Survey of nutrient levels in commercial shrimp feeds in India

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Since the introduction of white leg shrimp in 2009, shrimp culture has boomed in India to over 400,000 Mt in 2016. During the past years, Indian shrimp culture has spread from one main culture belt, Andhra Pradesh, into two more areas, Orissa and Gujarat. Culture conditions vary in salinity, water source (borehole/seawater), temperature and length of the winter period in the different culture areas.

The number of shrimp feed producers has increased dramatically in recent years. Initially, fish and chicken feed producers were the first to see shrimp feed as a potential for diversification. They were followed by large farmers setting up their own feed-mill operations. Currently large seafood processors are installing new feed-mills. It is expected that this trend will further fragment the feed market, challenging the existing key feed producers.

Globally there was a decline of fishmeal production in 2016 and also Indian domestic fishmeal production was affected, causing shortage of fish meal and fish oil during the summer crop. Contrary to earlier days when the bulk of the marine ingredients such as fishmeal, squid meal, and krill meal were imported, today shrimp feeds are formulated for more than 95 % with locally produced raw materials. Thanks to the implementation of modern production technology, most domestic producers of fishmeal/oil in India meet international quality standards nowadays. Although this allows feedmills to avoid the complex importation and stocking of marine ingredients, the prices of these local raw materials have increased to international levels. The selection of raw materials will influence the overall nutrient profile of the feed. Reducing marine ingredients will directly affect the level and availability of the essential lipids such as n-3 HUFA and cholesterol, unless the formulator compensates this by adding specialty ingredients providing these nutrients.

Compared to other (aquatic) species, formulating shrimp feed is more based on experience then on exact science. The optimal nutrient profile of a shrimp feed will depend on many factors, including the culture density, environmental conditions (temperature, salinity, oxygen, …), productivity of the pond water, the stability of the feed, feeding method and frequency, … These factors often are different depending on the season, region, farm or even pond which makes the selection of the ideal feed rather a complex and often unstable decision for the farmer. As a result, research in optimizing feed formulations under practical conditions continues to be a major objective for feed producers. Also, we can expect a wide variety in nutritional specifications among commercial shrimp feeds as composition may depend on the target market.

Increasing cost and fluctuating availability of raw materials in combination with an increasingly competitive market is demanding a creative mind from the shrimp feed formulator. The nutritional strategy is key to maintain or gain market share. Aside from that, diseases like white spot, vibriosis and white gut/feces are an emerging risk during the production cycle of shrimp in India and require a good nutritional support to the animal. The present study investigated the different nutritional strategies in commercial shrimp feeds during 2016, when the number of shrimp feed suppliers increased sharply. Feed samples of 8 major brands were collected in the market and analysed for proximate composition as well as a number of essential nutrients (amino acids, phospholipids, cholesterol, n-3 highly unsaturated fatty acids).

Sample collection and analysis

Since 2013, Nutriad has surveyed the composition of commercial shrimp feeds in India. Feeds have been analyzed on a range of nutritional parameters. For the present study, we restricted the samples to one pellet size, i.e. 3P, which constitutes the main consumed volume of commercial shrimp feed in India. Pellet 3P typically has the following specifications : crude protein (35 – 36 %), crude fat (4.5 – 6 %), crude ash (< 13 %) and crude fiber (2 – 5 %).

The selected feeds were collected from the market during the second quarter of 2016 from farmers and feed distributors. All feed samples were produced during Q2 of 2016 and stored under typical lab conditions, before sending for analysis. Three different samples of each type of feed was pooled into one representative sample. Therefore, the results of this survey are representative for the feed specifications during a specific window of time during the culture cycle of 2016.

Crude protein was analyzed following the Kjeldahl method (Commission Directive 93/28/EEC.OJ No L179.22.7.93). Crude fat has been determined with acid hydrolysis following the Soxhlet method (AOAC 996.06). Fatty acid composition was determined with the gas chromatographic method following fat extraction (AOAC 996.06; expressed as g/kg). Cholesterol was determined by direct saponification using the gas chromatographic method (AOAC 994.10; expressed as g/kg). Phospholipids were analysed with 31P-NMR spectroscopy using the internal standard method (SAA-MET002-03, expressed as % as is). The analyses of amino acids and nitrogen were performed by Evonik Degussa GmbH (official European method of amino acid analysis in feed, COMMISSION DIRECTIVE 98/64/EC of 3 September 1998; official method code 994.12 of the AOAC International 2000, and expressed % as is).

