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Research Article

Physical Properties, Crude Nutrient Content, and Nutritive Values of Fish Meals Produced from Overflowed Fishes for Laying Quails

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Abstract | The present research aimed to define the potential availability of overflowed fish catch by traditional fishermen and to compare meal yield rate, physical property, crude nutrient content, and nutritive value of fish meal produced from overflowed fishes by direct or steam cooking before drying. Samples of three overflowed fishes, i.e., sardine, ponyfish, and mackerel tuna, were processed into meal products by direct sun drying or steam cooking before drying. Fish meals analyzed for physical properties (bulk density, compacted bulk density, angle of response), moisture, and crude nutrient content (crude protein, crude ash, crude fat, crude fiber), and minerals (Ca, P). Their nutritive values were evaluated by mixing 5% of fishmeal with basal diet and fed to 180 laying quails for 6 weeks. Parameters measured included feed intake, egg production, FCR, and eggshell quality. There were three species of overflowed fishes that were potentially available for producing a fish meal, i.e., sardine, pony fish, and mackerel tuna. Meal yield rate varied from 19.1 to 29.6%. The mackerel tuna had the highest meal rate of 24.5-29.6%. The results suggested that fish meals provided by the steam cooking before drying had lower meal yield rate but better product qualities in terms of physical properties, moisture, and crude nutrient content, and nutritive values.

Keywords | Overflowed fish, Processing method, Fish meal, Physical properties, Laying quails

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INTRODUCTION

Japanese quail (*Coturnix coturnix japonica*) in West Sumatra is commonly raised for egg production. Quail eggs occupy a special market segment because of their low price and unique taste. Quails are commonly raised in small-scale or back yard farming. The diets of these birds are usually prepared by self-mixed feed using mainly locally available plant materials (corn, rice bran). Fish meal is an essential protein ingredient in the quail diet because quails require high-quality protein with an adequate balance in amino acids (Dahouda et al., 2013). Fish meal is a high palatable ingredient, rich in polyunsaturated fatty acids (PUFA), and had an excellent balance of essential amino acids (Hardy, 2010; de Koning, 2005). The use of fish meal in the poultry diet improved feed intake and amino acid balance which enhance feed utilization efficiency, growth rate, and egg production (Yisa et al., 2013; Asghedom et al., 2016). Fishmeal is also a good source of certain vitamins such as riboflavin, niacin, vitamins A and D, and minerals such as calcium, phosphorus, iron, zinc, selenium, and iodine (Olsen and Hasan, 2012).

A shortage of high-quality protein supplements is a major constraint to formula a good quality diet for laying quails. The market price of fish meal has continued to rise due to limited availability, increased demand, and development of local commercial poultry. The use of imported fish meal will remain high feed cost, while local fish meal available in the local market is not always of satisfactory quality. The quality of fish meal varies widely, depending on raw materials and processing methods (Khan et al., 2012; Tantikitti et al., 2016; Rahim et al., 2017). Some local fish meal is low protein content (37-39) (Erlania, 2012), presumably due to adulteration with cheap diluents as happened in Bangladesh (Hossain et al., 2003), consequently, formulation of quail diets can be a difficult task.

The region of West Sumatra province is directly adjacent to the Samudra Indonesian ocean. The length of the coastal line is approximately 375 km, and most of the people living in the coastal areas are traditional small-scale fishermen. They use small boats and simple mechanized fishing vessels and gears (hooks and lines, gillnet, bag nets, trap, and seines). The one-day fishing activity mainly concentrated in inshore areas. Fish catches are generally sold fresh in the fish landing center or marketed in the local market for human consumption. The total catch and price fish fluctuated, depending on the climate and fishing season. Fishing activity and fish caught are generally low in some months of the South-West monsoon period, and the price of fish usually is high. On the other hand, during a good fishing season, fish caught is often in quantities exceeding the local market capacity. There are no processing or cooling facilities available. The overflowed marketable size fishes are sold at a meager price or even not sold out. There are also several types of fish caught that are usually sold at low prices and less preferred by consumers due to several reasons, i.e., small meat portion, too bony, or with many scales, high oil content. These low-price fishes are difficult to sell during the good fishing season. Fishermen usually dry the unsold overflowed fishes under the sun in intact form by arranging the fishes on woven bamboo or fine wire mesh nylon net and sold in the half-dried state at a meager price of around IDR 3.000-6.000 per kg.

Thus, the overflowed fish should be processed to produce fish meal and can offer quail keepers a high-quality protein supplement at a reasonably affordable price. The half-dried state fish could be directly ground to produce a fish powder. The fishmeal produced in this manner had an average crude protein content of 56.6 % on a dry matter basis (Asghedom et al., 2006). The overflowed fish might also be processed by adopting an industrial process in which raw materials chopped and steam cooked before drying. Heating condenses the protein, breaks the fat depots, and releases oil and water (Rahman et al., 2016). The meal produced by steam cooking before the drying process usually consists of about 60-70% protein, 10-12% residual lipid, and 8-10% moisture, with the rest consisting of bones and salt (ash) (de Koning, 2005).

