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Non-Conventional Plant Resources Using for Fish Feed Formulation and Their Opportunities & Challenges

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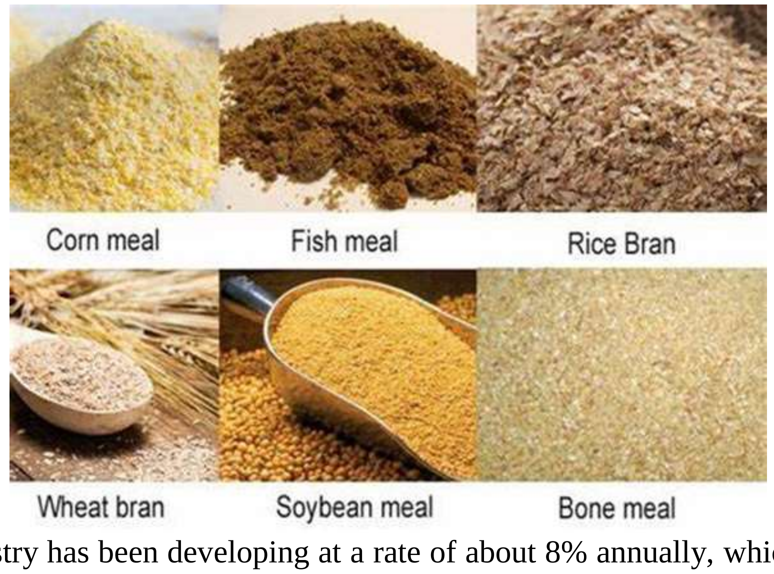
SUMMARY

Aquaculture, a rapidly growing sector in the global food industry, faces challenges in meeting the increasing demand for fish and fisheries products while addressing concerns about environmental impact, resource sustainability, and social responsibility. As the industry evolves towards more intensive farming methods, there is a critical need to find alternative protein sources to reduce reliance on fish meal, which is limited by declining marine fishery production. Terrestrial plant products and by-products offer promising alternatives, but their utilization is hindered by antinutritional factors (ANFs) and nutrient imbalances. This review examines the challenges and opportunities associated with key plant ingredients such as soybean meal, cottonseed meal, canola/rapeseed meal, peanut meal, and sunflower meal, highlighting strategies to mitigate ANFs and enhance nutritional quality through technological advancements. Despite inherent challenges, plant ingredients present viable solutions to meet the dietary needs of aquaculture species while promoting sustainability and reducing reliance on marine resources.

INTRODUCTION

Fish and fishery products are in high demand worldwide, which is driving the growth of aquaculture, a significant food business. According to the Handbook of Fisheries Statistics (2020), the aquaculture industry provided 8.2.1 million MT, or 45.99%, of the 178.5 million MT of fish produced globally in 18.1. There has been a noticeable change in the inland fisheries sector's rising contribution, driven by freshwater aquaculture, with the country's total fish output reaching 14.18 mmt in 2019–20. Around 88% of fish raised for food originates from freshwater aquaculture, which saw a rise in national aquaculture production from 1.9 million metric tons in 2000–01 to 6.2 million metric tons in FY 2017–18 (NFP, 2020). It's customary to characterize fish farming as extensive, semi-intensive, and intensive.



The aquaculture industry has been developing at a rate of about 8% annually, which has caused systems to becoming more and more intense. Because of the high stocking density used in intensive farming, the fish are reliant on the feed that is given to them. Aquaculture has been increasingly productive over the past several decades, but it hasn't done so without raising issues about the use of natural resources, the environment, and societal perception. Fishmeal (FM) is becoming more and more expensive. Its inconsistent supply, limited availability, and low quality have drawn attention to the need for FM to be partially or entirely replaced by other protein sources. The use of FM alternatives by the fish feed industry requires extreme caution. Nowadays, oilcake (mustard, groundnut, soybean, etc.) is produced from traditional plant resources in the aquaculture industry as a source of protein to promote development. In addition to the essential elements (protein, carbs, and fats), fish are additionally fed micronutrients, immunostimulants, feed attractants, artificial growth boosters, and colour enhancers (FAO, 1980) [51] in order to improve pigmentation, meat quality, disease resistance, and other desired characteristics. Through the process of bio-magnification, these artificial substances may have long-term residual effects that impact the health of fish and its customers.

