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# Fish Meal: Production and Quality Assessment forAqua Feed Formulation in Pakistan

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**AR conceived and designed the study. AM, NK and MHR conducted survey. AG performed chemical analysis. MN statistically analyzed the data. GA supervised the work and wrote the article. SF and LG helped in preparation of manuscript.**

**Key words**
**Fish meal, Fish meal production, Feed formulation.**

## ABSTRACT

In this study, 18 fish meal processing units were surveyed in Sindh and Balochistan to investigate production status, chemical composition, and fish species being used for producing fish meal. The overall production of single processing unit ranged from 40 to 500 metric tonns per month. Kampa Industry (Unit 1) was found to be the first largest contributor producing 100 metric tons in 24 h. The second largest producers of fish meal in this region were Abdul Baqi, Ghulam Hussain and Kampa Industry (Unit 2) which produced 300 to 500 metric tons per month. Proximate composition of fish meal samples collected from different units showed that protein contents were 50.51% – 61.26% and energy was determined as 4042.0 cal/g – 4558.0 cal/g. Dry mater was calculated as 87.43% – 93.13% and fat was noted as 15.29% – 26.23%. Ash was found to be 12.32%–18.32% and fiber remained as 7.52% – 13.12%. Phosphorus was found as 0.21%–1.8%. In fish meal preparation, 24 species belonging to different families were noted in which the most abundantly used species were sardine (*Dussumieria acuta*), mullet (*Liza carinata, L. subviridis*), *herring* (*Chirocentrus dorab*), elongated sole (*Solia elongate*), black fin sea bream (*Acanthopagrus berda*), grunts (*Pomadasys hasta*), croaker (*Otolithus ruber),* silver sillago (*Sillago sihama*), sea perch (*Lates calcarifer*) and jaw fish (*Johnius goma*). In majority of processing units, traditional methods were applied causing quality problem. Finally, it was concluded that quality of fish meal and production in our region is suitable for fish feed formulation. But the processing technique should be improved to match international standard, and to avoid declining in production of fish meal strategic management of fisheries resources will be required.

## INTRODUCTION

Fish meal is considered as protein rich animal source commonly used for preparation of poultry and aqua feed (Abbas *et al*., 2015; Rahim *et al*., 2015). It is mostly formed from wild fish having abundant bone which are not used for direct human consumption (Khan *et al*., 2012). Use of pelagic fish in fish meal was estimated as 75% in 2009, and 25% comes from trimmings (FAO, 2012). The fish landings are approximately 90 million tons and historically one third is converted into fish meal (FAO, 2012). Globally, the top ten manufacturers in 2007 produced 80% of the global production. Among these, the largest one is Peru, second one is China, and third one is Chile. The most important countries are Norway, Iceland and Denmark which produce fish meal in substantial amount per year. Approximately, 300 plants in the world are producing 5 million tons fish meal and 1 million ton of oil annually (FAO, 2011). Fish species used for the production of fish meal varies region wise. However, generally it was observed that they contain small, pelagic and bony fish which have low commercial importance if used for direct consumption (FAO, 2012). Globally, the production of fish meal remained 6 to 7 metric tons for the last 20 years. The average trade of the world showed 3 to 4 million tonnes production per year. Fluctuation in the production and export are directly related to the variations occurred in landing of raw fish for fish meal production (FAO,

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2012). It was noted that overfishing and lack of fisheries management also influenced the production of fish meal.