The present research aimed to define the potential availability of overflowed fish catch by traditional fishermen in different fishing seasons. The second objective of this study was to compare meal yield rate, physical properties, nutrient content, and nutritive value of fish meals produced from three species overflowed fishes by direct to and steam cooked before drying and grinding.

MATERIALS AND METHODS

Survey on overflowed fishes

The study was initiated by field surveys on 15 traditional fishermen who conducted fishing activity along the coast of Padang Pariaman district to define the potential availability of overflowed or low-market value fishes used as a raw material of fish meal. The selected fishermen visited in three fish landing centers. i.e., Pantai Ulakan, Pantai Tiram, and Pantai Kataping the district of Padang Pariaman, lies between 0° 11' to 0° 49' south latitudes and 98° 36' and 100° 28' east longitudes. They interviewed to collect data and information on fishing vessels and gears used, fishing trips, fish catch, and fishing season. They were also observed on the floor of the landing port by handling and sorting the catch into high, middle, and low market value species. The marketable-size fish were classified based on market price and season. The naming of the identified species based on references of Larson et al. (2013) and Kottelat (2013).

Fish meal processing and analyzing

Samples of three species of fresh overflowed or low-price fishes taken of about 60 kg each immediately after landing and transport to the laboratory in an ice-cool polystyrene box. There were gold strip sardine (*Sardinella gibbosa*), ponyfish (*Leiognathus splendens)*, and mackerel tuna (*Euthynnus affinis*). The fish samples were measured their body length and weight. The mean body length and weight were as follows: sardine 19.3 cm, 25.0 g; pony fish 7.7 cm, 9.4 g; and mackerel tuna: 33.6 cm, 558.5 g per head. The body length measurements carried out following the method as described by Grant and Spain (1997).

The fish samples then divided into two groups (@ 30 kg) and then subdivided into three subgroups (@ 10 kg) so that there were in total 12 experimental units (3 fish species x 2 processing methods and three replications). The first group processed by direct sun drying. The fishes were halved and arranged in an intact form on fine wire mesh nylon net and drying under the sun for several days as usually done by fishermen. The fishes regularly turned to achieve even and perfect drying. The dried, intact fishes then ground to produce direct sun-dried fish meal. The products stored in labeled air-tight plastic bags. The second fish group delivered in six processing steps: chopping, steam cooking, pressing, evaporating, drying, and grinding according to the method of steam cooking for the local level described by Abowei and Tawari (2011). The process began by chopping and crushing the fishes into porridge form. The porridge fish were placed and wrapped in a sisal cloth, steamed continuously in a cooker for 60 minutes, and then directly squashed and compressed using two thick wooden boards to remove the water and oil. The dehydrated cooked fish were dried in the sun and ground to produce steam cooked fish meal products. Fish meals the analyzed for physical properties (bulk density, angle of response), proximate composition (moisture, crude protein [CP], crude ash, crude fat [CF]), and minerals (Ca, P). Three replications performed, and the average values compared and analyzed. Proximate composition analyzed according to the standard methods of AOAC (2000).

Physical properties measured included angle of response, bulk density, and compacted bulk density. The angle of responses measured by using a cylinder placed on a flat surface of beaker glass according to the modified method described by Ogunsina et al. (2009). The cylinder filled from the top with shell meals. The cylinder lifted gradually, allowing the material to flow and a conical pile. The height (h) and diameter (d) (at base) of the triangle pile formed measured. The angle of response (α) expressed as degree (°) was calculated by the following formula: $\alpha = tg^{-1}(2h/d)$. Bulk density and compacted bulk density were determined measured by a 100-mm graduated cylinder according to the method described by Ruttloff (1981). The angle of response indicates the degree of freedom of particles to move in the stack and flowability of feed. Bulk density is the ratio of the weight of the sample (w) with the volume of space filled by the sample (v1), while compacted bulk density is the ratio of the weight of the sample (w) with the volume of space filled by the sample after compacted (v2). Bulk and compacted bulk density (g/ml) calculated by using the following formula: w/v1 and w/v2 in kg/m^3, respectively.

Feeding trial

The nutritive value was evaluated by mixing 5% of the fishmeal with basal diet and fed to 180 laying quails for six weeks. There were six dietary treatments: basal diet + 5% direct sun-dried sardine meal (P1), direct sun-dried ponyfish meal (P2), direct sun-dried mackerel tuna meal (P3), steam cooked sardine meal (P4, steam cooked ponyfish meal (P5) and steam cooked mackerel tuna meal (P6), respectively. Basal diets composed of corn (44%), commercial concentrate (30%), rice bran (12.5%), bone meal (2%), oyster shell meal (2.5%), premix (1%), and kitchen salt (0.5%). The experimental diets were formulated based on the recommendations of the NRC (1994). Proximate composition and metabolism energy of experimental diets were: CP: 17.9%, CF :4.1%; CF: 6.2%; Ca: 3.5%, P: 0.8%; ME: 2763 kcal/kg. The quails divided into 18 experimental units (@ ten birds); each treatment consisted of 3 replications. Parameters measured included feed intake, egg production, feed conversion ratio (FCR), eggshell quality, and income over feed cost. Data were analyzed using the two-way analysis of variance (ANOVA) using the SPSS 12.0 software with Duncan's method for difference comparison. The effects were considered to be significant when $P < 0.05$. The results were expressed as mean and variance of the data was presented as the standard error of the means (SEM). Statistical analyses were performed in SPSS for Windows Release.