Fish meal as an ingredient in fish diet

Fish meal is a major source of protein for the feed making company. The best supply of the necessary amino acids that fish need is fish meal. Additionally, the fish meal has a high protein content and adequate micronutrient availability. Conversely, certain highly unsaturated fatty acids are present in fish oil. Another factor pushing the use of fish meal in diets worldwide is the decline in the use of other meat and bone meals brought on by the bovine spongiform encephalopathy/mad cow disease. Fish meal has special nutrients like taurine and other as-yet-unidentified ingredients. If fish meal is completely replaced, fish health and growth response may suffer and these nutrients may be depleted. Although these advantages, the production of fish meal and fish oil is heavily reliant on the bycatch and productivity of marine fisheries. Statistics on the production of fish meal worldwide showed that production rates are falling by an average of 1.7 per year. The production of fish meal and fish oil worldwide has been impacted by severe strain on the marine capture fishery and diminishing stocks. Worldwide, the majority of fish meal is utilized as feed for land animals like hens and pigs. As a result, competition for fish meal as a premium feed ingredient is growing due to rising terrestrial animal output. Fish meal and fish oil are becoming more and more scarce, which has forced the aquaculture sector to look for new substitute feed components.

Alternative Components for Fish Feed: A Perspective

Products and byproducts from terrestrial plants

Oilseed meals, which are made from the cake left over after oil is extracted from soybean, cottonseed, canola, peanut, and sunflower seeds, are the most significant plant-based protein supplements (Halver and Hardy, 2002). Low-processed plant protein sources are cheap and easily accessible, but their use to carnivorous fish is restricted due to the inclusion of structural carbohydrates, starch, and a wide range of antinutritional factors (ANFs) (Øverland et al., 2009). Protease inhibitors, lectins, phytic acid, saponins, phytoestrogens, antivitamins, allergens, tannins, gossypol, and glucosinolates are the most prevalent ANFs in terrestrial plant products (Francis et al., 2001).

Soybean Meal (SBM)

According to Gatlin et al. (2007), soybean meal is now the most popular substitute for fish meal because of its affordable pricing, simple accessibility, excellent amino acid profile, and competitive nutritional content. But for many fish species, SBM-based diets have detrimental impacts on growth performance, nutrient utilization, and digestibility (Booman et al., 2018; Kaushik et al., 1995; Urán et al., 2008; Zhang et al., 2018). In such instances, enteritis was brought on by the ANFs in soybean meals (Knudsen et al., 2008; Krogdahl et al., 2015; Marković et al., 2016; Nayak, 2010; Sørensen et al., 2011). The most common type of soybean utilized is SBM, which comes in two forms: dehulled (containing about 48% crude protein) and hulled (containing approximately 44% crude protein) (NRC, 2001).

Cottonseed meal (CSM)

It is a byproduct of the companies that produce cottonseed oil and cotton fiber. CSM is the third most utilized seed by weight and has a crude protein concentration of around 41.7% (Gatlin et al., 2007). However, the toxicity of the gossypol is the main issue with CSM usage (Rinchard et al., 2002). However, because to its high crude fiber content and low lysine and methionine levels, there are further issues with CSM as a source of protein (Cheng and Hardy, 2002b). Gossypol is a potent natural antioxidant that has drawn a lot of interest for its biological actions, including enhancing immune responses and disease resistance, in the context of channel catfish (Ictalurus punctatus), according to studies (Yildirim et al., 2003). Canola oil and rapeseed are both plants *Brassica napus* and *Brassica campestris*.