Fish meal generally contains 60% to 72% protein, 5% to 12% fats and 10% to 20% ash. It also contains high amount of fatty acids among them the most common is omega-3 fatty acid. Fish meal directly influences the efficiency of feed having amino acid, phosphorus and fatty acid. In addition, production and availability of fish meal greatly influence the running cost of aquaculture sector. Feed contributes 60% to 80% of the total cost and fish meal is known as its main constituent. The quality of fish meal protein depends on temperature, processing technique and species used (Khatoon *et al*., 2006; Jena *et al*., 2012; Seed *et al*., 2012). About 25% of fish meal comes from the waste of the fish processing sector and 3.06 million tons of fish meal is consumed in aquaculture sector. The direct protein source in aqua feed is fish meal. Fish needs a balance combination of essential and non-essential amino acid, minerals, oil and carbohydrate for energy. Combination of high quality natural protein in feed can only be contributed from fish meal (Ponnusamy *et al*., 2012). Generally, feed is considered as high nutrition value which matches the requirement of fish. The biological value of feed becomes low with deficit in one or many amino acid. Fish meal is major and costly component of fish feed and are trying to replace by protein rich plants. It is observed that plant protein have less number of amino acid and trypsin inhibitors indigestible carbohydrate, so cannot be replaced totally (Aberoumand, 2012). About 43% of global fish meal production is utilized by aquaculture sector (Tacon and Metian, 2008; FAO, 2012).

The quality of fish meal improves the fecundity and feed conversion ratio. Protein components of fish meal differ from 60% to 72% due to species type and method of preparation. Since, the practical and economic crises for the industry are to produce the constant quality of fish meal from heredity different species of fish. So, analytical control is necessary for sustainable production of high quality fish meal. Thus, the present study was planned to evaluate the quality of different types of fish meal producing in the country, keeping in view that impurities like soil, stone and blood meal may affect its quality (FAO, 2012; Anonymous, 2012).

## MATERIALS AND METHODS

*Study area and sampling protocol*

Surveys were conducted along the coasts of Sindh (Ibrahim Haidri and Korangi industrial area) and Balochistan (Hub, Vinder and Sonmiani) for inspection of raw material (fish species) used for fish meal preparation. Different species used in every processing unit were individually listed to determine the number and type of species in processing of fish meal. The processing techniques and total production of fish meal along with consumer details were noted as well (Table I). Fish meal samples were taken from each processing plant and packed them in polythene bags to prevent absorption of humidity and to avoid them from the effect of sunlight. The fish meal samples were then stored at room temperature before chemical analysis.

*Chemical analysis*

The samples of fish meal collected from different processing units were analyzed according to the standard methods of AOAC (2000). Moisture was estimated at 105°C for 24h with the help of an oven (Labostar-LG122 Tabia Espec, Osaka, Japan). Crude lipid was estimated by Soxhlet extraction method (Folch *et al*., 1957). The Kjeldahl method (N×6.25) was applied for the determination of protein content by means of automatic Kjeldahl system (Buchi 430/323, Switzerland).Ash was obtained from muffle furnace at 550°C. Energy in each treatment was determined with the help of bomb-calorimeter. Proximate analysis was determined on wet weight basis (mg/100 g of fish meal sample).

*Statistical analysis*

The data on fish meal nutrients (protein, lipid, ash, fiber, phosphorous and gross energy) were statistically evaluated by using Minitab 17 (Zar, 1996; Rahim *et al*., 2015).

## RESULTS AND DISCUSSION

*Fish processing technique*

In the present study, it was found that two techniques were used for the preparation of fish meal in Sindh and Balochistan, Pakistan. In first technique, traditionally the wet raw material (fish) were brought into a conveyor and then cooked it in cooker by steam, then dried in sunlight and cooled before grinding. After grinding, fish meal powder was stored in bags. In second technique, raw material (fish) was mechanically processed. This process was performed by an automatic machine. The raw material was brought in conveyor, cooked in machine and then dried inside automatic machine by dryer and powdered by cutter. It was observed that in majority of fish meal processing plants the traditional methods were used to manufacture fish meal in the coastal region of Sindh and Balochistan. It was also noted that traditional methods have many bad aspects. These aspects were i) the bacterial contamination during drying raw fish on ground, ii) secondly the manual hooked apparatus was used which damaged fish meat and

