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A Potential Substitute to Fish Meal: The Veined Rapa Whelk, *Rapana Venosa*

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Abstract

In aquaculture industry, fish meal is considered to be the most important raw material in aquatic feeds, due to high quality and quantity of its protein. The necessity of fish meal has been increasing as the aquaculture industry grows. However, as the rapid growth of aquaculture sector has created a pressure on the sources of fish meal, a decrease in relevant fish populations have been encountered and fish meal price have increased. To date, several raw materials have been therefore investigated in order to replace fish meal in aquafeed and reduce production costs; but yet, not an exact one has been found to completely replace it. Taking into consideration the current situation, any raw material to replace fish meal has been of particular importance. Accordingly, regarding its high protein content and balanced amino acid profile, the veined Rapa whelk meal has been reviewed to replace the fish meal in aquafeeds.

Keyword: Rapana venosa; Fish meal; Aquafeed; Molluscan

Introduction

The aquaculture industry has been considered as the most promising future protein source for human consumption in the near future [1]. Ipso facto, depending on the increasing demand on aquaculture products, the amount of production obtained through aquaculture in the world has reached up to 106 million tonnes [2] and is expected to be much more in a close future. In parallel with this increment, aquafeed necessity has also been increasing evenly in order to supply the need for aquaculture sector.

Being considered as comprising the most nutritious and digestible ingredients for farmed fish, fish meal represents a great importance for the aquafeed industry [3]. However, the recent pressure on fishing activities in order to obtain required fish meal possesses a danger to population dynamics of the ecosystem for distant future and it is obvious that live stocks for fish meal are gradually going to be insufficient. As a result of lack of natural stocks used in aquafeed industry, the price of fish meal has also gone up. The amount of fishmeal used in aquaculture has therefore resulted in a downward slope to be able to offset their high prices, and being used more selectively as strategic ingredients at lower concentrations to meet the specific requirements of the target species [3], particularly larval fish and brood stock. Therefore, the presence of an animal or plant resource that can be an alternative to fish meal is of great importance.

Alternative Protein Sources

Researchers are recently trying to find out alternative protein sources in aquaculture diets. Numerous studies have been carried out on aquatic species in order to determine whether plant or animal based alternative protein sources may partially or completely replace fish meal in aquafeed.

Researchers have been lately focusing on the high availability and digestibility besides low price protein sources for fish meal substitutes. In this particular; it was reported by Cho, et al. [4] that, 40% fish meal could be replaced by feather meal [5], 20% by meat & bone meal [6], 60% by meat meal [7], 50% poultry by-product meal [8,9], 50% by defatted soybean meal [10] or 20% by defatted soybean meal [11], 20% hazelnut meal [12] 40% by corn gluten meal [13,14], soybean meal and 46% by defatted soybean meal in combination with blood meal, corn gluten meal and blue mussel meat [15] in the different fish species feeds.. In the view of some other researches carried on different species, it has also been found that the substitution of the field pea and narrow-leafed lupin to fish meal have been shown to be effective in Atlantic salmon feeds [16]; *Spirulina* found to be replacing up to 40% of the fish meal protein in tilapia diets [17], high levels of plant protein sources has been found to successfully replace fish meal in diets of on-growing Senegalese sole [18] and the list grows. When the aforementioned or previous researches taken into account; even though a considerable number of animal or plant based meals have been evaluated as potential protein sources in aquaculture feed, only a few are regarded as suitable or applicable [19].

Most of the plant origin meals include lower quality and quantity of protein and they may have lower palatability, deficient essential amino acid & fatty acid profile and might also contain higher levels of indigestible carbohydrates and anti-nutritional factors [20]. Within plant based protein sources, only soybean meal has been efficiently evaluated as major protein source in aquafeed and commonly used in aquafeed industry. Together with other nutritional benefits, soy meal has a high quality and quantity of protein, high digestibility and the best amino acid profile of the plant protein sources investigated [21]. However, some anti-nutritional factors of soybean meal and/or species-specific features of cultured animal limit the use of soybean meal in aquafeed. Moreover, according to Sánchez-Muros, et al. [21], increased soy cultivation causes the deforestation of areas with a high biological value [22,23], high water consumption [24], the utilisation of pesticides and fertilisers [22], and transgenic varieties [25], which cause significant environmental deterioration [23].

Therefore, attempts to find alternative protein sources continue to increase with great momentum. In this regard, some insect species are lately being investigated intensively as alternative protein sources in aquafeed. Several studies have been conducted on *Clariasgariepinus* [26,27], *Clariasanguillaris* [28], *Catlacatla*, *Labeorohita*, *Cirrhinusmrigala*, *Hypophthalmychthys molitrix* [29], *Orechromisniloticus* [30], *Oreochromismossambicus* [31], *Oncorhynchus mykiss* [32], *Psetta maxima* [33], *Oreochromis sp*. [34], *Salmo salar* [35], *Dicentrarchuslabrax* [36], *Pagellusbogaraveo* [37], *Sparusaurata* [38] and some positive results (up to 10-30% replacement of fish meal) obtained from the studies conducted. However, based on the literature reviewed it has also been mentioned that the nutritional composition of insects vary significantly and highly dependent on the species cultivated, developmental stage of the organism and culture media of the insects; their lipid, protein and mineral composition are all highly variable, even within a taxon at the same developmental stage [39]. For instance, the lipid concentration ranges between 15 and 35% for black soldier fly larvae and between 9 and 26% for housefly maggots according to dry matter basis analysis and such a wide variation seems to be an obstacle when formulating feeds at an industrial scale [39]. Besides; high chitin levels, lack of indispensable amino acids, lower protein digestibility ratios and fatty acid compositions seem to be other limiting factors on the use of insect meals.

