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Solid-state fermentation of sunflower meal using commercial yeast for use as an improved nutrient source in aquafeed

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Abstract
Aquaculture, a reliable source of economic gain and employment generation, mainly stands on formulated fish feed costs. Protein is the essential component of animal tissues and constitutes about 65-75% of fish tissue dry matter. Therefore, protein is considered an essential nutrient source, providing a group of essential and nonessential amino acids for both maintenance and growth. Feed proteins are expensive, and their inclusion in aquaculture diets has a significant blow on overall feed costs. And fishmeal (FM) makes up nearly 50% of the total feed cost, and limited FM supplies can no longer meet the needs of the expanding fish-feed industry. Hence, to bring down the feed cost and develop a low cost and high yield production system, fermented plant by-products like sunflower cake might be considered the most viable alternative protein with less antinutritional feed for economic fish production.

Keywords: Solid-state fermentation, sunflower meal, aquafeed

Introduction
The demand for a protein-based diet is rising due to the increasing population. The world per capita fish consumption increased from an average of 9.0 kg in the 1960′s to above 20.5 kg in 2018 (FAO, 2020) [8]. Fish is an essential source of easily digestible and essential amino acids rich protein for providing approximately 17% of the animal protein consumed by the world's population (FAO, 2014) [7]. It is a significant source of animal protein for low-income households due to its lower cost than other animal protein sources (Mohan *et al*., 2005) [21]. Currently, marine fish production is experiencing near-stagnation, and the only hope lies with aquaculture. Aquaculture farming has seen rapid growth since the 1980s, producing about 46% of the total fish food supply globally and is expected to reach over 50% of the total world fish supply (FAO, 2014) [7]. However, there are strains on the aquaculture industry related to sources of ingredients for aquafeed formulation. Feed represents the single most significant input in aquaculture operation, accounting for 40-60% of the total cost of fish production.

Fish meal: primary protein source in aquaculture
A significant part of aquaculture production's successful growth and intensification depends on aquafeed. Feed accounts for a significant part (30-70%) of an average fish farm (Rumsey, 1993; El-Sayed, 2004) [27, 6]. Traditionally, animal protein sources, particularly fishmeal (FM), have been the primary ingredient of aquafeeds (Glencross *et al*., 2007) [12]. FM is the most expensive ingredient in formulated fish feeds. Although FM production has remained relatively stable, averaging 6.07 million metric tonnes over the past two decades (Tacon *et al*., 2006) [35], its decline is likely. It can no longer meet the demand from the expanding aquafeed industry. The challenge facing the aquaculture industry is to reduce the dependence on FM and fish oil in aquafeeds (especially for farmed carnivorous finfish and marine shrimp) and identify economically viable and environmentally friendly alternatives to fishmeal and fish oil for the production of aquafeeds (Gatlin *et al*., 2007) [10].

Fishmeal is the main raw component used in manufactured fish feeds as a protein source. FM is an excellent source of protein, but off-late it has become expensive to be used as a protein source in the manufacture of aquafeed. With demand for FM increasing and the constraints like the government protection against overfishing, the decreasing availability of FM, and its soring price. This upward movement of the expenditure curve is a driving force behind the constant search for alternative protein sources. Thus, cost-effective, eco-friendly and quality feed can only sustain the feed based intensified aquaculture. In a semi-intensive system, farm-mixed feed comprising of rice bran and a plant protein source such as oilseeds (soybean, rapeseed, canola, cottonseed), grains (wheat and corn gluten), and legumes (peas, beans, peanut and lupins) is used for feeding the fish. Competition with human/animal food-producing sectors for commonly available ingredients led to reduced availability of feed ingredients, accentuating the search for alternative protein sources nutritionally compatible for cultivated species and cost-efficient for sustainable aqua-feed development.

Alternative Feeds

Grains and oilseed by-products are among the most promising alternative feed ingredients for formulating economic and environment-friendly aquafeed (Hardy, 2000) [13]. These protein-rich oilseed cakes arising out as the agro-industrial by-products have been extensively tested as low-cost feed ingredients (Storebakken *et al*., 2000) [33]. The utilization of oil cakes in aquafeed is limited by its' lack of certain essential amino acids; the presence of antinutritional factors (ANFs) (Ghosh and Mandal, 2015) [11]. Plant-based proteins as aquafeed ingredients require that the ingredients possess low fibre content, starch, and antinutritional factors. These ingredients must also have a relatively high protein content, desirable amino acid profile, high nutrient digestibility and good palatability (Lim and Lee, 2009) [19]. Several previous studies discuss the suitability of plant protein feeds or local agricultural by-products as an alternative protein source in fish feeds (Burr *et al.*, 2012; Bonaldo *et al.*, 2011) [4, 2]. Oil cakes are used for food and new approaches like enzymes, antibiotics, antioxidants, biofuel, etc.

