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A review on impacts of *Choerospondias axillaris* (Lapsi fruit) as supplement diet on growth performance of fish in Nepal

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Abstract
Traditional Fish Meals, the ideal protein source, is now threatened globally due to economic and environmental concerns. Many research is conducted to find the alternative for fish meals and most of the research indicates that inclusion of plant products in the fish diet is cheaper, eco-friendly, enhances growth, strengthens the immune system and prevents infections of fish. Hence, addition of the plant products as fish diets can potentially replace fish meal either partially or entirely for better fish production. As lapsi fruit is rich in Vitamin-C and native to Nepal, it can be used as a sustainable plant based supplement diet in fish feed. This paper reviews the research works published on the use of Lapsi fruit as a supplement diet in different fish cultures in Nepal and explores its potential application in aquaculture production, particularly as a replacement of fish meal. Among the reviewed fishes, Tilapia has the highest weight gain (273.03%) and maximum relative % of survival (83.34%) against infection of bacteria *Aeromonas hydrophila*, fed fish meal supplemented with 0.2% lapsi fruit extracts.

Keywords: Fish meal, protein source, plant based diet

Introduction
The global population is estimated to keep increasing over the next 50 to 60 years, peaking at approximately 10.3 billion by the mid-2080s, compared to 8.2 billion in 2024 [1]. This growing population can cause nutritional related issues, especially food security concerns throughout the world. As fish is an important source of food that provides nutrition (particularly protein) for humans, fish production has to be increased via aquaculture techniques in order to ensure food security and to maintain an uninterrupted supply of nutritious food.

As Nepal is the second richest country in the world in terms of water resources and climatically suitable for fish farming; fisheries seem to be a gold mine for Nepal. Fisheries in Nepal started in the early 1950's [2]. Ten fish species are recommended for aquaculture of which three are exotic species; Rainbow trout (*Oncorhynchus mykiss*), Pangas (*Pangasius hypophthalmus*) and Nile Tilapia (*Oreochromius niloticus*) and remaining seven are carp species of which three are indigenous species; Rohu (*Labeo rohita*), Naini (*Cirrhinus mrigala*) and Bhakur (*Catla catla*) and four are exotic species; Bighead carp (*Aristichthys nobilis*), Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*), and Common carp (*Cyprinus carpio*) [3].

To meet the high demand for fish as the cheapest animal protein source, aquaculture farmers are forced to engage in intensive, high-input, high-yield farming methods that impair growth and immune response to pathogens, ultimately leading to the outbreak of various diseases, resulting in huge economic losses [4]. In aquaculture production, fish feed is the most expensive input because of using animal protein sources like fishmeal and shrimp meal. However, its gradual increase in price and restricted availability has challenged the aqua-feed industry. To ensure the sustainable development of aquaculture, if plant sources can be used to supplement animal protein sources, not only will production costs be reduced, but growth and production will also increase with low side effects to the fish and consumer [5]. In this context, *Choerospondias axillaries* (Lapsi fruit) can be reliable alternative fish meal for sustainable aqua feed production as it is rich in vitamin C, antioxidants [6] and phytochemicals [7].

Lapsi (*Choerospondias axillaris*) is a large, deciduous fruit bearing tree and native to Nepal hills of the family Anacardiaceae. It is also known as "Nepali plum," and is also found in India, China, Thailand, Vietnam and Japan. It is cheap and easily available due to which it can be used as a plant based fish diet.The current review paper highlights the impacts of *Choerospondias axillaris* (Lapsi fruit) as a supplement diet on growth performance of various fishes in Nepal.

Tilapia

Tilapia, an African omnivorous freshwater fish, can be cultured in a wide range of aquaculture systems from simple low-density backyard ponds to highly intensive commercial farms, cages and raceways. It is one of the first fish species to be cultured in the world [8] and is now ranked third among the top farmed fish species, behind grass carp and silver carp [9]. In 1985, two species of tilapia, *Oreochromis niloticus* and *O. mossambicus* were introduced for the first time in Nepal from Thailand [10].

Labh *et al*. (2017) observed fish meal supplemented with LFE (lapsi fruit extracts) using 80% ethanol at 0.2% level fed to fingerlings of *O. niloticus* for 60 days and reported highest weight gain% and increased gill superoxide dismutase activity by 3-fold compared to control group. However, the lowest feed conversion ratio and alanine aminotransferase and aspartate aminotransferase activity were found in both liver and muscle. When challenged with *Aeromonas hydrophila*, maximum relative % of survival (83.34%) was noticed [11].

Shrestha, A. (2015) reported a significant increase in total protein and globulin levels in the liver, indicating an improved immune system due to the presence of vitamin C in LFE, which acts as an antioxidant. It was found increased mean final length, mean weight gain and specific growth rate (SGR) of Nile Tilapia. An inverse relation was found between food conversion ration (FCR) and the dose of LFE contained in the diets. The high survival rate observed in the fish can also be attributed to this immune system boost [12].

Silver Striped Catfish

Striped catfish (*Pangasianodon hypophthalmus*) is an exotic omnivorous fish and belongs to the Pangasiidae family, from Thailand, thus known as Thai pangas. This fish is one of the most suitable species for aquaculture due to survival in all kinds of environmental conditions and grows well in high stocking density (Fisheries Resources Survey System [FRSS], 2016) [13]. The origin of *P. hypophthalmus* is reported from the Mekong

River of Vietnam to the Chao Phraya River to Thailand [14]. In India, the fish was introduced from Bangladesh [15]. In Nepal, few farmers of Terai region have introduced pangas from India by their own efforts and doing successful cultivation for a few years [16].