RESULTS

Availability of Overflowed Fishes

The survey found that there were, on average, 21 to 22 fishing-trip days per month. The total catch of one fishing trip varied from around 31 to 50 kg/fishermen. There are in total of 18 species of marketable-size fish caught by the fishermen, which divided into three groups based on the sale price. The first was the high market value types with a selling price between IDR 20.000 to 45.000 per kg. There were: snappers (*Lutjanus spp.*), pomfret (*Colossoma macropomum*), groper (*Epinephelus tauvina*), shrimp (*Penaeus indicus*), mackerel (*Scomberomorus commerson*), skipjack tuna (*Katsuwonus pelamis*), and Indian mackerel (*Rastrelliger kanagurta*). Second, the moderate economic value of fish with selling prices ranging from IDR10.000-18.000 per kg. This fish made up of seven types, namely: redtail scad (*Decapterus kurroides*), mackerel scad (*Decapterus macarellus*), shorth-bodies mackerel (*Rastrelliger brachysoma*), anchovy (*Stolephorus commersonii*), moonfish (*Mene maculate)*, beltfish (*Trichiurus lepturus*), and threadfin bream (*Nemipterus tambuloides*).

The third was the overflowed and low market value of fish species with a selling price of IDR 3.000-12.000 per kg. They were mackerel tuna (*Euthynnus affinis*), gold strip sardine (*Sardinella gibbosa*), yellowstripe scad (*Selaroides leptolepis*), and ponyfish (*Leiognathus splendens*). The low market value fishes accounted for about 1.2-3.4 kg/fishermen or 3.8-6.9% from the total catch. Ponyfish (*Leiognathus* sp.), which are commonly called "maco" by the people of Padang Pariaman was found the cheapest fish and available throughout most of the year. Good fishing season for mackerel tuna and sardine lasted from September to February, while yellowstripe scad or local name of "ikan selar" was available only from September to November.

Yield rate and physical properties of fish meal

In Table 1 are presented the data of mean yield rates and the physical properties of fish meal. The yield rate of fish meal produced by direct sun drying was high significantly higher ($P<0.01$) than that provided by steam cooking. The yield of mackerel meal tuna (24.5-29.6%) showed the highest meal yield ($P<0.01$). The steam cooked fish meal had significantly ($P<0.01$) higher bulk density and compacted bulk density than fish meal produced by direct sun drying. There was no significant effect of processing and type of fish on the angle of response, but numerically steam cooked fish meal had a lower angle of response in all meal products than that direct-sun dried meal (Table 1).

Table 1: Percent of meal yield and physical properties of fish meal produced from overflowed fishes.

Parameter	Direct sun-dried fish meal				Steam cooked fish meal			
	Sardine	Ponyfish	Mackerel tuna	Mean	Sardine	Ponyfish	Mackerel tuna	Mean
Meal yield rate (%)	22.90 (0.46)	22.20 (2.94)	29.61 (0.68)	24.90^{A} (4.09)	20.67 (1.18)	19.10 (1.05)	24.53 (0.76)	21.43^{B} (2.80)
Physical properties								
- Bulk density (kg/m^3)	454.00^{b} (3.61)	367.33^{c} (22.90)	368.67^{c} (29.74)	396.67^{B} (49.66)	723.67^{a} (9.61)	689.00^{a} (13.00)	735.00^{a} (30.20)	715.89^{A} (23.97)
Compacted bulk density (kg/m3)	608.08^{b} (8.87)	537.24^{b} (16.31)	526.23^{b} (31.09)	557.18^{B} (44.42)	868.38^{a} (6.32)	847.53^{a} (31.63)	813.81^{a} (38.15)	843.24^{A} (27.54)
- The angle of response (°)	49.26 (0.49)	51.66 (0.44)	50,35 (0.80)	50.42 (1.20)	46.26 (1.43)	47.40 (5.87)	48.40 (0.51)	47.36 (1.07)

*(*SEM*): standard error of means. $^{a, b, c}$ values in the same row with different superscripts are significantly different.

Table 2: Mean crude nutrient, Ca, and P content of fish meal produced from overflowed fishes (% DM).

