Digestive and metabolic enhancer offsets reduced cholesterol level in shrimp feed

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Global fishmeal and fish oil prices are, to a large extent, linked to the supply situation in South America (Peru and Chile) and demand from Asia (primarily China). Currently, Peru is the largest source of fishmeal (FM) and fish oil (FO) output and also the world's largest producer and exporter of FM and FO. An unsuccessful season in Peru might cause as much as a 20% decrease in global output. Impacted by El Niño, Peru has recently canceled the first fishing season for anchovy in the north-central zone, creating new challenges for the global market of FM and FO.

Impact on essential lipids

Cholesterol is an essential nutrient for shrimp. It is a key compound of membranes and a precursor for the synthesis of ecdysteroid molting hormones. Reducing FM and FO in shrimp feeds will directly affect the level and availability of essential lipids such as n-3 HUFA, phospholipids and cholesterol. Cholesterol requirement studies show a wide range of cholesterol requirements from 0.5 to 5 g/kg for *L. vannamei* (Chen, 1993; Duerr & Walsh, 1996; Gong *et al.*, 2000). Practical shrimp diets are usually formulated with cholesterol levels starting from 0.07-0.1%. Lower levels than 0.07% are considered insufficient. Purified cholesterol can also be added to reach a targeted level. These sources are, however, becoming very expensive, therefore, requiring more cost-effective alternative options.

In times of high FM and FO prices, it is important for nutritionists to search for strategies to fulfill the cholesterol requirement in shrimp feeds. One of the solutions is LIPOGEST®, a digestibility and metabolic enhancer based on bile salts. Bile salts constitute an alternative source for the steroid ring and, therefore, can maintain the synthesis of molting hormones in situations where cholesterol levels are deficient in the diet (Lin *et al.*, 2017). Furthermore, bile salts improve the digestive capacity for lipids in the digestive system of shrimp by improving lipid emulsification

Table 1. Experimental feed formulation and chemical composition

Ingredients (%)	CHOL8	CHOL6
Peruvian fishmeal	13	13
Tuna fishmeal	5	5
Soybean meal	34.38	34.11
Rapeseed meal	7	7
Corn gluten	2	2
Wheat bran	5	5
Whole wheat	19.09	20.39
Rice bran	7	7
Squid meal	3	3
Vit/min premix	2	2
Lecithin (liquid, 60% PL)	1.5	1
Fish oil	1	0.5
Cholesterol (92%)	0.025	
Total	100	100
Analysis (as % product)		
Crude protein	37.35	37.31
Crude fat after hydrolysis	6.35	5.61
Crude ash	7.56	7.66
Crude fiber	3.2	3.3
HUFA	0.89	0.75
Cholesterol	0.080	0.064
Moisture	11.46	10.62

Table 2. Effect of LIPOGEST® on the performance of white shrimp *L. vannamei* fed a diet containing a low level of cholesterol. Different letters show significant differences ($p<0.05$). CHOL8: positive control with a cholesterol level of 0.08%; CHOL6: negative control with a cholesterol level of 0.06%; LIPOGEST: 1.25 kg/MT added to the CHOL6 feed.

	CHOL8	CHOL6	LIPOGEST
Survival (%)	90 ± 0.00	91.67± 2.89	90 ± 5.00
Initial weight (g)	1.05 ± 0.01	1.06 ± 0.00	1.05 ± 0.02
Final weight (g)	12.44 ± 0.84[ab]	10.83 ± 0.32[b]	12.21 ± 0.49[ab]
SGR (%/d)	4.42 ± 0.11[a]	4.15 ± 0.05[b]	4.38 ± 0.1[ab]
Growth (g/wk)	1.42 ± 0.1[ab]	1.22 ± 0.04[b]	1.39 ± 0.06[ab]
Feed intake (g)	28.58 ± 1.82	28.47 ± 2.06	27.16 ± 0.72
FCR	2.51 ± 0.03[a]	2.91 ± 0.13[b]	2.44 ± 0.11[a]
PER	1.07 ± 0.01[a]	0.92 ± 0.04[b]	1.10 ± 0.05[a]

and micelle formation, resulting in faster absorption of lipids in the hepatopancreas.

Shrimp trial

A feeding trial with white shrimp (*Litopenaeus vannamei*) demonstrated the effective replacement of FO and purified cholesterol with LIPOGEST®. As shown in Table 1, the positive control feed (CHOL8) was formulated to reach an optimal cholesterol level of 0.08%. The negative control feed (CHOL6) was formulated at a cholesterol level of 0.06% by lowering the fish oil and by omitting the purified cholesterol compared to the positive control diet. To this diet, 0.125% bile salt-based LIPOGEST® was added and compared to CHOL8 in an eight-week feeding trial.

Reducing the level of cholesterol significantly affected growth and feed conversion in white shrimp (Table 2). However, the addition of LIPOGEST® improved the growth compared to the negative control and restored the performance of the shrimp to the same level as that of the feed with higher cholesterol levels. FCR of the LIPOGEST® treatment was similar to that of the feed with higher cholesterol levels. Such improvements can be attributed to a more optimal digestion efficiency and regulation of cholesterol metabolism. In this line, Lin *et al*. (2017) demonstrated the significant effects of adding bile salts in cholesterol-deficient soybean meal-based diets for white shrimp.

Furthermore, this study showed that several ecdysteroid signaling response genes, such as the expression of ecdysteroid receptor, chitin synthetase and muscle growth markers, were improved by adding bile salts in cholesterol-deficient diets. In a more recent trial, the supplementation of bile acids at 0.025-0.1% in 14% FM shrimp feeds reduced the FCR and increased weight gain (Wang *et al*. 2023). Altogether, these results show that bile salt supplementation can mitigate the adverse effects of cholesterol deficiency caused by low FM inclusion.

Conclusion

In conclusion, within the current context of high prices of FM, FO and cholesterol, aquafeed formulators can count on LIPOGEST® to make aquafeeds perform with less marine lipids and cholesterol and, therefore, achieve significant cost-reductions without losing the performance and metabolic activities related to dietary cholesterol.

References available on request

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