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Crude protein and fat

Crude protein levels varied between 33.9 % and 40.7 %, with an average of 36.4 % ± 2.3 % of the analyzed samples (Fig. 1). 5 feeds out of 8 were found to have a higher protein content than the minimum specification on the label. On average, the feeds were 4% above the labelled feed specifications of 35 % crude protein, but in one case the analysed crude protein level was 20% higher than the level specified in the label. The crude fat specifications vary between different feed producers between 4.5 – 6 % with the majority having the fat specification above 5 %. All the analyzed feeds have crude fat contents higher than 5 %, with an average of 6.18 % ± 0.54 %. This is approximately 25 % above the specification. There was no clear relation between crude protein and crude fat content. This confirms the lack of consensus among shrimp nutritionists on the importance of the protein/fat ratio in the diet. The analysis of crude fat and protein does not reveal the origin or quality of the fats and proteins used.

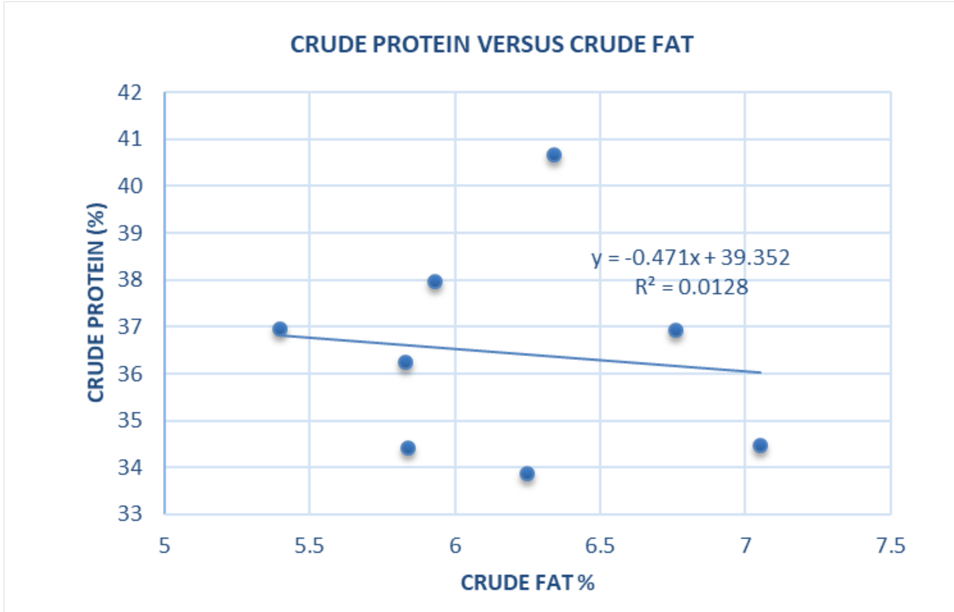

Figure 1. Crude protein versus crude fat of 8 commercial shrimp feeds.

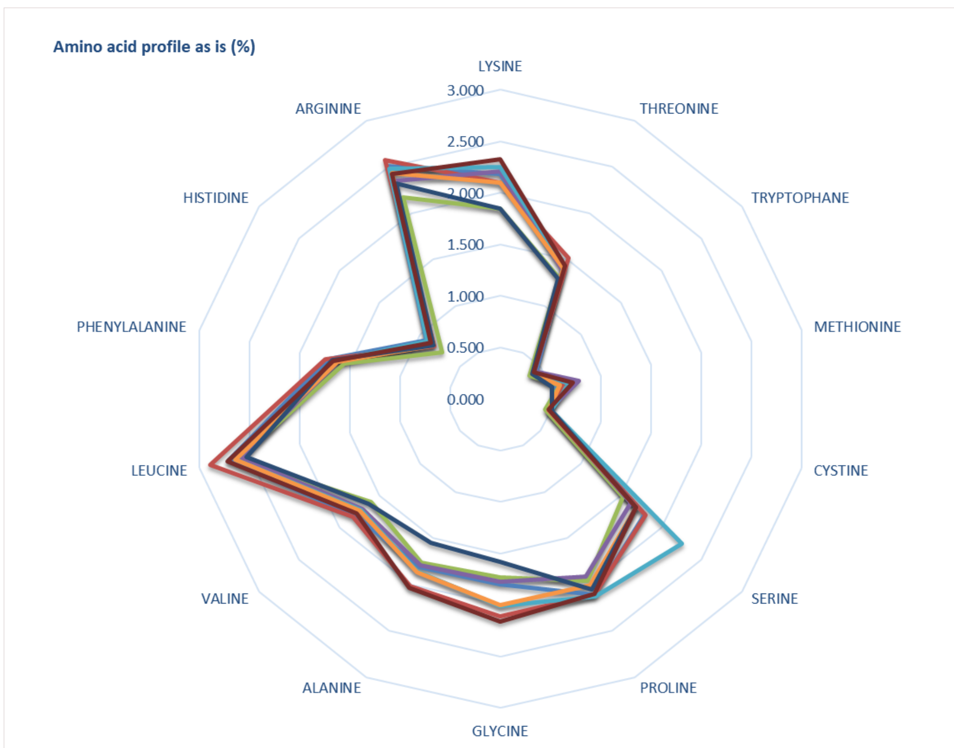

Figure 2. Amino acid profile for 8 commercial shrimp feeds (represented by different line colors).