Parameter	Direct sun-dried fish meal				Steam-cooked fish meal			
	Sardine	Ponyfish	Mackerel tuna	Mean	Sardine	Ponyfish	Mackerel tuna	Mean
Crude protein	70.53 (0.57)	70.10 (2.04)	70.54 (2.02)	70.39 (0.25)	75.07 (1.76)	70.17 (2.15)	72.93 (3.97)	72.72 (2.46)
Crude fat	5.34^{b} (0.41)	4.95^{b} (0.16)	7.10^{a} (0.24)	5.80^{A} (1.15)	1.04^{d} (0.43)	2.64^{c} (0.84)	3.49^{c} (0.56)	2.39^{B} (1.24)
Crude fiber	1,63 (0.77)	2.21 (0.31)	2.76 (0.91)	2.20 (0.57)	0.62 (0.83)	1.19 (1.14)	1.14 (0.54)	0.99 (0.31)
Crude ash	17.31^{b} (0.24)	22.76^{a} (0.36)	11.93^{c} (0.30)	17.33 (5.42)	17.94^{b} (0.37)	24.12^{a} (1.47)	12.26^{c} (1.02)	18.11 (5.93)
Ca	1.48^{b} (1.08)	4.24^{a} (0.85)	3.90^{a} (0.33)	3.21^{A} (1.50)	3.42^{a} (1.36)	6.42^{a} (0.65)	4.28^{a} (0.64)	4.71^{A} (1.54)
P	3.27 (0.05)	4.19 (0.07)	3.01 (1.09)	3.10 (1.19)	3.72 (0.17)	4.38 (0.18)	2.46 (0.26)	3.52 (0.97)
Moisture (% FW*	10.07^{a} (0.25)	7.80^{a} (0.33)	6.46^{b} (2.03)	8.11^{A} (1.82)	5.68^{b} (0.45)	3.62^{c} (0.56)	3.73^{c} (0.34)	4.35^{B} (1.16)

*: Fresh weight; $^{a, b, c}$ values in the same row with different superscripts are significantly different.

Crude nutrient and mineral content

Mean values of percentage of crude protein, crude fat, ash, minerals (Ca and P), and moisture content shown in Table 2. Crude protein content was not significantly (P> 0.05) affected by the processing methods and the types of fish. The crude fat content of the steam-cooked fish meal was highly significant (P <0.01) lower than that of direct sun-dried fishmeal. Mackerel tuna fish meal showed the highest fat content in both processing products, followed by sardine and ponyfish, respectively. There was a significant effect of processing and type of fish on crude ash and Ca content of meal products. There was also an inverse relationship between crude protein and a total ash content of samples. The fish meal produced from ponyfish showed the highest crude ash and Ca content (P<0.05), followed by sardine and mackerel tuna. Moisture content ranged between 3.7 to 10.0% and was significantly (P<0.01) affected by both processing and fish species. Fish meals produced by steam cooking had significantly lower moisture content than that of direct drying. The steam-cooked pony and mackerel tuna fish meals had the lowest moisture content (Table 2).

Quail laying performances

The results of the feeding trial shown in Table 3. There was no significant effect of different fish species and processing methods on feed intake, egg production, eggshell quality, and income over feed cost. However, there is a tendency that quails fed on a diet containing the steam cooked fish meals (P3, P4, P5) showed a higher percentage of eggshell weight and better egg production in terms of egg number and egg mass. The better egg production resulted in slightly better FCR than those fed on diets containing the direct sun-dried fish meals (P1, P2, P3) (Table 3).

DISCUSSION

The potency of overflowed fishes for fishmeal production

Fish meal manufactured from any type of wild-caught marine fish. The most common type of fish used were pelagic fishes that are low commercial important for direct human consumption (FAO, 2012; de Koning, 2005; Jeyasanta and Patterson, 2020). In the present study, of the total 18 types of fish caught by the small-scale traditional fishermen in the study sites, there were four low market value species, i.e., sardine (*Sardinella gibbosa*), ponyfish (*Leiognathus* sp.), mackerel tuna (*Euthynnus affinis*), and yellowstripe scad (*Selaroides leptolepis)*. Sardine and ponyfish usually deemed not suitable for human consumption because these fish contain a high percentage of oil and bone, respectively. Gold strip sardine with a local name of 'ikan tembang', is one of the small pelagic fish found in tropical waters with a depth of about 10-70 m (Suseno et al., 2014). They feed mainly on a variety of plankton (Pillai et al., 2003). Their abundance was available from October to February. This type of fish is known as high-oil content, which is widely used as raw material to produce sardine oil in several industries and used as fertilizer and fishmeal for aquaculture and poultry feed production (Jayaprakash, 2000; Pillai et al., 2003).

Table 3: Mean feed intake, egg production, and eggshell qualities of layer quail fed diets supplemented with fish meal produced from overflowed fishes.

