38 %, 2.07 – 2.8 %, and 93.3% - 100%%, respectively. Based on data obtained in this feeding trial concluded that traditional coconut oil could be recommended as an alternative lipid source in the diet to enhance the growth and survival rate of juvenile spiny lobster.*

Keywords: *Traditional Coconut Oil, Fish Oil, Alternative Lipid Source, Absolutely Growth, Spiny Lobster.*

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I. Introduction

Fish and crustacean require dietary lipids in their commercial diet to be used as an energy source, essential fatty acids for growth and development of fish (Pie *et al*., 2004). They are alsoan essential component of steroids and phospholipidsused as precursors in the synthesis of certain vitaminsand hormones. The use of dietary lipids can sparedietary proteins from use as energy and limitammonia production through a process called proteinsparing action (Gaylord and Gatlin, 2000). Higherenergy levels generally come from increased dietarylipid as lipid is an energy dense nutrient and readilymetabolized by fish (N.R.C., 1993). However, highdietary lipid content in the diet of fish could result inoxidative stress and invariably pathological conditions(Sakai *et al*., 1998). It could also result in decreasedgrowth as a result of reduction in feed consumption(Daniels and Robinson, 1986), increased lipiddeposition and poor nutritional value of fishmeal (Scaife*et al*., 2000).

The limited availability of fish oil and fish meal, together with the increase in aquaculture activities calls for the identification of alternative lipid and protein sources for the development of sustainable fish farming practices (Santigosa*et al*., 2011). Plant oils rich in C18 polyunsaturated fatty acids (PUFA) are potential candidates for this replacement (Al-Owafeir*et al*., 1996; Huang *et al*., 2008; Hafezieh*et al*., 2010). The past decade has seen an increase in the use of terrestrial plant oils, such as canola, soybean, flax, and palm oils, to replace fish oil inaquafeeds (Naylora*et al*., 2009). On the other hand, world production of oils from plant seeds has increased in recent years resulting in higher availability and lower or unchanged costs (Chhetri*et al*, 2008). These together with having renewable and reliable sources are major advantages of the oils over fish oil as ingredients in aquafeeds (Miller *et al*., 2008).However, plant oils cannot meet the fatty acid requirement of all fish species (Kamarudin*et al*., 2011).

One of the alternative lipid sources is traditional coconut oil. Coconut is plantedin almost places in the world especially in the tropical area as like Indonesia formany culinary food.Virtually everypartofthecoconutpalm has some human use. Before now, coconut oilhad received bad publicity because of its high level ofsaturated fat, but recent researches have corrected this misconception (Conrado, 2003). It has been found that the lauric acid present in coconut oil has antiviral,antiprotozoal, antibacterial properties and at the same time, increases body metabolism. Other advantages of coconut oil include being the most stable oil and its resistance to oxidative rancidity. Unlike most oils, coconut oil will not be damaged by warmer temperatures (Alice *et al.*, 2006). Coconut oil is very cheap and abundant in Indonesia compared to other oils. For now, it is not directly consumed by man so there is less competition on its usage.

Spiny lobster, *Panulirusornatus* (Fabricius 1798), isone of the most important crustacean in Indonesia. Their wide acceptance as an excellent food and high market value haveled to over-harvesting of wild stocks in many areas in Indonesia. To protect and sustainability of this species, Indonesian government revealed a policy by regulation of Ministry of Fisheries and Marine Affairs No. 1/ 2015 stated that prohibit to catch three kinds of crustacean : marine lobster, swimming crabs, and mud crabs based on two conditions : maturation and under small carapace sizes. The regulation was mentioned to sustainable fisheries production especially in three kinds of crustacean in Indonesia.

The Indonesia fisherman reared the lobster in sea net cage and generally they fed the lobsters with fresh fishery by-catch, but its continued use is unsustainable due to competitive pressure caused by declining inshore fishery catches, poor feed conversion, and negative environmental impacts. The development of high-performing, pelleted lobster feeds is a high priority for long-term industry sustainability.

Considering the lower cost price and high availability of vegetable oils in the tropics, their potential as alternative dietary lipids source for fish needs to be investigated. The aim of this study was to investigate the effect of replacement of fish oil with traditional coconut oil in the diet on the growth, feed conversion ratio, protein retention, lipid retention of spiny lobster (*P. ornatus*) that reared in the sea net cage.