Labh *et al*. (2017) reported feeding diets (40% protein) with 400 mg kg-1 extract of lapsi fruits prepared by using ethanol (70%) for 90 days and observed better weight gain percentage, SGR. Decreasing trends were observed in FCR as the dose of lapsi extract increased. Similarly, a cent percent survival rate was observed. Total serum protein, albumin, globulin and albumin/globulin ratio were found at the highest level. Better protein concentrations were observed in fish fed with a diet containing 400 mg kg -1 of lapsi extract supplemented diets. Enzymes like SGOT, SGPT, ALP from serum and NBT from blood were found the lowest as compared to other diets. Lowest SOD and Catalase enzymes of liver and gills were recorded [17].

Common Carp

Common carp (*Cyprinus carpio*) belongs to the family Cyprinidae-the largest family of freshwater fish, is the the fourth most widely cultivated freshwater fish species in the world [18] which was introduced in Nepal in 1956 and 1960 from India and Israel, respectively [19]. Originally native to temperate regions of Asia, especially China, common carp is now the most cultivated and refined carp species throughout the world [20].

As teleost fish, common carp lack the enzyme to biosynthesize Vitamin C which is essential to enhance the immune system of the body. Hence, Shakya *et al*. (2016) conducted an experiment to observe the impact of lapsi as a diet on common carp fish. For that, diet with 400 mg kg-1 of ethanol extract of lapsi fruits' pulp (LFP) along with dry fish powder, wheat flour and cod liver oil fed fingerlings was fed to fingerlings of Common carp fish for 10 weeks, resulted increase in weight increment percent, higher increment of SGR level, higher (73.2%) vitamin C level in brain and liver tissue with cent percent survival rate. However the lowest FCR was recorded. Hence, *Choerospondias axillaris* fruits (0.04%) can be used as supplementary diets which enhance the growth of common carp (*Cyprinus carpio*) and immunity [21].

Silver Carp

Silver carp (*Hypophthalmichthys molitrix*) (Valenciennes, 1844) (Cyprinidae), native to eastern asia, is one of the most versatile filter feeders that feed primarily on phytoplankton and zooplankton. Silver carp (*Hypophthalmichthys molitrix*) is ranked second among cultivated fish in world [22]. Silver carp is characterized by the flat and laterally compressed body covered by silvery scales.

Labh, S.N. (2020) reported that feeding supplemented diet of 0.8g/kg with ethanol extract (80%) of lapsi fruits to fingerlings of Silver carp for 90 days, found significantly higher weight gain, %weight gain, SGR, Haemoglogin (Hb), Mean Corpuscular Hb (MCH), Mean Corpuscular Hb Concentrations (MCHC) and lysozyme in experimental group where as FCR was found higher in the control diet group. However, there were no significant differences among the Haematocrit (Hct), Red Blood Cells (RBC), White Blood Cells (WBC) and Mean Corpuscular Volume (MCV) levels. It was reported that there was no mortality at the end of the study in all the groups [23].

Rohu

The rohu (*Labeo rohita*) is a species of fish of the carp family, found in rivers in South Asia. It is a column feeder which feeds on plant matter including decaying vegetation. It feeds on algae, periphyton (Rai & Yi, 2012), detritus and small proportion of crustaceans and rotifers. It is known that Rohu preferred plankton over artificial feed [24].

In the late 1970s breeding techniques of indigenous major carps (*Labeo rohita*, *Cirrhina mrigala* and *Catla catla*) were established (Singh and Yadav, 1996) which was a significant achievement in aquaculture history that provided momentum to the polyculture system in Nepal [25].

Like other teleost fish, *Labeo rohita* lacks the enzyme for endogenous synthesis of vitamin C. Since lapsi fruits are rich in vitamin C, Shakya *et al*. (2018) conducted an experiment

by including lapsi (400mg/kg) as a supplement diet by feeding to farm-raised fingerlings (3.2 ±0.014 g) for 90 days. It was recorded higher increase in length (57.43%) and weight (67.5%). Blood parameters like RBC, WBC, Hct, packed cell volume (PCV) and Hb were found significantly higher. High SGR(2.17±0.019), Vitamin C and Protein Concentration in brain and liver were recorded higher but FRC level was found decreased and cent percent survival rate was observed. Hence, 400 mg lapsi extract in one kg feed is recommended for successful culture of *L.rohita* in ponds [26].

Rainbow Trout

Rainbow trout, a cold water fish (*Oncorhynchus mykiss*) was introduced in 1968 and 1971 from India and reintroduced from Japan in 1988 [27]. Rainbow trout is an exotic fish belonging to the family of Salmonidae and native to the cold-water of rivers and lakes of North America. It is a carnivorous fish, depending upon small aquatic insects, crustaceans and small fish in the natural waters. However, it can be cultured in cemented raceways in flowing coldwater using artificial feed.

Shakya *et al*. (2019) observed cent percent survival rate with higher final average weight, weight gain %, SGR, Serum protein level, Vitamin C and Protein concentration in brain and liver and blood parameters like Haemoglobin, WBC and PCV when fed with 0.4g/kg lapsi pulp supplemented diet. However FCR was lower compared to the control diet fed trout. Hence, inclusion of lapsi fruit extract at 0.4 % concentration is recommended for better production [28].

Conclusion

Native to Nepal hills, Lapsi fruits contain high vitamin C. While feeding with a supplement of Lapsi fruit as diet, it was found to have a positive impact in various indicators like final average weight, weight gain %, SGR, survival rate etc. in fishes like tilapia, common carp, rainbow trout, rohu, silver carp and striped cat fish. Similarly it is cheap and locally available due to which the operational cost of fish farming is reduced. Many studies suggested the use of lapsi as a supplement in fish feed, can be the sustainable protein source alternative to fish meal in fish feed. Hence, it can be concluded that Lapsi can be used as a sustainable supplement diet in place of fish meal.

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