Amino acid profile

The amino acid profile gives a first idea on the quality of the proteins used as well as the nutrient density. This is far from a complete picture of protein quality which would include an assessment of the ingredients regarding processing parameters and protein digestibility. Amino acid nutrition in shrimp is complex due to the interaction from the leaching of amino acids prior to ingestion, lack of digestibility values, and the role of specific amino acids in feed attractiveness. The current knowledge on the requirements of amino acid requirements in white shrimp is still very limited (NRC 2011). In the absence of scientific studies determining absolute requirements for essential amino acids (EAA), the composition of the whole body could give guidelines on the desired profile of essential amino acids in the diet (ideal protein concept). In this study the average (± standard deviation for 8 samples) lysine content was 2.11% ±

0.17% and methionine 0.63% ± 0.09% (Fig. 2). Arginine an amino acid that could play a role it the attractivity of the feed has an average of 2.41% ± 0.12%.

Phosphoplipids, n-3 HUFA, cholesterol

The n-3 HUFA content is an indicator for the quantity of marine fats used in the feed, either derived from fish oil or from marine protein meals containing fat. Marine shrimp do not have the ability to biosynthesize n-3 HUFA and the dietary requirements of *Litopenaeus vannamei* were found to be at least 1 % (Kanazawa et al. , 1979; Kontara et al., 1995; Shiau, 1998). Five out of the 8 feeds had n-3 HUFA values around 5 g/kg, whereas crude fat levels varied between 5.8 and 7.1 g/kg (avg 6.18 % ± 0.54; Fig. 3). One feed exhibited more than 7g/kg n-3 HUFA and two feeds were below 3 g/kg n -3 HUFA.

Cholesterol requirement studies show a wide range in cholesterol requirements from 0.5 to 5 g/kg for *L. vannamei* (Chen, 1993, Duerr and Walsh, 1996; Gong et al., 2000). Duerr and Walsh (1996) showed that dietary cholesterol levels below 1 g/kg limit growth in *L. vannamei*. Morris et al. (2011) reported the cholesterol requirement for *L. vannamei* grow-out to be somewhere between 0.76 and 1.1 g/kg, however, a regression analysis predicted the cholesterol requirement for maximum growth to be 1.5 g/kg. Gong et al. (2000) estimated that the cholesterol requirement for *L. vannamei* was 3.5 g/kg in the absence of supplemented phospholipids. At 1.5% and 3% phospholipids, dietary cholesterol requirements reduced to 1.4 and 1.3 g/kg, respectively. The cholesterol levels found in the analysed feeds were all well below 1 g/kg (Fig. 4). The average cholesterol level was 0.64 g/kg ± 0.16, with half of the feeds around 0.7-0.8 g/kg and one feed sample as low as 0.34 g/kg.

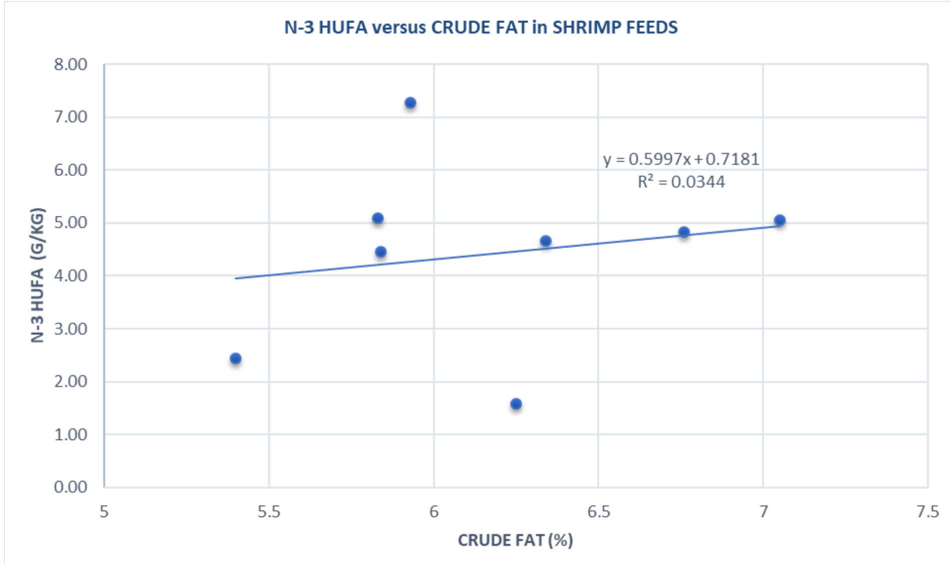

Figure 3. Dietary level of n-3 HUFA versus crude fat for 8 commercial shrimp feeds.