II. Material and Methods

Experimental lobster and diets

A total of 36 juvenile lobster, with a mean initial body weight of about 2.0 g, were obtained from wild captured in Moramo bay, Southeast Sulawesi, Indonesia and distributed randomly in 12 sea cages (3 juvenile/cage) in Tapulaga Bay. During acclimatization period, the lobster juvenile were fed combination between trash fish and lobster pellet during aninitial 2-week. After this, randomly assigned triplicate cages of were fed to satiety two timesdaily (08.00 am and 06.00 pm)with one of four experimental diets for four months of rearing. Thediets were formulated to meet all the knownapproximately nutritional requirements of lobster . Extruded diets (3 mm diameter), containingapproximately 362 g. kg^{-1} crude protein and approximately165 g. kg-1crude lipid, were prepared in Fish Nutrition Laboratory, Faculty of Fisheries and Marine Science, Halu Oleo University with varying contents of TCO added atthe expense of marine FO (Table 1). TCO was thoroughlymixed with the FO before the oil mixtures were used to coatthe experimental diets. The four experimental diets included TCO at 120, 60,40 and 20 g.$kg^{-1}$of the diet, replacing 100% (P100), 50%(P50), 33% (P33) and 17% (P17) of the added FO,respectively. The experiment was conducted insea cages, Tapulaga bay, Konawe, Southeast Sulawesi, Indonesia.

Table 1. Diet formulation and results of proximate analysis of experimental diet

Ingredients	Diet (g/100 g)			
	A	B	C	D
Shrimp head meal	27	27	27	27
Telescopium meal	29	29	29	29
Soybean meal	15	15	15	15
Corn meal	3	3	3	3
Sago meal	3.5	3.5	3.5	3.5
Wheat gluten meal	3	3	3	3
Braine meal	2	2	2	2
Fish oil	0	6	8	10
Traditional coconut oil	12	6	4	2
Squid oil	0.5	0.5	0.5	0.5
Top Mix	5	5	5	5
Proximate Analysis (%)				
Moisture	10.7	8.43	8.73	9.24
Crude protein	36.2	36.0	36.3	36.2
Crude lipid	14.6	17.2	15.7	16.5
Ash	10,9	11.1	12.1	12.0
Fiber	11,1	11.5	11.6	11.2

Experimental diets were prepared by mixing the dry ingredients started from small amount till big amount of feed ingredients. Fish oil, squid oil and or traditional coconut oil were added in the diet at the end of mixing process for 30 min. Hot water was then blended to the mixture to attain a consistency appropriate for pelleting. The moist mash from each diet was passed through a 3-mm die in a meat grinder, and the pellets were dried in a drying oven (50°C) a moisture content of less than 10%. The protein content of each diet was confirmed using Kjeldahl analysis. Lipid contents of basal diets were confirmed using the Folch method, moisture were confirmed by using oven at 105°C. Crude ash of diets were determined by burning the diet in furnace 600°C for eight hours (AOAC, 1995). Diets were stored in plastic bags and placed in room temperature, and before use each diet was ground and sieved to an appropriate size.During the experiment, the net cage were cleaned from wild sea weed and gastropod stacked in the net to released water current and dissolved oxygen. Sampling lobster to determine the growth rate and feed consumption were conducted in every two weeks for 90 days of feeding trial. During the experiment, water quality of culture area was always monitored. All parameters of water quality such as water temperature, pH value andwater salinity were optimum and support for growth of lobster. The ranges of water temperature, pH value and water salinity were 29-31^{o}C, 7-8 and 33 – 35 ppt, respectively. Lobster were fed with 20% of biomass weight in twice a day (17.00 and 22.00) for 120 days of rearing.

Statistical analysis

The effects of dietary TCO on weight gain, specific growth rate, lipid retention, feed convention ratio and survival rate were analyzed by one way ANOVA. If there is any significantly different between individual treatments, it will be continued by using Tukey’s test. Differences were regarded as significant when P < 0.05.

Calculation

The following formulae were applied to the data: Specific growth rate (SGR) was calculated as % daily growth increase:

$$\text{WG} = Wt - Wo$$

$$\text{SGR} = \frac{Ln\ Wt - Ln\ Wo}{t}\ x\ 100$$

Where Wo and Wtare the initial and final body weights,respectively.Feed conversion ratio (FCR) was calculated as the amount of dry diet consumed and the total biomass gain :

$$\text{FCR} = \frac{\text{Feed Intake ,g}}{\text{wet weight gaing}}$$

III. Results

At the end of feeding trial, survival rate of lobster was 100 % in all treatments. There was no significantly different on weight gain between the lobster fed with all dietary treatments (P > 0.05). Weight gainof*P. ornatus* fed with the test diets were ranged between 2.51 – 4.25 g.