Canola meals

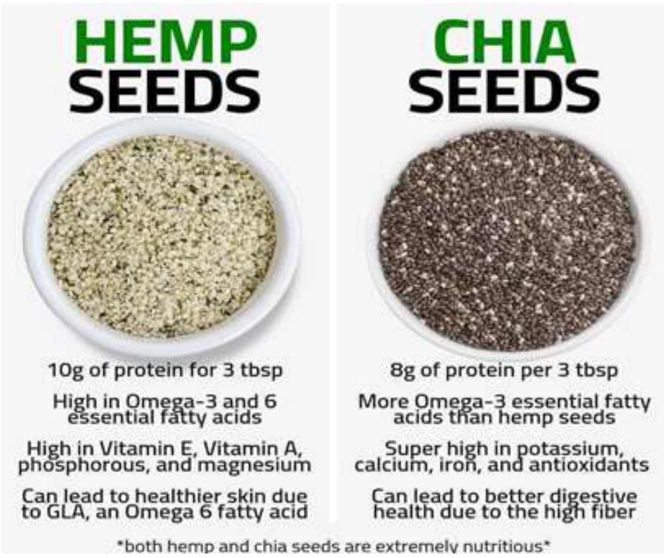
About 35% crude protein and 12% crude fiber are found in canola meal, which is produced during the oil extraction process (Sørensen et al., 2011). For carnivorous fish, canola has limited use due to its relatively high crude fiber and phytate content (Drew et al., 2007). The existence of ANFs limits the use of rapeseed meal as animal feed (Davies et al., 1990).

Peanut meal (PM)

It is a by-product of oil extraction from whole or broken peanut seeds, and according to Babal et al. (2005), it has an average crude protein concentration of 45.6% but a varied chemical makeup. Lysine deficiency affects several fish species, including PM (Lim, 1997). Aspergillus flavis, a fungus that causes aflatoxin, frequently contaminates peanuts (Bezerra da Rocha et al., 2014; Marroquín-Cardona et al., 2014; Richard, 2007).

Sunflower meal (SFM)

After the oil is extracted from dehulled sunflower seeds, the oil cake is used to make this. According to Sørensen et al. (2011), SFM contains minimal antinutritional components and is very appealing for fish. It possesses high amounts of lignin and fiber (18–23%) but low levels of lysine (Mérida et al., 2010). Despite the low digestible energy resulting from the carbohydrate portion, sunflower meal demonstrated an excellent utilization of protein by the digestive system (Sanz et al., 1994).



Hemp Seed

Aquaculture – Sample (2022) discovered that in striped bass diets, up to 50% of fish meal can be replaced with hemp seed meal without impacting growth or digestibility.

Poultry – The hemp seed meal had a 5:1 ratio of Omega-6 (linoleic plus γ-linolenic acid) to Omega-3 (α-linolenic) fatty acids. Adding hemp seed meal to laying hens' diets reduced the percentage of palmitic acid in the yolk while increasing the percentages of linoleic and α-linolenic acids(Silversides et al., 2002).

Dairy – Hempseed cake was used as a protein feed instead of soybean meal in intensively fed developing calves, and it resulted in equal weight gain and carcass characteristics, as well as enhanced rumen function, due to the increased Fiber content of hemp seed cake compared to soybean meal (Eriksson, 2007).

Chia seed

The chemical composition of chia seeds has been analysed by many researchers. Chia seeds contain a high content of fats (30–33%), carbohydrates (26–41%), dietary Fiber (18–30%), proteins (15–25%), vitamins, minerals, and antioxidants (wet basis). A control diet (30% protein) was enriched with chia seeds powder (CSP) and offered to Nile tilapia. Stimulating effects of dietary CSP were observed on the performance especially at the 10 g/kg diet. Feeding fish on CSP diets significantly enhanced haematological, antioxidants and immune indices.