Sunflower cake (SFC)

Sunflower cake is a by-product of oil production from sunflower seed – it is the protein-rich residue of the seed that remains after the oil extraction. The industry produces Sunflower cake in millions of tons, attracting attention as a potential substitute for its use in aquafeeds. Biochemical comparison of SFC with FM suggests some potential as a substitute for declining supplies of the increasingly expensive FM (Brown *et al*., 2014) [3]. The total protein content and specific amino acid profiles of the two are comparable, although sunflower cake has relatively lower levels of lysine and threonine (Maina *et al*., 2007) [20]. Trials on the palatability, digestibility and nutrient utilization using SFC diets generally encourage aquaculture tests (Dayal *et al*., 2011) [5]. The crude protein content of SFC is high, 27.8 to 37.4%, which may vary with seed quality and processing (Munguti *et al*. 2006) [22]; it can also be a suitable replacement for mustard oil cake due to competitive nutrition value and price. SFC has been tested with favourable outcomes for some fishes, such as rainbow trout (Sanz *et al*. 1994) [29] and tilapia (Olvera-Novoa *et al*. 2002) [23]. However, the inclusion level of sunflower cake in the fish and freshwater prawn diet should be adjusted to achieve proper nutritional balance and performance.

Antinutritional factors associated with sunflower cake (SFC)

Protease and arginase inhibitors, coupled with the tannin component chlorogenic acid (Tacon *et al*., 1984) [34], limit the use of sunflower meals in feed. High crude fibre content reduces the feed's pelleting quality and protein digestibility when included at high levels (Kamarudin *et al*., 1989) [17]. Sunflower meal contains lower antinutritional factors than soybean, cottonseed and rapeseed meals (Heuze *et al*., 2012) [15]. Unprocessed plant proteins are not suitable as aquafeed ingredients since they contain antinutrients that are undesirable for fish (Francis *et al*., 2001) [9]. Low production cost and high nutritional value make these agro-industrial oilseed residues suitable substrates for fermentation. Therefore, great attention towards the operative use of plant-based bio-resources as a source of functional ingredients with the improved operation of fermentation (Karboune and Khodaei, 2016; Sadh *et al*., 2018) [18, 28].

Solid-State Fermentation

Solid-state fermentation (SSF) is defined as the fermentation involving solids in the absence (or near absence) of free water; however, the substrate must possess enough moisture to support the microorganism's growth and metabolism. (Pandey *et al*., 1995 and 2000) [24, 25]. Fermentation is one of the earliest methods in food preparation (Pederson, 1971; Steinkraus *et al*., 1983) [26, 32] and is also considered a new approach for increasing the functionality of the feed. The term 'Fermentation' was derived from the Latin verb '*fervere*', which means to boil and is described as the biological conversion of complex organic substrates into simple compounds by various microorganisms like yeast, fungi, and bacteria.

The fermentation was probably discovered by observing changes in fruit juices and other substances kept for more than a day. By the 1970s, scientists' interest was focused on the effects of consumption of fermented probiotic products. Globally, fermented foods from plant and animal sources are essential to the human diet (Stanbury *et al*., 1995) [31]. SSF aims to bring cultivated yeast, fungi, and bacteria in tight contact with the insoluble substrate and achieve the highest nutrient concentration from the substrate. The solid substrate supplies nutrients to the culture and serves as an anchorage for the attachment of microbial cells. During fermentation, the moisture content of the medium changes due to evaporation and metabolic activities. Thus, the substrate's optimum moisture level is crucial in solid-state fermentation (Baysal *et al*., 2003) [1]. Fermentation is a process used to produce high or superior nutritional value products and assist in preservation without freezing or canning. Fermented foods may be defined as processed foods through the activity of microorganisms.

Application of fermented sunflower meal in aquaculture farming

An improvement of Nile tilapia growth by replacing fish meal with yeast fermented sunflower meal at 25% concentration was noticed due to increased amino acids in submitted fermented yeast for the sunflower meal (Soltan *et al*., 2015) [30]. Hassaan *et al*. (2018) [14] found that yeast fermented sunflower meal (YFSFM) fed at a 25% level had better growth in Nile tilapia than at higher inclusions, i.e., at 50% and 75% levels of YFSFM. A significant reduction in the fibre content was observed by fermentative action of SSF by *S. cerevisiae* or *B. subtilis* on None Starch Polysaccharides (NSP's) structures within the matrix of the sunflower meal. Similarly, 5% fermented sunflower seed meal showed better growth with a fungal microorganism (Jannathulla *et al.*, 2018) [16].