Table 2. Growth performance, Protein and Lipid Retention and Survival rate of Juvenile Lobster

Parameters	Treatment diet			
	A	B	C	D
Initial weight (g)	1.64± 0.64	1.21 ± 0.03	1.62 ± 0.45	1.56 ± 0.65
Final weight (g)	5.66 ± 1.03	3.72 ± 0.84	4.67 ± 0.49	4.19 ± 0.62
Weight gain (g)	4.02 ± 0.2	2.51±0.59	3.06±0.81	2.61±0.81
SGR (%)	2.29 ± 0.78	1.98 ± 0.51	1.72 ± 0.54	1.67 ± 0.81
FCR	4.36 ± 0.51	4.90 ± 0.34	5.10 ± 1.06	5.18 ± 0.67
PR	3.58 ± 0.21	4.08±0.53	4.38 ± 0.33	3.56 ± 0.41
LR	2.07 ± 0.73	2.56 ± 0.05	2.80 ± 043	2.56 ± 0.11
SR	100	100	100	100

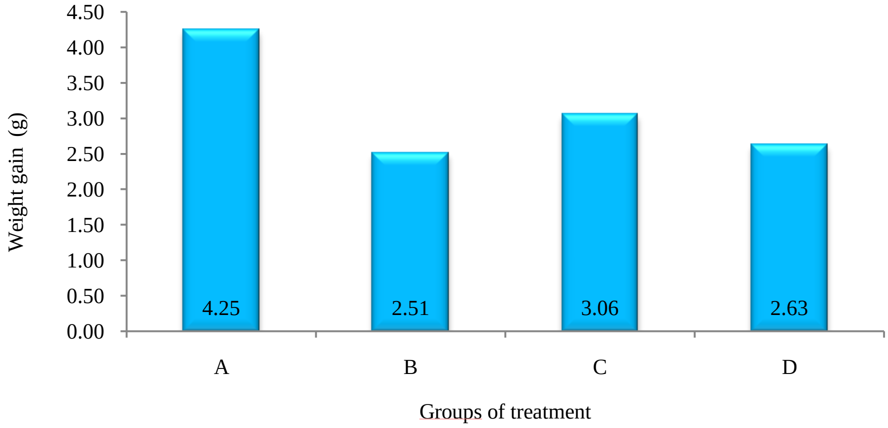

Fig. 1 Average of weight gain of spiny lobster fed with all dietary treatment

SGR of the lobster fed with different ingredients composition of substitution of FO with TCO in the diet were similar (not significantly different). In the 112 days of rearing, SGR of lobster fed with experimental diets were ranged between 1.05 – 1.35 %.

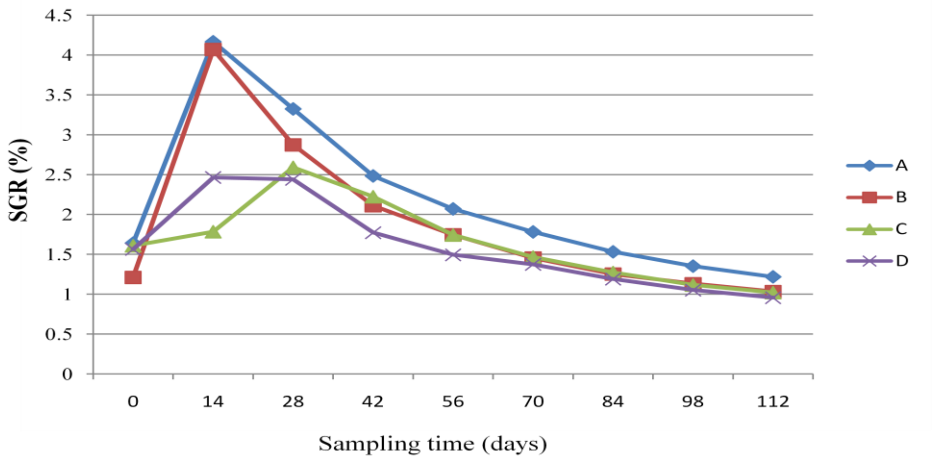

Fig.2 Average of SGR of spiny lobster during a feeding trial.

FCR of the lobster fed with test diets were not significantly different. FCR of the lobster fed with all test diets ranged between 2.36 – 2.91. Statistically, FCR of lobster fed with all different feed test were not significantly different ($P > 0.05$).

