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COMPARISON OF NUTRITIONAL CHARACTERIZATION IN SELECTED INDIAN MAJOR CARPS (LABEO ROHITA, CATLA CATLA AND CIRRHINUS MRIGALA) FROM WILD AND CULTURED SOURCES

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ABSTRACT

Fish are a vital component of human nutrition, providing high-quality protein, essential fatty acids, vitamins and minerals that contribute to health and food security. The present study aimed to perform a comparative nutritional characterization of three Indian major carps*Labeo rohita* (rohu), *Catla catla* (catla) and *Cirrhinus mrigala* (mrigal) collected from wild and cultured sources in the Madurai district, Tamil Nadu. Proximate composition (protein, lipid, ash, moisture and carbohydrate) and amino acid profiles were analysed using standard AOAC and HPLC methods. The results revealed notable differences between wild and cultured groups. Cultured fishes exhibited higher protein (16.75–18.31%) and lipid (2.24–2.58%) contents, whereas wild counterparts showed higher moisture (74.52–76.06%) and ash (2.04–2.10%) levels. Carbohydrate contents were minimal in all samples (<1.1%). Amino acid analysis indicated that glutamic acid, aspartic acid, lysine, leucine and alanine were predominant across species. Cultured fish demonstrated relatively enhanced concentrations of both essential and non-essential amino acids, particularly lysine (8.52–10.43 g/100 g), leucine (7.31–8.74 g/100 g) and glutamic acid (16.92–19.52 g/100 g), reflecting better nutritional uptake and metabolic efficiency under optimized feeding conditions. Overall, the findings highlight that cultured Indian major carps possess superior protein and amino acid quality compared to their wild counterparts, attributed to improved dietary management and controlled rearing environments. These results emphasize the nutritional value of aquaculture-produced fish and provide insights for optimizing feed formulations and sustainable aquaculture practices aimed at enhancing the quality and productivity of freshwater fish species.

INTRODUCTION

Fish plays a vital role in global food and nutritional security, serving as an excellent source of high-quality protein, essential fatty acids, vitamins and minerals required for human health and development [1, 2]. In developing countries like India, fish not only contributes to food supply but also provides livelihood and income for millions of people engaged in the fisheries and aquaculture sector [3]. The biochemical composition of fish primarily its protein, lipid, carbohydrate, ash and moisture content that determines its nutritional quality, energy value, and consumer acceptance [4, 5]. These parameters can vary significantly depending on species, feeding habits, habitat, season and reproductive stage [6, 7].

Among freshwater species, the Indian major carps (IMCs) - *Labeo rohita* (rohu), *Catla catla*(catla) and *Cirrhinus mrigala* (mrigal) constitute the cornerstone of Indian inland aquaculture. These carps are favoured for their rapid growth, high market demand and good flesh quality [8,9]. India being the

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second-largest aquaculture producer globally where these three carps collectively account for over 80% of the country's freshwater fish production [10]. Ecologically, *C.catla* is a surface feeder, *L.rohita* is a column feeder and *C.mrigala* is a bottom feeder, resulting in natural differences in their feeding ecology and nutrient intake [11, 12].

Fish protein is of superior nutritional value compared to other animal proteins, as it contains all essential amino acids in balanced proportions [13]. It plays a crucial role in growth, reproduction and repair of body tissues [14]. Lipids, another important biochemical constituent, act as a major energy source and are rich in omega-3 polyunsaturated fatty acids (PUFAs), such as Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These fatty acids are well known for their cardio-protective, anti-inflammatory and neurodevelopmental functions [15,16]. Minerals such as calcium, phosphorus, magnesium and iron present in fish also contribute to various physiological and enzymatic processes essential for human metabolism [17,18]. The nutritional composition of fish is influenced by their habitat (wild or cultured environments). Wild fish generally feed on natural food resources available in their ecosystem, while cultured fish depend on formulated feeds or supplementary diets that may alter their biochemical composition [19, 20]. Several studies have shown that cultured fish often have higher lipid and lower protein content compared to their wild counterparts due to differences in diet and activity levels [21, 22]. Therefore, assessing and comparing the nutritional composition of wild and cultured fish species is essential to evaluate their relative dietary value, optimize aquaculture practices, and improve feed formulations.

Given the increasing demand for fish as a health-promoting food source, it is important to understand how aquaculture practices influence the nutritional characteristics of commonly consumed species. Hence, the present study aims to perform a comparative nutritional characterization of selected Indian major carps*Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*from wild and cultured sources, focusing on proximate composition, amino acid, fatty acid and mineral profiles. This comparative evaluation will provide valuable insights into species-specific nutritional variations and contribute to the development of sustainable and nutritionally enhanced aquaculture strategies.