**Table I.- Fish meal production, area of supply and techniques used by fish processing units of Sindh and Baluchistan, Pakistan.**

| Name of plant | Fish used for preparation of fishmeal (common name) | Production (tons /month) | Area of supply and mode of business | Techniques applied |
|---|---|---|---|---|
| Hassan Angara Fish Meal Plant | Croaker, snapper | 40–50 | Sindh | Traditional sun dry |
| Liaquat Fish Meal Unit | Indian mackerel, sardine, sting ray | 150–200 | National and local | Traditional sun dry |
| Ahmed Fish Meal Plant | Catfish, croaker, sea perch | 100–150 | Punjab, Sindh | Traditional sun dry |
| Al-Hamad Fish Meal Plant | Cat fish, Indian mackerel, herring | 50–100 | Karachi | Traditional sun dry |
| Hameed Fish Meal Unit | Sardin, Indian scads, mullet | 100–150 | Sindh, Punjab | Traditional sun dry |
| New Sonmiani Fish Meal Plant | Mullet, Indian mackerel, grunts | 100–300 | Karachi | Traditional sun dry |
| Gulam Hussain Fish Meal Plant | Mullet, sting rays, elongated sole | 300–500 | National | Traditional sun dry |
| Kampalani Fish Meal Plant | Sardine, croaker, cobia, herring | 80–200 | Punjab, Sindh | Traditional sun dry |
| Abdul Rashid Unit | Silver Sillago, sardine, blackfin sea bream | 100–300 | National and local | Traditional sun dry |
| Yaqeen Fish Meal Plant | Mangrove red snapper, Indian scads, | 100–200 | Sindh, Punjab | Traditional sun dry |
| Mateen Fish Meal Plant | Mullet, sardine, sea bream, cobia | 100–200 | National or local | Traditional sun dry |
| Maaz Fish Meal Plant | Grunter, sardine, long-rayed silver | 120–300 | National | Traditional sun dry |
| Abdul Baqi | Sea bream, Indian mackerels, red snapper, mullet | 300–500 | National and local | Traditional sun dry |
| Kampa Industry Unit 1 | Mullet, sea bream, Indian mackerel, red snapper | 100 metric tonnes in 24h | National | Traditional sun dry |
| Kohing Fish Meal Plant | Indian mackerels, red snapper, mullet | 80-150 | Sindh, Punjab | Traditional sun dry |
| Shameem Fish Meal Plant | Sardine, sting rays, mullet, red snapper | 1 time 30 tonnes | Export to Germany | Mechanical |
| New Fish Meal Plant | Sardin, sea bream, snapper, | 200–300 | Punjab, Sindh | Mechanical |
| Kampa Industry Unit 2 | Mullet, sea bream, Indian mackerels, red snapper, mullet | 300–500 | National or local | Traditional sun dry |

thus protein contents were reduced. On the other hand, in mechanized method the chances of protein loss was least due to drying in machine and bacterial contamination was low as well. Evidence to support this is available as higher protein contents found in fish meal produced by Mateen processing plant using mechanized method (Abbas and Siddiqui, 2001; Khan *et al*., 2012).

*Fish species used for fish meal preparation*

Globally, many types of species are used for the preparation of fish meal (FAO, 2012). Among them, the oily and pelagic species are important to utilize in fish meal. During the last two decade, due to drastic decline of catch and peaks of mismanagement of the particular fish species, the fish meal production has also fluctuated as the catch varies (FAO, 2012). In Pakistan, 24 finfish species were recorded for fish meal preparation. Among these, the most abundantly used species were herring, silver pomfret, elongated sole, sardine, mangrove red snapper, mullet, grunter, sea perch, long-rayed silver, black sea bream, hilsa, catfish, sting rays, grunts, Indian threadfin, jaw fish, cobia, croaker, sciaenid, Indian scads, oil sardine, Indian mackerels (Table I). Similar results were reported by Khan *et al*. (2012).