When taken into consideration the unfavourable properties of above mentioned meals and high fishmeal prices, investigation of new alternative protein sources are still being seen rational and necessary.

The Veined Rapa Whelk *Rapana venosa*

As the second largest phylum in the animal kingdom, Mollusca contains a great number of species and the members of the phylum are predominantly aquatic [40]. Some of those species' meals are commonly used (both edible and non-edible parts) in aquafeed or evaluated as fresh flesh in aquaculture more particularly in broodstock nutrition owing to their nutritional values. In this particular, literature reports that Molluscs are important dietary sources of fat soluble vitamins (E, D3 and A), essential fatty acids [41], protein [40] and minerals and therefore are quality raw materials for fish feed. As being distributed worldwide and easy available, several species of Molluscs might be proper candidates to substitute fish meal.

Within Molluscan species, the veined Rapa whelk is a marine origin gastropod which is native to coastal waters of the Sea of Japan, Yellow Sea, Bohai Sea, and the East China Sea to Taiwan [42,43]. Over the years, it was transported by ballast water of vessels and/or hull fouling and spread throughout the North Seas [44,45], Black Sea, Adriatic Sea, Azov Sea, Aegean Sea, Chesapeake Bay on the East Coast of the United States and the Rio de la Plata between Uruguay and Argentina [46]. Being as one of the worst invader species worldwide [47], it is well known for its high fecundity rate, earlier sexual maturity [48,49], rapid growth rate, longevity [50], high tolerance to fluctuating salinities & water temperature, oxygen deficiency and water pollution [51,52].

The Veined Rapa whelk feeds mainly on other Molluscan species such as oysters, mussels or clams [53-55], thus leads to rapid decrease of bivalve molluscan fauna in the ecosystem [56]. Because of predation behaviour over bivalves, veined Rapa whelk severely threats the food web where it establishes. According to the report on current and future management of Black Sea fisheries [57] it has been stated that veined Rapa whelk is in the position of "a predator without enemy" thus exercising great pressure on blue mussel (*Mytilus galloprovincialis*), stripped venus clam (*Chamelea gallina*), noble oyster (*Ostrea edulis*) populations as well as many other shellfish species' populations and seriously endangering the ecological balance of the Black Sea. Since bivalve molluscs are nutritional sources of various fish species, decreases in their stocks directly affect other fish stocks either. Therefore preventing the growth of excessive populations of veined Rapa whelk is of significant importance [53]. Especially for the last ten years a remarkable fishery has taken place particularly in Turkey and Bulgaria for its economic value as it is consumed as human food in Eastern Asia [58].

The Veined Rapa whelk has high protein rate (Table 1) and satisfactory amino acid content (Table 2). Even though the nutritional values may vary depending on the season, feeding habits or habitat of the organism; veined Rapa whelk provides a relatively consistent nutritive value year-round. Consequently, when considering the parameters such as rapid growth of its population, its broad distribution around the world waters, lack of its predators, apprehensive reports on its ecological effects and its nutritional value; veined Rapa whelk might be a proper source in aquafeed.

Rapana venosa **meal**	**g/100g (dry matter based)**
Crude Protein	72.09
Crude Lipid	1.89
Ash	3.82
Moisture	7.83

Table1: Proximate analysis of veined Rapa whelk meal*.
*Our Laboratory reports

As protein is a valuable component in aquafeed, it must be in adequate amounts for the cultured organism. In order to meet the requirements of each species, proteins, which are formed by individual amino acids, must include all indispensable amino acids that cannot be synthesized by the fish. In this regard, veined Rapa whelk meal is an outstanding source because of its very high protein and balanced amino acid content.