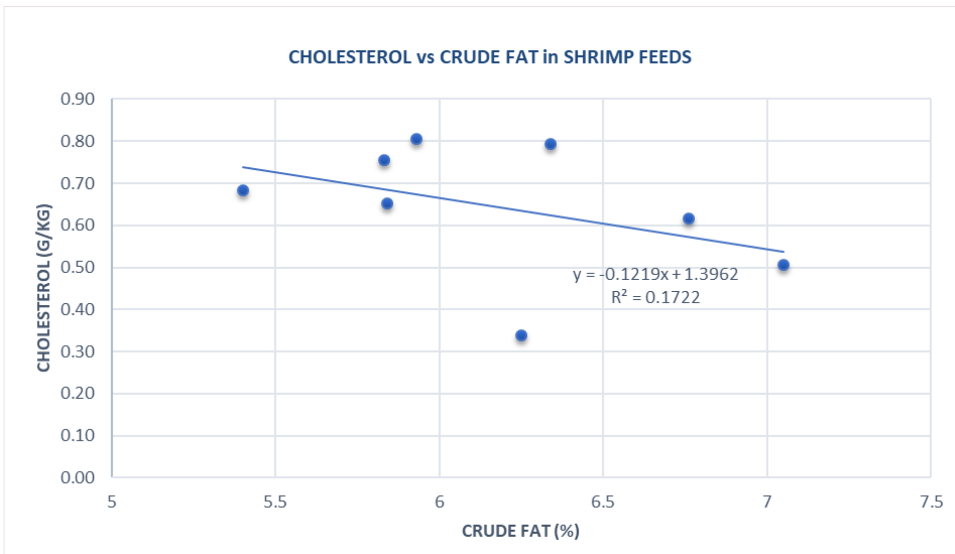

Figure 4. Dietary level of cholesterol versus crude fat for 8 commercial shrimp feeds.

Dietary phospholipid is required for optimal growth of penaeid shrimp including *L. vannamei* (Glencross et al. 1998; Paibulkichakul et al. 1998; Thongrod and Boonyaratpalin 1998).

Addition of 1.5% of phosphatidyl choline (PC) from either a 95% pure soybean source, 94% pure chicken egg source, or deoiled soybean lecithin (23% PC) increased growth of *L. vannamei* relative to a PC-deficient diet (Coutteau et al. 1996). Recommended levels of dietary phospholipids from soybean sources range from 1.25% to 6.5%, depending on shrimp species, developmental stage, as well as purity of the lecithin (Coutteau et al., 1997). The average levels of phospholipids in the current study were 1.74 % ± 0.43, with the lowest level being 1.13% and the highest 2.5% (Fig. 5). Comparing different studies on phospholipid requirements can be troubled by the differences in analytical methods used. The present study used NMR spectroscopy to quantify total phospholipid content in the shrimp feeds. This method is more accurate than traditional methods based on HPLC or iatroscan as the NMR quantification is independent from fatty acid composition and phospholipid profile of the phospholipids.