Opportunities of plant ingredients

The benefits of using plant substances in aquaculture techniques are numerous, notwithstanding a few negative traits. By using different levels of technology, major hurdles in plant ingredients may be overcome. For instance, the removal of the carbohydrate portion results in a greater protein level in soy protein concentrates (soybean and corn gluten meal). Extrusion, heat treatment, and crop fractionation are methods that may be used to treat the anti-nutritional chemicals of plant constituents that are heat labile and heat stable, respectively. Simple techniques like de-hulling crops and more sophisticated techniques like solvent purification are both used in the fractionating process of plant feed components. The nutritional value of plant feed is improved by the enzymatic treatment of plant materials (phytase, for example, removes phytates). When fed these processed goods, fish have showed greater digestibility of crude protein and phosphorus, as well as higher growth and feed intake. Aquaculture has been using plant oils extensively for the past ten years since they are more readily available and less expensive. The main components used to produce plant oils are rapeseed, sunflower, palm, and soybean oil. It has been shown that soybean oil, linseed oil, and palm oil work well as a partial replacement for fish oil. The increased concentration of PUFA (poly unsaturated fatty acid) (oleic and linoleic acids) that soybean and rapeseed oils have is what fish need. In terms of the water requirements of the crops that produce plant oil, plant oil is sustainable. In semi-arid or dry climates, these crops may be grown extensively with little water needed. Different co-products are also produced as a result of the increased production of ethanol and biofuel from plants. After additional processing, those co-products can be used to aquaculture techniques. Certain co-products, such dried distillery grain, have a modest protein content and do not comprise anti-nutritional elements. These dried distilleries grains have a reduced phosphorus content, which reduces their ecological imprint.

Plant Ingredients	Challenges	Opportunities
Soybean meal	Contains heat stable anti-nutritional factors e.g. Saponins, phytic acid Some of the processing methods (e.g. Solvent extraction) leaves the anti-nutrient compounds still in the meal	Favourable EAA profile and high content of protein Ability to produce soy protein concentrate (low in anti-nutritional factors, soluble carbohydrates)
Pulses	Higher carbohydrate content than protein Presence of anti-nutritional factors especially phytic acid and tannins	Ability to produce protein concentrates which can increase the protein amount
Corn gluten meal	Deficiency in lysine and arginine and high level of leucine Wet milling of corn gluten meal- leaves xanthophyll pigments Increased production of genetically modified corn gluten meal	67% of crude protein in dry matter basis Not contain harmful anti-nutritional factors
Wheat gluten meal	Deficiency in lysine, Methionine, and Arginine	Contains 85% of protein in dry matter basis Higher digestibility in Atlantic salmon, Rainbow trout, and Coho salmon No morphological changes in distal intestine tissues of fish
Sun flower meal	Higher content of fibre Low digestive performance in fish due to high content of protease inhibitors, arginase inhibitors, and phytic acids	Ability to use against the salmon louse infection Preprocessing methods such as dehulling removes larger amount of fiber
Canola/ Rapeseed	Contains higher amount of fiber, glucosinolates Presence of anti-nutritional factors specially phytic acids, glucosinolates.	Ability to produce canola protein concentrate by aqueous extraction of fiber (higher protein content) Reasonable level of linolenic acid and low level of linoleic acid in rapeseed oil trigger the own production of EPA and DHA in salmonids at reasonable level
Lupins	Deficiency in methionine and lysine Presence of anti-nutritional factor especially alkaloids	High content of arginine and glutamic acid contains a low level of anti-nutritional factors

Summary of challenges and opportunities in major plant ingredients as reviewed by VKM and Sørensen *et al*.