*Production and export*

Small pelagic fishes, by-catch of shrimp trawlers and fish offal are used for the production of fishmeal on industrial scale. About 102,133 m. tons of small pelagic (predominantly Sardinella, Thryssa, and small Clupoids) were landed in 2013 yielding 68,160 m. tons of fish meal (Anonymous, 2012; Fig. 1). Fish meal was utilized locally for poultry meal and exported as well. In 2013, fish meal of 3,023 m. tons valued at 0.306 million rupees was exported to main country China (Figs. 2, 3). Total export performance of fish and fishery products during the period from 2003 to 2013 has mixed trend. In 2013 the total export was 120,888 metric tons valued at Rs. 25.782 billion (Fig. 3).

**Table II.- Fish species used for fish meal preparation by different processing plants in Sindh and Balochistan, Pakistan.**

| Common name | Scientific name |
|---|---|
| Herring | *Chirocentrus dorab* |
| Silver pomfret | *Pampus argenteus* |
| Elongated sole | *Solia elongate* |
| Sardine | *Dussumieria acuta* |
| Silver sillago | *Sillago sihama* |
| Mangrove red snapper | *Latjanus argentimaculatus* |
| Mullet | *Liza subviridis* |
| Grunter | *Pomadasys kaakan* |
| Mullet | *Liza carinata* |
| Sea perch | *Lates calcarifer* |
| Long-rayed silver | *Gerres filamentosus* |
| Black fin sea bream | *Acanthopagrus berda* |
| Hilsa | *Tenualosa illisha* |
| Catfish | *Arius maculates* |
| Sting rays | *Himantura uarnak* |
| Grunts | *Pomadasys hasta* |
| Indian threadfin | *Polynemus indicus* |
| Jaw fish | *Johnius goma* |
| Cobia | *Rachycentron canadum* |
| Croaker, Scienids | *Otolithus ruber* |
| Indian scads | *Decapterus russellii* |
| Oil sardine | *Sardinella longiceps* |
| Indian mackerels | *Rastrelliger kanagurta* |

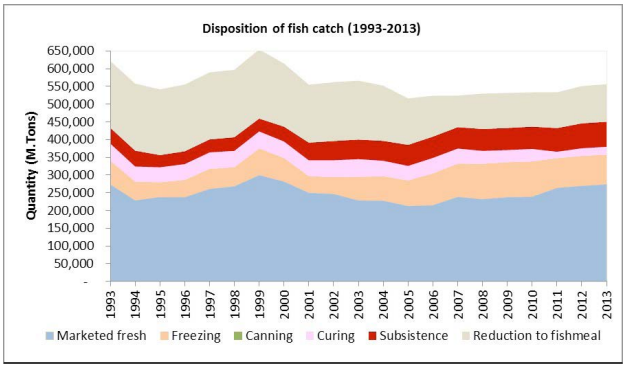


Fig. 1. Disposition of marketed fresh, freezing, canning, curing, subsistence and reduction to fish meal during 1993 to 2013 in Pakistan (Source: Anonymous, 2012; Khan, 2012).

The export mainly comprised of frozen fish, frozen shrimps, lobsters and crabs, dried fish and molluscs. However, a small amount of live lobsters and live crabs was also included in the export. Among the fish products only small quantity of fish meal was exported. Annual unit price (AUP) of fishery, dried salted products and fish meal remained as Rs. 204,33.00, Rs. 203.00 and Rs. 140.11 thousands, respectively (Fig. 4).

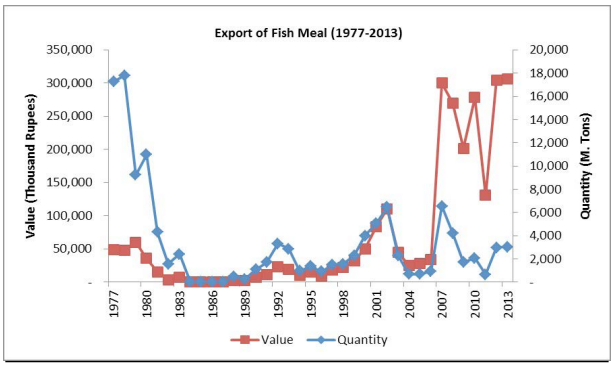


Fig. 2. Export of fish meal from Pakistan to different countries during 1977 to 2013 (Source: Anonymous, 2012; Khan, 2012).