Conclusion

Solid-state fermentation improves the nutritional quality of SFM by decreasing the fibre quantity during the fermentation of feeds with the help of microorganisms. Nutritional quality of SFM improvement by fermentation with raising crude protein and reducing structural carbohydrates during microbial enrichment. It can be concluded that solid-state fermented sunflower meal provides good overall benefits associated with the increased nutritional value of the unprocessed sunflower meal.

References

1. Baysal Z, Uyar F, Aytekin C. Solid-state fermentation for production of α-amylase by a thermotolerant *Bacillus subtilis* from hot-spring water. Process Biochemistry. 2003;38(12):1665-1668.
2. Bonaldo A, Parma L, Mandrioli L, Sirri R, Fontanillas R, Badiani A, *et al*. Increasing dietary plant proteins affects growth performance and ammonia excretion but not digestibility and gut histology in turbot (*Psetta maxima*) juveniles. Aquaculture. 2011;318(1-2):101-108.
3. Brown CL, Yang TB, Fitzsimmons K, Bolivar R. The value of pig manure as a source of nutrients for mass culture of Nile tilapia in ponds. Agricultural Sciences. 2014;5:1182-1193.
4. Burr GS, Wolters WR, Barrows FT, Hardy RW. Replacing fishmeal with blends of alternative proteins on growth performance of rainbow trout (*Oncorhynchus mykiss*), and early or late-stage juvenile Atlantic salmon (*Salmo salar*). Aquaculture. 2012;334:110-116.
5. Dayal JS, Rajaram V, Ambasankar K, Ali SA. Sunflower oil cake as a replacement for fish meal in feeds of Tiger shrimp, *Penaeus monodon* reared in tank and net cages. The Indian Journal of GeoMarine Sciences. 2011;40(3):460-470.
6. El-Sayed AFM. Protein nutrition of farmed tilapia: searching for unconventional sources. In New dimensions in farmed tilapia: proceedings of the Sixth International Symposium on Tilapia Aquaculture, 2004, 364, 378.
7. FAO (Food and Agriculture Organization of the United Nations). FishStatJ- software for fishery statistical time series, 2014.
8. FAO. The state of World Fisheries and Aquaculture 2020. Sustainability in action. Rome, 2020.
9. Francis G, Makkar HP, Becker K. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture. 2001;199(3-4):197-227.
10. Gatlin III DM, Barrows FT, Brown P, Dabrowski K, Gaylord TG, Hardy RW, *et al*. Expanding the utilization of sustainable plant products in aquafeeds: a review. Aquaculture Research. 2007;38(6):551-579.
11. Ghosh K, Mandal S. Nutritional evaluation of groundnut oil cake in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings after solid-state fermentation with a tannase producing yeast, *Pichia kudriavzevii* (GU939629) isolated from the fish gut. Aquaculture Reports. 2015;2:82-90.
12. Glencross BD, Booth M, Allan GL. A feed is only as good as its ingredients–a review of ingredient evaluation strategies for aquaculture feeds. Aquaculture nutrition. 2007;13(1):17-34.
13. Hardy RW. New developments in aquatic feed ingredients and potential of enzyme supplements. Avances en Nutrición Acuicola, 2000.
14. Hassaan MS, Soltan MA, Mohammady EY, Elashry MA, El-Haroun ER, Davies SJ. Growth and physiological responses of Nile tilapia, *Oreochromis niloticus* fed dietary fermented sunflower meal inoculated with *Saccharomyces cerevisiae* and *Bacillus subtilis*. Aquaculture. 2018;495:592-601.
15. Heuze V, Tran G, Chapoutot P, Renaudeau D, Bastianelli D, Lebas F. Safflower (*Carthamus tinctorius*) seeds and oil meal, 2012.
16. Jannathulla R, Dayal JS, Ambasankar K, Muralidhar M. Effect of Aspergillus niger fermented soybean meal and sunflower oil cake on growth, carcass composition and haemolymph indices in *Penaeus vannamei* Boone, 1931. Aquaculture. 2018;486:1-8.
17. Kamarudin MS, Kaliapan KM, Siraj SS. The digestibility of several feedstuffs in red tilapia. In Fish Nutrition Research in Asia, Proceedings of the Third Asian Fish Nutrition Network Meeting. 1989, 118-122.
18. Karboune S, Khodaei N. Structures, isolation and health-promoting properties of pectic polysaccharides from cell wall-rich food by-products: A source of functional ingredients. Current Opinion in Food Science. 2016;8:50-55
19. Lim SJ, Lee KJ. Partial replacement of fishmeal by cottonseed meal and soybean meal with iron and phytase supplementation for parrotfish *Oplegnathus fasciatus*. Aquaculture. 2009;290:283-289.
20. Maina JG, Beames RM, Higgs D, Mbugua PN, Iwama G, Kisia SM. The feeding value and protein quality in high-fibre and fibre-reduced sunflower cakes and Kenya's "omena" fishmeal for tilapia (*Oreochromis niloticus*). Livestock Research for Rural Development. 2007;19:164.
21. Mohan Dey M, Rab MA, Paraguas FJ, Piumsombun S, Bhatta R, Ferdous Alam M, *et al*. Fish consumption and food security: a disaggregated analysis by types of fish and classes of consumers in selected Asian countries. Aquaculture Economics & Management. 2005;9(1-2):89-111.
22. Munguti JM, Liti DM, Waidbacher H, Straif M, Zollitsch W. Proximate composition of selected potential feedstuffs for Nile tilapia (*Oreochromis niloticus Linnaeus*) production in Kenya. Die Bodenkultur. 2006;57(3):131-141.
23. Olvera-Novoa MA, Olivera-Castillo L, Martinez-Palacios CA. Sunflower seed meal as a protein source in diets for *Tilapia rendalli* (Boulanger 1896) fingerlings. Aquaculture Research. 2002;33:223-229.