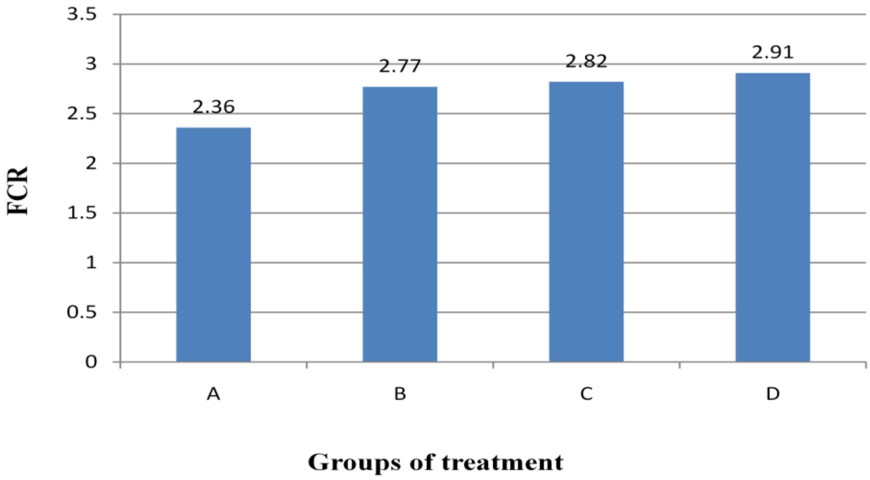

Fig. 3 Average of FCR of the lobster fed with different feed test

Survival rate of the lobster till the end of feeding trial was ranged between 83.3% - 100%.

IV. Discussion

In Indonesia the lobster experiment is rarely conducted and this research is the first reported that successfullyreared spiny lobster larvae using artificial feeds and cultured in floating net sea cage. Survival rate of all treatment were not significantly different till the end of experiment. They were ranged between 83.3% - 100%.

Based on the results of the experiment has shown that traditional coconut oils have considerable potential as replacements of fish oil in diets for growing of *P. ornatus*. It is noteworthy that the traditional coconut oil as lipid alternative source inthis study have no significant deleterious effects on thegrowth performance relative to that obtained from lobster fed fish oil in the diet. Thegrowth of *P.ornatus* fingerlings over 112 days of rearing in the sea net cage wasnot compromised by feeding diets in which different lipid sources in the diet (TCO and FO). This results suggested that *P. ornatus*can effectively utilize these composition of TCO as a lipid source. However,there were no significantlydeference in feed intake betweenthe test treatments of the study. Despite this, thecombined influences of both feed intake and growth,when revealed as FCR, did not show significantly differencesbetween treatments. Notable was the deterioratingFCR value with the inclusion of traditional coconut oil. Ourresults are similar to the observations on *Homaruslongipes* (Babalola&Apata ,2012),*Coho salmon*,(Dosanjh et al., 1984); rainbow trout, (Greene &Selivonchick,1990); brown trout, (Arzel et al., 1994) and Atlanticsalmon, (Hardy et al., 1987; Thomassen&Røsjø,1989; Polvi&Ackman, 1992; Koshio et al., 1994).

Generally, the dietary lipid usually affected the fillet and liver fatty acid of spiny lobster. Supplementing diets with vegetableoils resulted in lowered SFA in all of the *P. pelagicus*body parts analyzed.Results of formerly research as showed same with studies with pikeperch (Schulz *et al.*, 2005; Kowalska*et al.*, 2010) and rainbow trout (*Oncorhynchusmykiss*) (Caballero *et al.*, 2002). The presence of dietary phospholipids is reported to greatly affect lipid digestibility, absorption and transport (Caballero *et al.*, 2003; Morais*et al.*, 2005). According to Olsen *et al.* (1999, 2000) a diet containing phospholipids have higher apparent lipid digestibility than diets containing high amount of triacylglycerols. This supports observation in this study that fish on PO, had higher apparent lipid digestibility than those from the other group, because of their higher concentrations of palmitic acid which is a component of phospholipids.

Vegetable oils contains higher concentrations of saturated and monounsaturated fatty acids, these provides suitable dietary fatty acids that induces β-oxidation which supply enhanced energy through lipid oxidation, this resulted in improved growth of fish by sparing protein for fish growth (Lim *et al.*, 2001). In vitro studies done on mitochondrial β-oxidation in fish suggest that there exist a substrate preference for saturated and monounsaturated fatty acids over polyunsaturated fatty acids (Henderson, 1996). The principal site of fatty acid metabolism is the liver.

The results of the economic performance in this study show that TCO diet is the least expensive diet and theone that had the best economic conversion ratio. The use of FO on the other hand increased the feeding cost.The reduced cost of TCO based diet could be attributed to the readily availability of the oil (Bimbo, 1990), coupledwith the stability of the price in many tropical countries where aquaculture is being practiced. In conclusion, the results of this study suggest that cheap and readily available traditional coconut oil can be used to replace expensive and scarce fish oli, with no negative effect on the growth, FCR and nutrient digestibility of P. ornatus. It is therefore recommended that TCO could be supplemented into the diet of *P.ornatus*for improved nutrient utilization and growth performance. Moreover, further study aimed at increasing the concentration of the essential fatty acids (especially the long chain polyunsaturated fatty acid) in the fillet is needed.

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