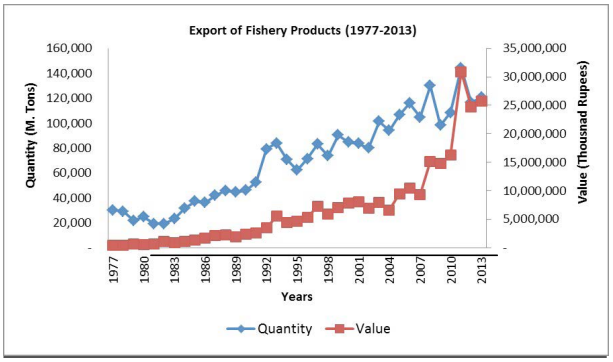


Fig. 3. Export of fishery products from Pakistan to different countries during 1977 to 2013 (Source: Anonymous, 2012; Khan, 2012).

Fish and shrimp are processed in the form of chilled, frozen, salted and canned products in processing units. The processing units of the country are very old (averaging 40 years) and with outdated machineries. Among these plants, 25 processing plants are working at Karachi, where as 30 new processing plants have been established at Gwadar. These plants are comparatively small in size and have lesser processing capacity than that of Karachi. Annually, about 78% of the catch is fit for human consumption, of which 66% is marketed as fresh, and 12.8% in frozen, 12.5% subsistence used by fishermen and 8.6% converted into dried and salted product. About 25% of the total production is converted into fish meal (Niazi *et al.*, 2005; Khan, 2006a, b; Khan and Khan, 2011; Anonymous, 2012; Fig. 1).

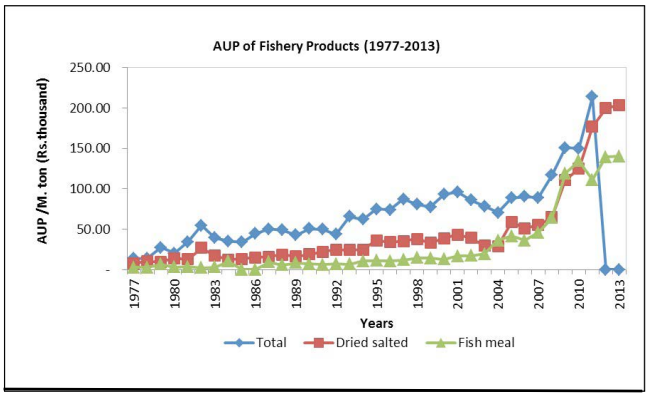


Fig. 4. Annual unit price (AUP) of fishery, dried salted products and fish meal from 1977 to 2013 in Pakistan (Source: Anonymous, 2012; Khan, 2012).

During the present survey, it was found that the production of a single processing unit ranged from 40 to 500 metric tons per month (Table I). Higher fish meal production was observed in Kampa Industry unit 1 producing 100 metric tonnes in 24 h. The second large producers of fish meal in this region were Abdul Baqi, Ghulam Hussain and Kampa Industry unit 2 which gave production of fish meal from 300 to 500 tonnes per month (Table I). Fourth contributors of fish meal were New Sonmiani fish meal plant, Liaquat plant, Hameed fish meal unit, Maaz fish meal plant, Abdul Rashid, Kohing fish meal plant, Mateen fish meal plant, Hassan Angara fish meal plant and Al-Hamad fish meal plant produced less than 300 tonnes of fish meal (Table I).