Parameter	Direct sun-dried fish meal				Steam cooked fish meal			
	Sardine	Ponyfish	Mackerel tuna	Mean	Sardine	Ponyfish	Mackerel tuna	Mean
Feed intake								
g/bird	734.35 (*29.16*)	755.82 (*26.43*)	699.33 (*47.97*)	729.83 (28.51)	740.56 (*23.23*)	735.43 (*4.56*)	708.40 (*55.46*)	728.13 (17.28)
g/d/bird	26.23 (1.04)	27.10 (0.80)	24.98 (1.71)	26.10 (1.07)	26.45 (0.83)	26.27 (0.16)	25.30 (1.98)	26.00 (0.62)
Egg production								
Egg production (egg/bird)	27.00 (*0.30*)	25.13 (*1.36*)	26.27 (0.50)	26.13 (0.94)	27.23 (0.15)	26.77 (*0.76*)	27.07 (*0.15*)	27.02 (0.24)
Egg production (g/bird)	290.71 (*11.46*)	277.72 (*9.28*)	276.73 (7.57)	281.72 (7.80)	294.10 (7.99)	283.55 (*10.35*)	290.07 (6.25)	289.24 (5.33)
FCR	2.53 (*0.08*)	2.72 (*0.15*)	2.53 (*0.15*)	2.59 (0.11)	2.52 (*0.06*)	2.60 (0.08)	2.45 (*0.24*)	2.52 (0.08)
Eggshell quality:								
Egg weight (g/egg)	10.77 (*0.35*)	11.06 (*0.22*)	10.53 (*0.10*)	10.79 (0.26)	10.80 (*0.31*)	10.59 (*0.24*)	10.72 (*0.20*)	10.70 (0.06)
Shell egg weight (g/egg)	0.86 (*0.03*)	0.86 (*0.50*)	0.86 (*0.00*)	0.86 (0.00)	0.84 (*0.03*)	0.84 (*0.02*)	0.85 (*0.04*)	0.84 (0.01)
Percentage of shell weight (%)	7.26 (*0.41*)	7.88 (*0.37*)	8.58 (*0.81*)	7.91 (0.66)	8.38 (*0.47*)	9.46 (*0.58*)	7.63 (*1.36*)	8.49 (0.92)
Egg shell thickness (mm)	0.19 (*0.01*)	0.20 (*0.00*)	0.19 (*0.00*)	0.19 (0.00)	0.19 (*0.00*)	0.20 (*0.00*)	0.19 (*0.01*)	0.19 (0.00)
IOFC (IDR/bird) *	3,310.2	2,844.2	2,941.6	3,032.0	2,844,2	2,844.2	2,941.6	2,966.6

* income over feed cost.

Ponyfish is a type of demersal fish, passive in its movements, lives in shallow coastal waters, forming a large herd, sometimes enter the river mouth with a body length is generally 6-12 cm (LIPI, 2010). According to Wiadnya et al. (2014) ponyfish has deep rounded body shape, highly protrusible mouth, silver color, a ventral profile of the body more convex than the dorsal profile; abdomen before anal more strongly curved. Utama and Trihayuni (2015) reported that ponyfish are bony fish, which is a cheap source of animal protein and affordable for low-income people. Mackerel tuna with local name "ikan ambu ambu" belong to the family Scombridae. It is generally of silver color with bluish-green in the top part of the body and slightly silvery below. The length of the head is almost equal to or less than their body depth (Goutham and Mohanraju, 2015). The pelagic and shoaling fish feed on phytoplankton and widely distributed in shallow water in Southeast Asia (Indaryanto et al., 2015). Mackerels found to be available throughout the year with the peak season from September to February in the study sites.

The yellow stripe scad (*Selaroides leptolepis)* is a marine pelagic species and commonly occurring in the coastal waters of Vietnam, Cambodia, Malaysia, and Indonesia (Kempter et al., 2015). Their abundance was lasted for three months each year, from September to November. They feed mainly on mussels and snails, which classifies the species as predatory. Yellow stripe scad suggested not to use as raw material for a fish meal due to several reasons. The populations of this species decline in nature due to environmental quality degradation and overfishing (Andriani et al., 2015; van Oostenbrugge et al., 2001). Agusa et al. (2007) reported that yellow stripe scad had high concentrations of heavy metals, such as V, Cr, Zn, Pb, Sn, and Bi.

Meal yield rate and physical properties

The meal yield rate, nutrient content, and nutritive value of fish meal vary depending on raw materials and processing methods (de Koning, 2005; Khan et al., 2012). In this study, the mean yield rates ranged from 19.1 to 29.6%, which is slightly higher than the average conversion factor of fish to fish meal of 20-23% reported by Abowei and Tawari (2011) and de Koning (2005). The present study found that the yield rate of fish meal produced by steam cooking before drying (21.3%) was lower than that of direct drying (24.9%). The steam cooked fish meal, which processed in several stages, such as chopping, cooking, and pressing causes some processing losses resulted in a reduction of product weight. The result supported by Chandrasekar et al. (2017) who reported that the conversion percentage from raw fish to fish meal is more in the traditional method (22.5%) as compared to modern fishmeal units (18%).

The fish meal produced from mackerel tuna showed the highest yield rate in both processing methods. Mackerel tuna not only had the most significant body size, but the proportion of muscle is also much higher for tuna than two other fishes. According to Joseph et al. (1988), mackerel tuna has compacted meat composed of white and red muscles. The white muscles function during short bursts of activity, while the red flesh, which has a relatively large mass, allow the fish to swim at high speeds (up to 45 km/h) for long periods without fatigue (Joseph et al., 1988; Bushnell and Holland, 1997).

According to Pike (1989), bulk density and flow characteristics are essential in the storage of fish meal. Raw material, drying method, and moisture content affect flow properties. The lower the oil content generally more readily, the feed will flow. Moisture content below 8% improves flow characteristics (Pike, 1989). The present results showed that physical properties can be improved by steam cooking before drying. The steam cooked fish meal had higher bulk and compacted bulk density than fish meal produced by direct sun drying. The steam cooking process could improve and increase density and storage capacity. The improvement of these two physical properties is related to moisture and the nutrient content of the fish meal (especially minerals) and particle size. As shown in Table 3, the steam cooked fish meal showed higher crude ash and mineral content than the direct drying products. Steam cooked fish meal also had lower moisture content and more uniform and finer particle size than the direct drying, which were light brown and fairly large particle size. Latif (2006) reported that the highest value of bulk density of fishmeal obtained 510 kg/m^3 with a moisture content of 11.3%, and the lowest was 480 kg/m^3 with a moisture content of 13.1%. Sardine fish meal showed higher bulk density value due to smaller particle size, while the lowest was pony fish meal due to rough texture. The angle of responses in this study was higher than the previous data measured by Latif (2006) who reported that the angle responses fishmeal produced from trash fish by the local fish meal industries were 45.3% and 36.1%, respectively. The angle of response of steam-cooked fish meal was low, because the significant lower moisture and crude content (Table 2), lead to being better flowability rate and more efficient for bulk handling (Geldart et al., 1990).