Amino acid	***R.venosa*** **meal[a]**	**Anchovy meal[b]**	**Menhaden meal[b]**	**Herring meal[b]**	**Krill meal[c]**	**Soybean meal[d]**
L-Lysine	42.2	61.5	61.2	58	43.6	33.0
L-Threonine	23.8	27.8	32.0	29	21.1	17.9
L-Valine	16.2	41.1	42.5	40	25.4	24.3
L-Leucine	46.6	62.8	56.1	60	38.7	41.9
L-Methionine+L-Cystine	24.2	22.5	29.8	26	26.1	16.5
L-Isoleucine	19.4	39.5	36.2	35	25.0	23.3
L-Phenylalanine	23.1	33.5	29.3	30	37.0	26.6
L-Histidine	19.1	18.6	14.6	16	10.6	14.1
L-Arginine	33.0	45.6	49.9	50	33.3	39.0

Table 2: Amino acid profile of *Rapana venosa* meal (g/1000g, dry matter).
[a]Our Laboratory reports; [b]Anderson et, al. [59]; [c]Xu et, al. [60]; [d]Karr-Lilienthal et, al. [61]

Essential amino acid profile of the veined Rapa whelk appears to be relatively lower than the fish meal. However, since the fish meal prices has grown apace, the use of fish meal in aquafeed decreased and the meal of fish by-products [62-66] and soybean meal increased on the contrary. Considering the fact that co-product fish meal represents only 33 % of total fish meal supply [67] and soybean meals have lower quality and quantity of protein than fish meal and the limitations on their usage in aquafeed due to some unfavourable properties, the substitution of veined Rapa whelk meal seems reasonable.

In terms of lipid content even though veined Rapa whelk meal has a well-balanced fatty acid composition, it is deficient alone for the diet (Table 3). However, it is obvious that this deficiency is not a problem as it is not used as a major lipid source in fish feed.

Trivial name	Systematic name	Fatty acid	*R. venosa*
Myristic acid	Tetradecanoic Acid	14 (0)	3.16
Pentadecenoic acid	2-Pentadecenoic acid	15 (1n-13)	1.01
Palmitic acid	Hexadecanoic Acid	16 (0)	13.03
Palmitoleic acid	9-Hexadecenoic Acid	16 (1n-7)	1.12
Stearic acid	Octadecanoic Acid	18 (0)	14.48
Oleic acid	9-Octadecenoic Acid	18 (1n-9)	3.62
Linoleic acid	9,12-Octadecadienoic Acid	18 (2n-6)	2.95
Paullinic acid	13,-Eicosenoic acid	20 (1n-7)	12.96
Dihomolinoleic Acid	11,14-Eicosadienoic Acid	20 (2n-6)	8.95
Arachidonic acid	5,8,11,14-Eicosatetraenoic Acid	20 (4n-6)	11.51
Timnodonic Acid (EPA)	5,8,11,14,17-Eicosapentaenoic Acid	20 (5n-3)	4.78
Docosa-5,13-dienoic acid	5,13-Docosadienoic acid	22 (2n-9,17)	6.25
Clupanodonic Acid	7,10,13,16,19-Docosapentaenoic Acid	22 (5n-3)	7.17
Cervonic Acid (DHA)	4,7,10.13.16,19-Docosahexaenoic Acid	22 (6n-3)	9.01

Table 3: Fatty acid composition of *Rapana venosa* meal (% of total fatty acids) extracted using Chloroform: Methanol solution (2:1)*.

*Our Laboratory reports

Conclusion

A proper diet must provide all essential nutrients in adequate proportions. However, the nutritional content provided by each raw material is also different, as the requirements of each species are different. For this reason, when feeds are formulated, the specific needs of each organism considering their developmental stages are determined and steps are taken. The most important thing to note at this point is the necessity of essential nutrients in feed, therefore in raw materials. Raw materials that contain the desired characteristics and quantity of nutritional components are considered to be of high quality and are widely used. However, no more quality protein source has been found to replace fish meal in aquafeed yet. In this regard, it still seems rational to use other aquatic organisms in aquafeed as these organisms are thought to have the required nutritional content that aquaculture species may need. When taken in the account the idea mentioned above, the use of whelks as protein source in aquafeed has been become reasonable.

In the literature, no previous studies have been encountered on the use of veined Rapa whelk meal in aquafeed. There is only one study [68] has been reported on the use of *Rapana rapiformis* meal which belongs to the same genus. In that study, non-edible parts of *Chicoreus virgineus* and *Rapana rapiformis* species' were used as major protein sources in diets of *Penaeus indicus* juveniles and *Rapana rapiformis* meal has been found to be able to substitute in the diet up to 30% without causing any loss in survival or less growth. In that study, only non-edible portions of the organism were used. However, during the fishery of veined Rapa whelk, smaller individuals are also captured but not evaluated as export products due to lower price and market demand. For this reason both edible, non-edible processing residues (digestive gland, gonadal regions etc.) and off-sized whelks might also be evaluated in aquafeed industry.

Raw materials used in feeds are expected not only to be a source of protein that provides better growth, but they are also expected to provide features such as enhanced reproduction, disease protection, environmental stress resistance, better coloration and delicious meat. In this regard, it has been previously reported by Luo, et al. [69] that the hemocyanin and its functional units from veined Rapa whelk showed phenol oxidase activity [70,71], antimicrobial activity [70,72], antiviral activity [73], antitumor activity [74,75] and healing properties on skin burns [76].

Considering aforementioned properties of veined Rapa whelk and the gap in the literature it has been thought that veined Rapa whelk might be evaluated in aquafeed as protein source. However, a complete analysis of chemical composition should be carried out in order to determine whether it contains anti-nutritional components; and digestibility analysis should be done for a better understanding of bio-availability of its protein.

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