MATERIAL AND METHOD

Sample collection:

Samples of the selected Indian major carps (*Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*) were collected from both wild and cultured environments in and around the Madurai district, Tamil Nadu. Immediately after collection, the samples were cleaned, filleted and placed in labelled, sterilized polythene bags (100g each). These were then stored in an insulated ice box and promptly transported to the laboratory for further analysis.

Sample Processing

The collected fish samples were first dressed and gutted by carefully removing scales, fins and viscera using scissors and a kitchen knife. The dressed fish were then thoroughly washed with clean tap water to remove blood, slime, dirt, microbes and other unwanted particles. After washing, the samples were cut into small pieces with a knife and scissors and subsequently ground into a homogenous mixture.

Estimation of Proximate Parameters

The proximate composition of the fish samples was determined as follows:

Protein content: Crude protein was estimated using the micro-Kjeldahl method [24].

Lipid content: Crude lipid was determined according to the method described by the Association of Official Analytical Chemists (AOAC, 1990) [25].

Ash content: Ash content was measured following AOAC procedures (1990) [25].

Moisture content: Moisture was determined using AOAC (1990) standard protocols [25].

Amino Acid Analysis

For amino acid profiling, freeze-dried fish muscle samples were hydrolysed with 6N hydrochloric acid at 110 °C for 24 hours. The hydrolysate was then neutralized, filtered and analysed using high-performance liquid chromatography (HPLC), following standard protocols [26]. Both essential and non-essential amino acids were quantified, and their concentrations were expressed as g/100 g of protein.

Data Analysis

All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation (SD). Statistical analysis was conducted using Microsoft Excel and SPSS version 20.0.

RESULTS AND DISCUSSION

Proximate composition

Table 1. The proximate composition of Catla catla, Labeo rohita, and Cirrhinus mrigala from wild and cultured environments

Species	Source	Proximate composition (%)				
		Moisture	Protein	Lipid	Ash	Carbohydrate
Catla catla (Catla)	Wild	76.06±2.24	17.67±0.31	1.32±0.16	2.06±0.06	0.83±0.21
	Culture	74.42±3.72	18.31±0.41	2.58±0.76	1.75±0.10	1.01±0.12
Labeo rohita (Rohu)	Wild	74.52±1.07	16.99±0.49	1.96±0.14	2.10±0.13	0.70±0.09
	Culture	77.36±1.21	17.23±1.53	2.24±0.12	1.88±0.65	0.90±0.09
Cirrhinus mrigala (Mrigal)	Wild	74.80±1.43	15.23±0.84	1.83±0.26	2.04±0.03	0.61±0.16
	Culture	75.04±1.65	16.75±0.90	2.47±0.37	1.41±0.12	0.86±0.15

The proximate composition of selected farmed and wild fish species (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) was analysed, showing variations in protein, lipid, ash, moisture and carbohydrate contents among species and sources.

Protein content

Protein content ranged from 16.75% (C. mrigala, farmed) to 18.31% (C. catla, farmed). Among the studied species, higher protein levels were found in cultured environment (*C. catla* (18.31±0.41%), *L. rohita* (17.23±1.53%) and *C. mrigala* (16.75±0.90%)). Protein contents in wild counterparts were slightly lower (*C. catla* (17.67±0.31%), *L. rohita* (16.99±0.49%) and *C. mrigala* (15.23±0.84%). These values are consistent with standard protein contents of 15–19% in Indian major carps.

Lipid content

Lipid content varied between 1.32% (C. catla, wild) and 2.58% (C. catla, cultured). In general, cultured species have higher lipid levels than wild ones (*C. catla* (2.58±0.76% vs. 1.32±0.16%), *L. rohita* (2.24±0.12% vs. 1.96±0.14%) and *C. mrigala* (2.47±0.37% vs. 1.83±0.26%)). This trend reflects improved nutritional management in aquaculture, enhancing lipid deposition.

Ash content

Ash content ranged from 1.41% (C. mrigala, farmed) to 2.06% (C. catla, wild). Wild fishes generally contain higher ash content than cultured ones (*C. catla* (2.06±0.06% vs. 1.75±0.10%), *L. rohita* (2.10±0.13% vs. 1.88±0.05%) and *C. mrigala* (2.04±0.03% vs. 1.41±0.12%)). These observations indicating that wild fishes may accumulate more minerals through their natural diets.