Crude nutrient and nutritive value of fishmeal

Crude protein of fish meal produced from the overflowed fish ranged from 70-75%. It is higher than the crude protein content (58-68%) of a local fish meal provided from trash fish reported by Sitompul (2004). The protein content is within the normal range recommended for the fish meal by NRC (1994) and met the grade 1 specification prescribed in the Indonesian National Standard (SNI) for fish meal (SNI, 1996). NRC (1994) stated that the protein content of fish meal varies from 60.0-72.3 % depending on the type of fish and the method of preparation. According to Rahim et al. (2017), protein components of fish meal differ from 60% to 72% due to species type and method of preparation. There was no significant effect of fish species and processing methods on the protein content. However, there is a tendency that the steam cooking process increased protein content. In the other study, Asmah et al. (2014) reported the protein content was significantly higher in cooked fish compare to raw fish. Crude protein content fish meat *Amblypharyngodon mola* increased from 3.56% to 5.28% after steam cooking due to loss of moisture and fat (Devi and Sarojnalini, 2012).

Moisture and fat content are other important parameters in fishmeal since these play a major role in the physical properties, shelf life, and storage time of fishmeal. The present results showed that steam cooked fish meal had lower moisture and fat content than the direct-sun dried products. The simple wet process involves steam cooking, which ruptures oil deposits, and detaches physiologically bound water, pressing, which removes large fractions of the liquids from the mass (Abowei and Tiwari, 2011). The pre-drying treatment has been given sun-dried products to lower crude fat and moisture content. The high temperature steaming process followed by the pressing process causes a substantial part to separate with fat and water. Heating condenses the protein, breaks the fat depots, and also releases oil and water (Rahman et al., 2016). In the present study, the crude fat content was high in the direct sun-dried (5.8%) and low in the steam-cooked fish meal (2.4%). Sipayung and Suparmi (2014) reported that the moisture content of steam-cooked fish meal produced from trash fish was reduced from 7.51 to 5.31% % by increasing the steaming temperature from 80ºC to 100ºC. Ariyawansa (2000) reported that the moisture content of fish meal depends on the condition of fish, method of processing, and drying. Moisture contents between 5% and 10% are quite reasonable (de Koning, 2005).

The present results indices there is a tendency that quails fed on diets containing steam cooked fish meal had better egg production and feed utilization efficiency than that fed on direct sun-dried products. Asmah et al. (2014) reported that during cooking, heat treatment and the evaporation of water affect the physical and chemical changes in fish, and therefore digestibility is increased due to protein denaturation. The mineral composition might also contribute to the positive effects of steam cooking fish meal on laying performance. The fish meal produced from the steaming process had a higher content of Ca and P. Similarly, Sainani and Kapute (2019) reported cooking increased Ca dan P content of tilapia fish. Thus, it is of beneficial effort for the quail farmers to improve the processing method by steam cooking before grinding for efficient feed production of high-quality local fish meal from overflowed fishes.

CONCLUSION

There are three species of overflowed marine fishes catch of traditional fishermen that are potentially available for producing a fish meal in the sites of Pariaman coastal region, i.e., sardine, pony fish, and mackerel tuna. Meal yield rate varied from 19.1 to 29.6%. The mackerel tuna had the highest meal rate of 24,5-29,6%. Fish meal processed by steam cooking produced lower meal yield rate but better product qualities in terms of physical properties, moisture, and crude nutrient content. The results suggested that the steam cooked process would better produce fish meals from overflowed marine fishes for better product qualities in terms of moisture, crude nutrient content, and nutritive values.

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AUTHOR CONTRIBUTION

Khalil designed the study, managed data and literature, and wrote the manuscript draft. Yuliaty Shafan Nur participated in fish sample preparation and processing, chemical analysis, feeding trial and sample collection. Andri participated in field survey, data analysis and writing the paper.

CONFLICT OF INTEREST

The authors have declared no conflict of interests.