Plant	Part to be used	Form	% Inclusion in feed	Importance	Reference
Protein Source					
Mulberry (*Morus alba*, Linn.)	Leaves	Meal	100 %	Enhanced feed efficiency and GSI	Bag *et al.*, 2012 [20]
Duckweed	Plant	Powder	10-25 %	Growth enhancement	Aslam and Zuberi, 2017 [19]
Azolla	Plant	Powder	10-40 %	Enhanced growth, feed utilization and carcass composition	Mosha, 2018 [99]
Cowpea (*Vigna unguiculata*)	Seed	Powder	20-30 %	Enhanced growth performance and survival	Olvera-Novoa *et al.*, 1997 [106]
Spirulina (*Spirulina platensis*)	Algae	Powder	40 %	Enhanced growth performance	Olvera-Novoa *et al.*, 1998 [105]
Carbohydrate/ Energy Source					
Banana (*Musa paradisiaca*)	Peels	Powder	5 %	Enhanced growth and immunity	Sreeja *et al.*, 2013; [127] Giri *et al.*, 2016 [57]
Beet root (*Beta vulgaris*)	Fruit	Powder	10 %	Growth and color enhancement	Jha *et al.*, 2012 [73]
Guava (*Psidium guajava*)	Leaves	Extract	2 %	Enhanced growth	Abdelhamid *et al.*, 2012 [2]
Moringa (*Moringa oleifera*)	Leaves	Extract	2 %	Enhanced growth	Suleiman *et al.*, 2018 [132]
Papaya (*Carica papaya*)	Leaves	Extract	20 %	Enhanced growth and nutrient utilization	Olaniyi and Salau, 2013; [104] Muralidhar *et al.*, 2017 [100]
	Seed	Powder	6 g/Kg feed	Enhanced growth performance, survival and feed utilization	Towers, 2014 [141]
	Unripe fruit / leaves	Paste / powder		Enhanced growth and feed utilization	Tewari and Ram, 2012; [139] Tewari *et al.*, 2018 [138]
Pointed gourd (*Trichosanthes dioica*)	Fruit	Paste	5, 10 & 15 %	Enhanced serum parameters	Kaur *et al.*, 2016; [18] Kaur *et al.*, 2017c [76]
Coriandrum sativum				Enhanced immunity and protection against *Aeromonas hydrophila*	Innocent *et al.*, 2011
Garden Pea pod *Pisum sativum*	Empty pod	Powder	20 %	Improved growth performance	Tewari *et al.*, 2019 [137]
Sweet Potato *Ipomea batatas*	Peel	Powder	15 %	Improved growth	Omoregie *et al.*, 2009; [107] Faramarzi *et al.*, 2012 [52]
Immunostimulant					
Garlic *Allium sativum*	Fruit	Powder	20 g/Kg fish feed	Enhanced growth, feed utilization and immunity	Nya and Austin, 2009 [103] Adineh *et al.*, 2020 [109]
Ashwagandha *Withania somnifera*	Roots	Powder	20 g/Kg fish feed	Enhanced growth and protection against bacteria	Sharma *et al.*, 2017 [117]
Giloy *Tinospora cordifolia*	Leaves	Powder	1%	Enhanced specific growth rate and feed conversion ratio	Upreti and Chauhan, 2018 [142]
Aloe vera	Leaves	Gel & Extract	1% & 2%	Improve growth, feed utilization, blood parameters and immunity	Khan *et al.*, 2018 [83]
Amla *Phyllanthus emblica*	Fruit	Powder	3%	Growth enhancement and flesh quality improvement	Srivastava *et al.*, 2019 [130]
Phyllanthus niruri	Leaves	Extract	20 mg/Kg	Activate the immune system	Muthlakshmi *et al.*, 2016
Guava *Psidium guajava*	Leaves	Extract	10 mg/g	Reduced mortality against *A. hydrophila*	Gobi *et al.*, 2016 [58]
Astragalus membranaceus	Root & Stem	Powder	0.5 and 1 %	Enhanced immunity	Yuan *et al.*, 2007 [146]
Neem *Azadirachta indica*	Leaf	Extract	1 g/Kg	Enhanced survival and immuno-stimulatory effects	Kaur *et al.*, 2019 [71] Kaur *et al.*, 2017d [82]
Turmeric *Curcuma longa*	Root	Powder	0.5 %	Enhanced growth and resistance against *Pseudomonas fluorescens*	Mahmoud *et al.*, 2014 [90]
Tulsi *Ocimum sanctum*	Leaf	Extract	0.2 %	Enhance immune response & disease resistance against *Aeromonas hydrophila*	Das *et al.*, 2015
			3 %	Increased storage life of Tuna chunks under chilling condition	Suyani *et al.*, 2020 [133]
		Powder	2 %	Improved growth & survival	Sikotariya and Yusufzai, 2019 [119]
Moringa oleifera	Leaf	Powder	15 %	Enhanced growth and improve skin mucus immunity	Bisht *et al.*, 2020 [26]
Color Enhancement					
Carrot *Daucus carota*	Waste	Powdered meal	5 %	Enhanced growth and pigmentation	Jain *et al.*, 2019b [71]
Spirulina platensis and *Haematococcus pluvialis*	Algae	Powder	1.5- 2 % and 1 % resp	Color enhancement	Ako *et al.*, 1997 [11]
Marigold *Tagestes erecta* and Ixora *Ixora coccinea*	Flower	Powder	5 %	Color enhancement	Golandaj *et al.*, 2015 [59]
Hibiscus rosa siensis	Flower	Powder	10 %	Promote pigmentation	Bagre *et al.*, 2011 [21]
Amaranth *Amanranthus spp.* and Mint *Mentha spp.*	Leaves	Powder	1 %	Enhanced growth and body coloration	Ahilan *et al.*, 2008 [10]