*Chemical composition*

The protein contents were noted as 56.03% and energy was determined as 4283.42cal/g (Table III). Dry mater was found as 90.14% and fat was calculated as 18.56%. Ash was determined as 15.93% and fiber was noted as 10.40%. Phosphorus was found as 0.79%. Generally, the protein contents of fish meal ranged from 50.51% to 61.26%. These findings are in agreement with the observations of

**Table III.- Chemical composition of fish meal samples collected from different processing units of Sindh and Balochistan, Pakistan.**

| Name of processing unit | Processing type | Dry matter (%) | Protein[1] (%) | Fat (%) | Gross energy (cal/g) | Ash (%) | Fiber (%) | Phosphorus |
|---|---|---|---|---|---|---|---|---|
| Hassan Angara Fish Meal Plant | Sunlight dry traditional | 91.25$^{b}$ | 57.51$^{b}$ | 16.15$^{a}$ | 4356$^{b}$ | 17.56$^{c}$ | 8.42$^{a}$ | 0.54$^{a}$ |
| Liaquat Fish Meal Plant | Sunlight dry traditional | 92.11$^{b}$ | 60.10$^{c}$ | 15.51$^{a}$ | 4213$^{b}$ | 16.56$^{c}$ | 7.52$^{a}$ | 1.51$^{b}$ |
| Ahmed Fish Meal Plant | Sunlight dry traditional | 87.56$^{a}$ | 55.31$^{bc}$ | 17.51$^{b}$ | 4403$^{c}$ | 15.32$^{b}$ | 11.71$^{b}$ | 0.90$^{b}$ |
| Al-Hamad Fish Meal Plant | Sunlight dry traditional | 90.13$^{ab}$ | 52.51$^{a}$ | 19.35$^{bc}$ | 4412$^{c}$ | 17.41$^{c}$ | 10.34$^{b}$ | 0.52$^{a}$ |
| Hameed Fish Meal Unit | Sunlight dry traditional | 90.41$^{ab}$ | 53.51$^{b}$ | 17.33$^{b}$ | 4406$^{c}$ | 18.32$^{c}$ | 11.35$^{b}$ | 0.81$^{a}$ |
| New Sonmiani Fish Meal Plant | Sunlight dry traditional | 88.57$^{a}$ | 59.51$^{c}$ | 16.41$^{a}$ | 4290$^{b}$ | 14.32$^{a}$ | 10.14$^{b}$ | 0.81$^{a}$ |
| Ghulam Hussain Fish Meal Plant | Sunlight dry traditional | 90.29$^{b}$ | 55.43$^{b}$ | 19.55$^{c}$ | 4272$^{b}$ | 14.61$^{a}$ | 10.53$^{b}$ | 0.21$^{a}$ |
| Kampalini Fish Meal Plant | Sunlight dry traditional | 88.32$^{a}$ | 57.31$^{bc}$ | 18.53$^{bc}$ | 4312$^{bc}$ | 15.32$^{b}$ | 9.12$^{b}$ | 0.50$^{a}$ |
| Yaqeen Fish Meal Plant | Sunlight dry traditional | 90.02$^{b}$ | 59.15$^{c}$ | 17.31$^{b}$ | 4056$^{a}$ | 14.41$^{a}$ | 8.95$^{b}$ | 0.82$^{a}$ |
| Abdul Rahid Unit | Sunlight dry traditional | 87.96$^{a}$ | 56.52$^{bc}$ | 18.13$^{b}$ | 4115$^{a}$ | 14.12$^{a}$ | 11.41$^{b}$ | 0.83$^{a}$ |
| Maaz Fish Meal Plant | Sunlight dry traditional | 90.26$^{b}$ | 60.32$^{c}$ | 17.21$^{b}$ | 4218$^{b}$ | 12.32$^{a}$ | 10.15$^{b}$ | 0.31$^{a}$ |
| Abdul Baqi Fish Meal Plant | Sunlight dry traditional | 87.43$^{a}$ | 58.13c | 18.15$^{b}$ | 4042$^{a}$ | 13.18$^{a}$ | 10.31$^{b}$ | 0.21$^{a}$ |
| Kampa Industry Unit 1 | Sunlight dry traditional | 90.01$^{b}$ | 52.41$^{ab}$ | 20.15$^{c}$ | 4558$^{c}$ | 15.02$^{b}$ | 12.31$^{b}$ | 0.51$^{a}$ |
| Kohing Fish Meal Plant | Sunlight dry traditional | 90.17$^{b}$ | 60.23$^{c}$ | 17.13$^{b}$ | 4239$^{b}$ | 13.28$^{a}$ | 8.12$^{b}$ | 0.31$^{a}$ |
| Mateen Fish Meal Plant | Mechanical | 88.03$^{a}$ | 61.26$^{c}$ | 26.23$^{d}$ | 4425$^{c}$ | 16.26$^{b}$ | 12.27$^{b}$ | 0.89$^{a}$ |
| New Fish Meal Plant | Mechanical | 91.55$^{bc}$ | 53.48$^{b}$ | 19.15$^{c}$ | 4119$^{a}$ | 14.12$^{a}$ | 12.15$^{b}$ | 1.2$^{a}$ |
| Shameem Fish Meal Plant | Sunlight dry traditional | 93.13$^{c}$ | 51.71$^{a}$ | 15.29$^{a}$ | 4346$^{b}$ | 27.26$^{c}$ | 5.15$^{a}$ | 0.7$^{a}$ |
| Kampa Industry Unit 2 | Sunlight dry traditional | 92.19$^{b}$ | 50.51$^{a}$ | 20.13$^{c}$ | 4496$^{c}$ | 15.19$^{b}$ | 13.12$^{c}$ | 1.8$^{b}$ |