REFERENCES

- Abowei JFN, Tawari CC (2011). Some basic principles of fish processing in Nigeria. Asian J. Agric. Sci., 3(6) 437-452.
- Agusa T, Kunito T, Sudaryanto A, Monirith A, Kan-Atireklap S, Iwata H, Ismail A, Sanguansin J, Muchtar M, Tana TS, Tanabe S (2007). Exposure assessment for trace elements from consumption of marine fish in Southeast Asia. Environ. Pollut. 145(3): 766–777. https://doi.org/10.1016/j.envpol.2006.04.034
- Andriani N, Saputra SW, Hendrarto B (2015). Biological aspect and the utilization rate of Yellowstripe scad (*Selaroides leptolepis*) captured by cantrang nets in the waters of Pemalang Regency. Man. Aquat. Resour. 4(4): 24–32.
- AOAC (2000). Official methods of analysis of the association of official analytical chemists. Vol. I. 17th edn. Association of Official Analytical Chemists, Arlington, USA.
- Ariyawansa S (2000). The evaluation of functional properties of fishmeal. The final project report. Fisheries Training Program. The UN University, Iceland.
- Asghedom G, Kjos NP, Austbo D (2006). Effect of fishmeal supplementation on egg production of Rhode Island Red Layers in Eritrea. Tanzania J.Agric. Sci. 7(2): 77–86.
- Asmah R, Sumaiyah SA, Nurul SR (2014). Comparison of protein, total fat, and omega-3 fatty acids content in yellowtail catfish (*Pangasius pangasius*) and long-tail shad (*Hilsa (clupea) macrura*) in raw and pressurized fish. Int. Food Res. J., 21(6): 2147–2153.
- Bushnell PG, Holland KN (1997). Tunas. Virginia Mar. Res. Bull., 29(1 and 2): 3-6.
- Chandrasekar V, Jeyanthi P, Gopal N (2017). Comparative economic performance of traditional and modernized fishmeal units in Veraval, Gujarat. Indian J. Fish., 64 (Special Issue): 166-171. https://doi.org/10.21077/ijf.2017.64.special-issue.76249-23
- Dahouda MS, Adjolohoun EH, Montchowui M, Senou M, Hounsou NMD (2013). Growth performance of quails (*Coturnix coturnix*) fed on diets containing either animal or vegetable protein sources. Int. J. Poult. Sci., 12 (7): 396-400. https://doi.org/10.3923/ijps.2013.396.400
- de Koning AJ (2005). Properties of South African fish meal: a review. South Afr. J. Sci. 101: 21-25.
- Devi WS, Sarojnalini C (2012). Impact of different cooking methods on the proximate and mineral composition of *Amblypharyngodon mola* of Manipur. Int. J. Adv. Biol. Res. 2(4): 641-645.
- Erlania (2012). Excistency of fish meal industry in Tegal city, Central Java (in the Indonesian language). Media Akuakultur, 7(1): 39-43. https://doi.org/10.15578/ma.7.1.2012.39-43
- FAO (2012). The state of world fisheries and aquaculture. pp. 230.