24. Pandey A, Ashakumary L, Selvakumar P. Copra waste-a novel substrate for solid-state fermentation. Bioresource Technology. 1995;51(2-3):217-220.
25. Pandey A, Soccol CR, Nigam P, Soccol VT. Biotechnological potential of agro-industrial residues. I: sugarcane bagasse. Bioresource technology. 2000;74(1):69-80.
26. Pederson CS. Microbiology of food fermentations/ Carl S. Pederson, 1971.
27. Rumsey GL. Fish meal and alternate sources of protein in fish feeds update. Fisheries. 1993;18(7):14-19.
28. Sadh PK, Kumar S, Chawla P, Duhan JS. Fermentation: a boon for production of bioactive compounds by processing of food industries wastes (by-products). Molecules. 2018;23(10):2560.
29. Sanz A, Morales AE, de la Higuera M, Cardenete G. Sunflower meal compared with soybean meal as partial substitutes for fish meal in rainbow trout (*Oncorhynchus mykiss*) diets: Protein and energy utilization. Aquaculture. 1994;128:287-300.
30. Soltan MA, Hassaan MS, Abdella MS, El-Syaad GA, El-Ashry MA. Yeast fermented sunflower meal as a replacer for fish meal in diets of the Nile tilapia, *Oreochromis niloticus*. Egyptian Journal of Aquatic Biology and Fisheries. 2015;19(2):65-72.
31. Stanbury PF, Whitaker A, Hall SJ. Microbial growth kinetics. Principles of fermentation technology. Butterworth Heinemann, Oxford, United Kingdom. 1995, 13-34.
32. Steinkraus KH. Fermented foods, feeds and beverages. Biotechnology advances. 1983;1(1):31-46.
33. Storebakken T, Shearer KD, Baeverfjord G, Nielsen BG, Asgard T, Scott T, De Laporte A, *et al.* Digestibility of macronutrients, energy and amino acids, absorption of elements and absence of intestinal enteritis in Atlantic salmon, *Salmo salar*, fed diets with wheat gluten. Aquaculture. 2000;184(1-2):115-132.
34. Tacon AGJ, Webster JL, Martinez CA. Use of solvent extracted sunflower seed meal in complete diets for fingerling rainbow trout (*Salmo gairdneri Richardson*). Aquaculture. 1984;43(4):381-389.
35. Tacon AG, Hasan MR, Subasinghe RP, FAO. Use of fishery resources as feed inputs to aquaculture development: trends and policy implications (No. 1018). Rome: Food and Agriculture Organization of the United Nations, 2006.
36. Temelkovska K, Pavlovska G. Reducing the oxidation of cold pressed sunflower oil by adding rosemary or parsley. International Journal of Food Science and Nutrition. 2021;6(5):65-9.