Similar superscripts indicate no statistical difference among treatments.

[1]Measured as nitrogen × 6.25.

Abbas and Siddiqui (2001) and Khan *et al*. (2012) who studied feed ingredients available in the local market of Pakistan including fish meal. They found 52.74 to 67.65 % protein in the available fish meal. Same results were also reported by Al-Mahmud *et al*. (2012). This variation in percent protein contents may be due to different species and methods used for the preparation of fish meal. However, this range of protein content is less than that of Nigerian fish meal as reported by Sogbesan and Ugwnmba (2008). Fish meal constituting low protein contents in this region was due to lack of proper and standard methods for fish meal processing. In the present study, proteins contents of analyzed fish meal was in agreement with the values given by Moghaddam and Mesgaran (2007). According to Moghaddam and Mesgaran (2007), protein content in fish meal sample was found to be 59.1%.

As protein is considered as an important component of fish feed, percent composition of protein depend upon many factor *i.e*., types of species used, nature and freshness of fish and its by-product, and methods of preparation (Ricque-marie *et al*., 1998). Amino acid composition is directly proportional to crude protein in fish meal (Gomez-Requeni *et al*., 2003). Generally, fish meal contains 60% to 72% protein (Shepherd and Jacksona, 2013). It was investigated that typically fish feeds may contain 30 % to 45 % of protein, while shrimp feed contains 25% to 40% protein by weight. In compound diets of carp and marine carnivorous fish the inclusion of fish meal ranged from 40% to 55% (FAO, 2012). In these diets, fish meal can be substituted to some degree but not totally (Abbas and Siddiqui, 2001, 2013; Abbas *et al*., 2011, 2015). Even soybean which is commonly used in the replacement of fish meal does not have the essential amino acid. Soybean has lysine and tryptophan but is deficient in methionine and cysteine which is the sulfur rich amino acid. On the basis of these fact, it is clear that fish meal must be included in fish diets so as to match the protein requirements of fish.