- Geldart D, Mallet MF, Rolfe N (1990). Assesing the flow ability of pounders using angle of respose. Handling and Prossesing, 2(4): 341-345.
- Goutham J, Mohanraju R (2015). Some aspects of mackerel diversity and morphometric studies of *Rastrelliger* genera from Port Blair Andaman waters. IJFAS, 3(1): 196-198.
- Grant CJ, Spain AV (1997). Variation in the body shape of three species of Australian mullets (Pisces: Mugilidae) during the course of development. Aust. J. Mar. Freshwater Res. 28:723-738
- Hardy, RW (2010). Utilization of plant proteins in fish diets: effects of global demand and supplies of fishmeal. Aquact. Res. 41:770–776 https://doi.org/10.1111/j.1365-2109.2009.02349.x
- Hossain MH, Ahmad MU, Howlider MAR (2003). Replacement of fish meal by broiler offal in broiler diet. Int. J. Poult. Sci., 2(2): 159-163. https://doi.org/10.3923/ijps.2003.159.163
- Indaryanto FR, Imai H, Wardiatno Y (2015). Genetic variation of short body mackerel, *Rastrelliger brachysoma* of Jawa Island, Indonesia based on mtDNA control region sequences. AACL Bioflux. 8(5): 648-655.
- Jayaprakash AA (2000). The Indian oil sardine. *In*: Pillai, V.N., Menon, N.G. (Eds.), Marine fisheries research and management. Central Mar. Fish. Res. Inst., Cochin, pp. 259-281.
- Jeyasanta KI, Patterson J (2020). Study on the effect of freshness of raw materials on the final quality of fish meals. Indian J. Mar. Sci. 49(01): 124-134.
- Joseph J, Klawe W, Murphy P (1988). Tuna and Billfish - fish without a country. 4th edition, Inter-American Tropical Tuna Commission (ed.), La Jolla, California. pp. 69.
- Khan TA, Khan N, Ashraf M, Qureshi NA, Mughal MS, Abbas G (2012). Source, Production, and Chemical Composition of Fish Meal in Pakistan. J. Vet. Anim. Sci. 2: 65-71.
- Kempter J, Kielpiński M, Panicz R, Mikolajczyk K, Keszka S (2015). Genetic traceability of selected populations of the yellowstripe scad, *Selaroides leptolepis* (Actinopterygii: Perciformes: Carangidae), based on the analysis of microsatellite DNA CELFISH Project Part 3. Acta Ichthyol. Piscat. 45(3): 299–305. https://doi.org/10.3750/AIP2015.45.3.08
- Kottelat M (2013). The fishes of the inland waters of Southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. Raffles Bull. Zoo. Suppl. 27: 1-663.
- Larson HK, Williams RS, Hammer MP (2013). An annotated checklist of the fishes of the Northern Territory, Australia. Zootaxa. 3696 (1): 1-293.
- Latief F (2006). Physical properties of fish meal and meat bone meal. Master thesis. Fak. Anim. Sci., IPB University, Bogor.
- LIPI (2010). Indonesian fish topang ponyfish. Database of Indonesian topang ponyfish (*Leiognathus Equulus*) (in Indonesian language). Access through www.oseanografi.lipi.go.id
- NRC (1994). Nutrient requirement of poultry. National research council. National Academy Press, Washington.
- Ogunsina BS, Olaoye IO, Opeyemi OO, Adebenjo AO (2009). Nutrition, physical and mechanical properties of sponges gourd seeds. Proc. 3rd Int. Conf. WASAE and 9th Int. Conf. NIAE, January 25–29, 2009, Ile Ife, Nigeria. pp. 198–206.
- Olsen RL, Hasan MR (2012). A limited supply of fishmeal: Impact on future increases in global aquaculture production. Trends Food Sci. Technol. 27(2012): 120-128. https://doi.org/10.1016/j.tifs.2012.06.003
- Pike IH (1989). Fish meal and oil press articles. The international association of fish meal manufactures. U.K. International and West German press.
- Pillai NGK, Ganga U, Jayaprakash AA (2003). Indian oil sardine. *In*: Joseph, M.M., Jayaprakash, A.A. (Eds.), Status of exploited marine fishery resources of India. Central Mar. Fish. Res. Inst., Kochi, pp. 18-24.
- Rahman MM, Han HS, Kim KW, Kim KD, Lee BJ, Lee SM (2016). Apparent digestibility coefficients of the extruded pellet diets containing various fish meals for olive flounder (*Paralichthys olivaceus*). Fish. Aquat. Sci. 19: 27-35. https://doi.org/10.1186/s41240-016-0027-7
- Rahim A, Abbas G, Naeem M, Ferrando S, Gallus L, Khan N, Hafeez-ur-Rehman M, Ghaffar A, Mateen A (2017). Fish meal: Production and quality assessment for aqua feed formulation in Pakistan. Pakistan J. Zool. 49(1): 319-326. https://doi.org/10.17582/journal.pjz/2017.49.1.319.326
- Sainani H, Kapute F (2017). Effect of cooking method on the proximate and mineral composition of lake Malawi tilapia (*Oreochromis karongae*). Afr. J. Food Agric. Nutr. Dev. 17(4): 12589-12599. https://doi.org/10.18697/ajfand.80.16715
- Ruttloff C (1981). Technologie Mischfuttermittle. VEB Fachbuchverlag, Leipzig.
- Sainani H, Kapute F (2019). Effect of cooking method on proximate and mineral composition of lake Malawi tilapia (Oreochromis karongae). Afr. J. Food Agric. Nutr. Dev. 17 (4):12589-12599. https://doi.org/10.18697/ajfand.80.16715.
- Sipayung MY, Suparmi D (2014). Effect of steaming temperature on physical and chemical properties trash fish (in Indonesian language). J. Fak. Perikanan Univ. Riau. 2 (1): 1-3.
- Sitompul S (2004). Amino acid analysis of fish meal and soybean meal. Buletin Teknik Pertanian. 9(1): 33-37.
- SNI (Standarisasi Nasional Indonesia, Indonesian National Standard) (1996). Fish meal as feedstuff (in the Indonesian language). SNI 01-2715-1996/Rev.92. https://jajo66.files.wordpress.com/2008/05/sni-tepung-ikan.pdf.
- Suseno SH, Syari C, Zakiyah ER, Jacoeb AM, Izaki AF, Saraswati, Hayati S (2014). Chemical composition and fatty acid profile of small pelagic fish (*Amblygaster sirm* and *Sardinella gibbosa*) from Muara Angke, Indonesia. Orient. J. Chem. 30 (3): 1153-1158. https://doi.org/10.13005/ojc/300328
- Tantikitti C, Chookird D, Phongdara A (2016). Effects of fishmeal quality on growth performance, protein digestibility, and trypsin gene expression in pacific white shrimp (*Litopenaeus vannamei*). Songklanakarin J. Sci. Technol. 38 (1):73-82.
- Utama AA, Triharyuni S (2015). Abundance and biomass estimates of commercial fish species using hydro-acoustic method in Jakarta bay, Indonesia. Ind. Fish. Res. J., 21(1): 39-44. https://doi.org/10.15578/ifrj.21.1.2015.39-44
- Van Oostenbrugge JAE, Van Densen WLT, Machiels MAM (2001). Risk aversion in allocating fishing effort in a highly uncertain coastal fishery for pelagic fish, Moluccas, Indonesia. Can. J. Fish. Aquat. Sci. 58(8): 1683–1691.
- Wiadnya DGR, Widodo, Marsoedi, Kusuma WE, Setyohadi D, Soemarno (2014). Morpho-species of common Silverbellies (Family: Leiognathidae) found in East Java's Coastal Sea, Indonesia. J. Bio. Env. Sci. 5(2): 107-121.

• Yisa AG, Edache JA, Udokainyang AD, Iloama CN (2013). Growth performance and carcass yield of broiler finishers fed diets having partially or wholly withdrawn fish meal. Int. J. Poult. Sci. 12: 117–120.

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