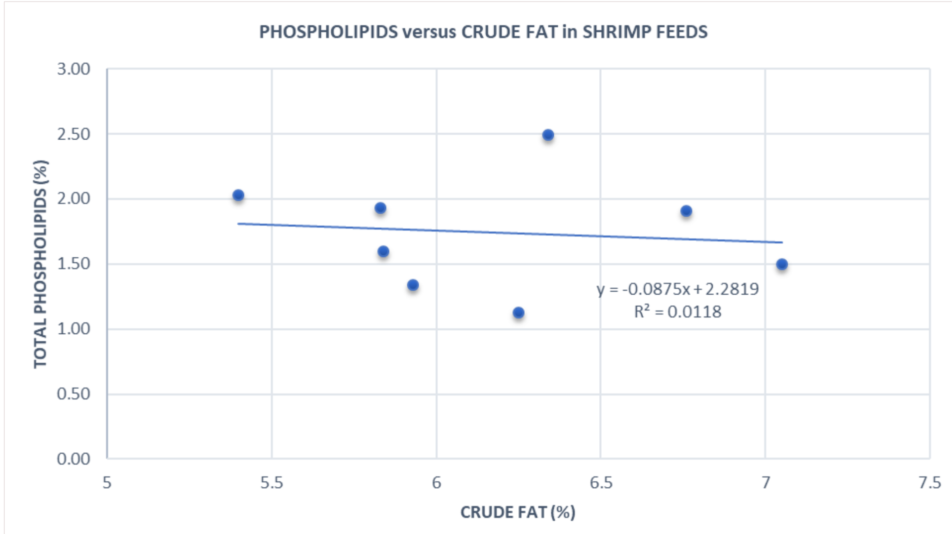

Figure 5. Dietary level of phospholipids versus crude fat for 8 commercial shrimp feeds.

The level of the essential fat nutrients, cholesterol, n-3 HUFA and phospholipids, were not correlated at all with the total level of dietary fat (Fig. 3, 4, 5 : non-significant correlations). This indicates that the dietary fat originates from blending fats from marine as well as vegetable origin.

Trends revealed from comparing surveys 2014 and 2016

Comparing the present survey for 2016 with a similar survey in 2014 (based on 4 commercial feeds), we see some significant trends. Overall the average crude protein increased from 35.8% to 36.4% in 2016. Average crude fat levels are similar in both surveys, ie around 6.2%. n-3 HUFA and cholesterol levels have dropped with 16% and 24%, respectively, , whereas the average inclusion of phospholipids increased with 38 % between 2014 and 2016. The changes in the lipid profiles reflect possibly the effects of the trend to replace fish meal and fish oil, particularly in 2016 when the domestic supply of these raw materials was insufficient. Average levels indicate that overall reduced levels of cholesterol and n-3 HUFA, likely due to increased replacement of marine by vegetable ingredients, were compensated with increased levels of phospholipids and crude protein.

Reducing the level of essential lipids like cholesterol, phospholipids and n-3 HUFA significantly affected growth, feed conversion and protein efficiency in white shrimp in a controlled feeding trial in clear water (van Halteren et al., 2016). The above trends in the feed industry promote the application of digestibility enhancing additives which improve the absorption efficiency of the increasingly limited levels of cholesterol and n-3 HUFA. Digestive enhancers like bile salts and phospholipids are natural emulsifiers capable of enhancing the digestive capacity for lipids in the digestive system of shrimp by improving the lipid emulsification and micelle formation, resulting in a faster absorption of lipids in the hepatopancreas. Furthermore, bile salts constitute an alternative source for the steroid ring which shrimp cannot synthesize, which is at the basis of their requirement for dietary cholesterol. Adding bile salts to the diet lower in essential lipids restored the performance of the shrimp to the same level as the control diet with elevated levels of essential lipids (van Halteren et al., 2016). By improving the utilization

Table 1. Variation in fat composition in commercial shrimp feeds between 2014 versus 2016 (data represent average and stdev).

	2014	2016
	Average ± s.d. (n=4)	Average ± s.d. (n=8)
Crude fat (%)	6.28 ± 0.86	6.18 ± 0.54
Crude protein (%)	35.82 ± 0.20	36.44 ± 2.25
n-3 HUFA (g/kg)	5.23 ± 2.48	4.42 ± 1.74
Cholesterol (g/kg)	0.84 ± 0.16	0.64 ± 0.16
Phospholipids (%)	1.26 ± 0.29	1.74 ± 0.43

efficiency of dietary lipids, shrimp formulations can be made more cost-effective by reducing the formulated values for phospholipids, cholesterol and n-3 highly unsaturated fatty acids (HUFAs) without affecting the performance (Coutteau et al., 2011).

Conclusions

The present study collected samples from 8 commercial shrimp feed brands (pellet size P3) in India during 2016 for the analysis of selected nutrients. The shrimp feed samples exhibited a wide range of levels for the nutrients analysed. The shrimp feeds contained on average (± s.d. for the eight samples) 36.4 ± 2.3% crude protein, 6.28 ± 0.86 % crude fat, 2.11 ± 0.17% lysine, 0.63 ± 0.09% methionine, 2.41 ± 0.12% arginine, 4.42 g/kg ± 1.74 g/kg n-3 HUFA, 0.64 ± 0.16 g/kg cholesterol, 1.74 ± 0.43% phospholipids. Furthermore, the survey showed an overall trend in the industry between 2014 and 2016 to offer feeds with lower levels of cholesterol and n-3 HUFA, whereas crude protein and phospholipid levels were increased over the same period, likely due to the increasing replacement of marine ingredients by vegetable raw materials.

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More information

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