CONCLUSION

The increasing demand for fish and fisheries products necessitates the development of sustainable aquafeed formulations that minimize reliance on fish meal and optimize the utilization of alternative protein sources. While terrestrial plant ingredients offer potential solutions, their effective incorporation into aquafeeds requires addressing challenges related to ANFs, nutrient imbalances, and digestibility limitations. Through technological innovations such as fractionation, enzymatic treatment, and genetic modification, these challenges can be overcome, unlocking the nutritional value of plant ingredients and promoting the growth and health of farmed fish. By embracing these opportunities and adopting responsible aquafeed practices, the aquaculture industry can enhance its resilience, minimize environmental impact, and contribute to global food security in a sustainable manner.

REFERENCES

Aslam, S., Zuberi, A., & Nazir, A. (2017). Effect of duckweed by replacing soybean in fish feed on growth performance of Grass carp (*Ctenopharyngodon idella*) and Silver carp (*Hypophthalmichthys molitrix*). *Int J Fish Aquat Stud*, *5*, 278-282.

Bandara, T. (2018). Alternative feed ingredients in aquaculture: Opportunities and challenges. *J. Entomol. Zool. Stud*, *6*(2), 3087-3094.

Bisht, M., Kumar, A., & Shah, T. K. (2020). Effect of Moringa oleifera leaf powder on skin mucosal immune responses and growth performance of guppy, *Poecilia reticulata* (Peter, 1860). *Aquaculture research*, *51*(12), 4984-4990.

Drew, M. D., Borgeson, T. L., & Thiessen, D. L. (2007). A review of processing of feed ingredients to enhance diet digestibility in finfish. *Animal Feed Science and Technology*, *138*(2), 118-136.

El-Nadi, A. S., Abozaid, H., Elkady, R. I., & Khames, D. K. (2017). Influence of different levels of potato peels on growth performance and carcass analysis of Nile Tilapia. *Internafional Journal of ChemTech Research*, *10*(2), 582-587.

Francis, G., Makkar, H. P., & Becker, K. (2001). Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture*, *199*(3-4), 197-227.

Giri, S. S., Jun, J. W., Sukumaran, V., & Park, S. C. (2016). Dietary administration of banana (Musa acuminata) peel flour affects the growth, antioxidant status, cytokine responses, and disease susceptibility of rohu, *Labeo rohita*. *Journal of immunology research*, *2016*.

Hardy, R. W. (2010). Utilization of plant proteins in fish diets: effects of global demand and supplies of fishmeal. *Aquaculture research*, *41*(5), 770-776.

Kaushik, S. J., Cravedi, J. P., Lalles, J. P., Sumpter, J., Fauconneau, B., & Laroche, M. (1995). Partial or total replacement of fish meal by soybean protein on growth, protein utilization, potential estrogenic or antigenic effects, cholesterolemia and flesh quality in rainbow trout, *Oncorhynchus mykiss*. *Aquaculture*, *133*(3-4), 257-274.