Lipids are important for developing accurate profile of fatty acids in fish feed (Rodriguez-Barreto *et al*., 2012). They are well known for energy source as well as to maintain fish body metabolism (El-Husseiny *et al*., 2013; Rahim *et al*., 2015; Abbas *et al*., 2015). During manufacturing process of fish meal lipids are usually separated from raw material in the form of oil or solid fats, though some amount of fats remains in fish meal. This amount of lipid occurs from 4% to 20% in fish meal. Since, lipids of fish meal are very digestible and are used by all type of animal. Fish meal has omega-6 and omega-3 fatty acid which are the major source of (PUFAs) essential polyunsaturated fatty acids. In addition, fish meal has more omega-3 fatty acid in contrast to plants having omega-6 fatty acid and greatly affects weight of fish (El-Husseiny *et al*., 2013). In the present study, lipid level was found from 15.29% to 26.23%; the variation in lipid contents was due to oily sardine used as raw material in processing plants (Ponnusamy *et al*., 2012). This study agreed with the finding of Khan *et al*. (2012). However this range of lipid is considerably higher than that investigated by Abbas and Siddiqui (2001). According to Abbas and Siddiqui (2001), the lipid contents in locally available ingredient ranged from 2% to 10%. Furthermore, they suggested that this value is satisfactory for the aqua feed formulation. However, fat contents determined in the present study was greater than that investigated by Al-Mahmud *et al*. (2012).

In the present study, gross energy contents ranged from 4042 cal/g to 4558 cal/g in fish meal samples collected from different processing units. These values tally with the findings of Khan *et al*. (2012), but are less than those reported by Abbas and Siddiqui (2001). It is well known that energy is important for metabolism, and energy rich feed is necessary to balance the requirements of fish varying from species to species (Mongile *et al*., 2014). Moreover, energy is required to convert the protein available in the feed as part of body. During the preservation of fish meal the antioxidant is used to stabilize the energy of the fish meal due to large number of PUFAs present in oil. These PUFAs can easily destroyed and become rancid when it is exposed to oxygen. This process is called oxidation during which the heat is released (Azhar and Nisa, 2006). The energy present in fish meal may decrease up to 20% if it is not stabilized. The decrease of energy in fish meal is due to the damage of the chemical structure of PUFAs in lipids of fish meal. Therefore, less amount of energy will be available for fish physiology (Moghaddam and Mesgaran, 2007; Azhar and Nisa, 2006).

Ash is the remaining of fish meal after they are completely burn. In the present study, ash content of the fish meal ranged from 12.32% to 18.32% (Table III). Greater the amount of ash in fish meal samples indicate greater mineral content. Majority of fish meal ash is constituted by phosphorus and calcium. It was observed that ash in fish meal is directly influenced by fish bones (Chavez-Sanchez *et al*., 2000). Therefore, if we want to decrease ash content of fish meal the bones must be removed in large amount. Low ash in fish meal indicates the additional process for bones reduction in processing plants. This will increase in the contribution of protein content in fish meal (Moghaddam and Mesgaran, 2007).

Phosphorus is an important component for animal body. Fish can directly obtain their mineral requirements from water. Anyhow, phosphorus is the most essential mineral that must be supplied in the diet (Chavez-Sanchez *et al*., 2000). Phosphorus and calcium are structural

constituents of bones scales and teeth (Ye *et al*., 2006). It also plays key role in much metabolic process. It is also limiting factor for growth and feed efficiency. In the present study, phosphorus was recorded from 0.21% to 0.83 % (Table III) which is satisfactory value (NRC, 1993).

## CONCLUSION

The quality of fish meal in Pakistan is satisfactory. The protein and energy contents in fish meal manufactured by various fish meal processing plants match with the standard value of feed formulation. Production of fish meal is also in reasonable condition but production of fish meal may decreases in long term, the price of small fish will increase due to high price of edible fish. People will consume small fishes directly and as a result of this supply of raw material (fish) will be declined. The method of preparation is still traditional and it should be mechanized for further improvement of fish meal quality.

*Statement of conflict of interest*

Authors have declared no conflict of interest.

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