Khan, I., Dhawan, A., & Ansal, M. D. (2018). Effect of Aloe vera supplemented feed on survival and growth of common carp (*Cyprinus carpio*). *Indian Journal of Animal Nutrition*, *35*(2), 206-213.

Mosha, S. S. (2018). A review on significance of Azolla meal as a protein plant source in finfish culture. *Journal of Aquaculture Research and Development*, *9*(7).

Rakhmawati, R., Marlina, E., & Warji, W. (2020, July). Efficacy Dietary Supplementation of Banana Peel Meal on Growth and Cannibalism level of Giant Freshwater Prawn (*Macrobranchium rosenbergii*). In *IOP Conference Series: Earth and Environmental Science* (Vol. 537, No. 1, p. 012037). IOP Publishing.

Ringø, E., Hemre, G. I., Amlund, H., Aursand, M., Bakke-McKellep, A. M., Olsen, R. E., & Svihus, B. (2009). Criteria for safe use of plant ingredients in diets for aquacultured fish.

Sikotariya, S., & Yusufzai, S. I. (2019). Effect of Ocimum sanctum (Tulsi) powder on the growth and survival in Cirrhinus mrigala fingerlings. *Journal of Entomology and Zoology Studies*, *7*(4), 239-244.

Sørensen, M., Morken, T., Kosanovic, M., & Øverland, M. (2011). Pea and wheat starch possess different processing characteristics and affect physical quality and viscosity of extruded feed for Atlantic salmon. *Aquaculture Nutrition*, *17*(2), e326-e336.

Srivastava, A., Ansal, M. D., & Khairnar, S. O. (2020). Effect of Ashwagandha (Withania somnifera) root powder supplementation on survival, growth and flesh quality of an Indian Major Carp, *Labeo rohita* (Ham.) fingerlings. *Animal Nutrition and Feed Technology*, *20*(3), 515-524.

Suleiman, A. M., Orire, A. M., & Sadiku, S. O. E. (2018). Impacts of Moringa oleifera leaves and Lannea barteri bark as growth promoting additives and survival rates in the diets of *Clarias gariepinus* fingerlings. *J Fish Res. 2018; 2 (2): 6-16. J Fish Res 2018 Volume 2 Issue*, *2*.

Tacon, A. G., Hasan, M. R., & Metian, M. (2011). Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects. *FAO Fisheries and Aquaculture technical paper*, (564), I.

Tewari, G., & Kaur, R. (2022). Fish feed supplementation using nonconventional plant resources: Way to sustainable aquaculture. *The Pharma Innovation Journal. SP-11 (5)*, 309-321.

Tewari, G., Pandey, A., Shanthanagouda, A. H., & Hundal, J. S. (2019). Effect Of Pea Pod As Feed Ingredient On Growth Performance of Common Carp, *Cyprinus Carpio*. *Journal of Experimental Zoology India*, *22*(2).

Trushenski, J. T., Kasper, C. S., & Kohler, C. C. (2006). Challenges and opportunities in finfish nutrition. *North American Journal of Aquaculture*, *68*(2), 122-140.

Upreti, P., & Chauhan, R. S. (2018). Effect of leaf powder of giloy (*Tinospora cordifolia*) in fish feed on survival and growth of post larvae of Catla. *Journal of Applied and Natural Science*, *10*(1), 144-148.

Vielma, J., Mäkinen, T., Ekholm, P., & Koskela, J. (2000). Influence of dietary soy and phytase levels on performance and body composition of large rainbow trout (Oncorhynchus mykiss) and algal availability of phosphorus load. *Aquaculture*, *183*(3-4), 349-362.

Yadwinder Kaur, Y. K., Asha Dhawan, A. D., & Shanthanagouda, A. H. (2017). Effect of neem leaf extract incorporated diet on survival, growth and flesh quality of common carp (*Cyprinus carpio*).