Moisture content

Moisture content of the studied species ranged from 74.04% (C. mrigala, farmed) to 76.06% (C. catla, wild). Higher moisture levels were observed in wild species (*C. catla* (76.06±2.24%), *L. rohita* (74.52±1.07%) and *C. mrigala* (74.80±1.43%)). Farmed counterparts showed slightly lower moisture (*C. catla* (74.42±3.72%), *L. rohita* (77.36±1.21%), *C. mrigala* (75.04±1.65%).

Carbohydrate content

Carbohydrate content was minimal in all species, ranging from 0.61% (C. mrigala, wild) to 1.01% (C. catla, farmed). Farmed species exhibited slightly higher carbohydrate levels compared to wild species.

Amino acid profile

The amino acid composition of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* from wild and cultured environments is presented in Table 2.

In *C. catla*, glutamic acid (19.52 g/100 g) was the most abundant amino acid in cultured fish, followed by aspartic acid (11.14 g/100 g), lysine (8.52 g/100 g), and Leucine (8.74 g/100 g). The wild counterpart showed slightly lower concentrations for most amino acids. Similarly, *L. rohita* showed high levels of glutamic acid (16.92 g/100 g), lysine (9.32 g/100 g) and alanine (7.78 g/100 g) in cultured samples compared to wild ones.

Table 2. The Amino acid composition of Catla catla, Labeo rohita, and Cirrhinus mrigala from wild and cultured environments

Amino Acid	*Catla catla*(Catla)		*Labeo rohita* (Rohu)		*Cirrhinus mrigala* (Mrigal)	
	Wild	Culture	Wild	Culture	Wild	Culture
ESSENTIAL AMINOACIDS						
Histidine	3.28	4.43	4.86	5.12	3.12	3.66
Isoleucine	3.18	3.30	3.66	4.25	2.94	3.22
Leucine	7.96	8.74	7.14	7.77	7.09	7.31
Lysine	8.03	8.52	8.76	9.32	9.08	10.43
Phenylalanine	0.17	0.95	2.73	3.52	2.98	3.44
Methionine	1.60	1.98	1.94	2.02	2.00	2.06
Threonine	4.08	4.40	3.88	4.28	3.98	4.25
Tryptophan	1.17	1.52	0.98	1.23	0.12	0.31
Valine	5.13	4.86	4.31	4.47	4.27	4.51
NON - ESSENTIAL AMINOACIDS						
Alanine	6.58	7.44	6.92	7.78	6.31	7.21
Arginine	5.21	5.91	3.87	4.08	4.66	5.68
Aspartic acid	10.98	11.14	9.86	10.74	10.07	11.92
Glutamic acid	18.21	19.52	14.75	16.92	16.43	17.95
Cysteine	0.69	0.86	1.97	2.12	1.21	1.28
Glycine	5.64	7.01	3.63	4.16	3.88	4.97
Proline	1.94	2.88	2.97	3.86	2.66	3.50
Serine	4.10	4.14	4.08	4.13	4.11	4.17
Tyrosine	2.82	3.52	3.02	3.32	3.27	3.49

In *C. mrigala*, glutamic acid (17.95 g/100 g), lysine (10.43 g/100 g) and aspartic acid (11.92 g/100 g) were predominant in the cultured group, again indicating enhanced amino acid deposition under farming conditions. Among essential amino acids (EAA), leucine, lysine and isoleucine were most abundant in all species, ranging from 7.09–8.74 g/100 g for leucine, 8.03–10.43 g/100 g for lysine and 2.94–4.25 g/100 g for isoleucine. Non-essential amino acids (NEAA) such as glutamic acid and aspartic acid dominated across species, accounting for a major portion of total amino acids.Overall, cultured fishes exhibited slightly higher concentrations of both EAA and NEAA compared to their wild counterparts

DISCUSSION

The proximate analysis revealed that cultured *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala* generally exhibited higher protein and lipid contents, while wild counterparts had slightly higher moisture and ash levels.

Figure 1. The Proximate nutrition composition (%) in (a) *Catla catla*, (b) *Labeo rohita*, (c) *Cirrhinus mrigala* in Wild group compared to the cultured group

Elevated protein in cultured fish reflects improved feed quality and nutrient availability, enhancing growth and muscle development. Higher lipid content in farmed fish indicates greater energy reserves, which support metabolism and physiological activities, whereas higher ash in wild fish suggests greater mineral accumulation from natural diets, important for skeletal development and enzymatic functions. Minimal carbohydrate content in all species aligns with the protein- and lipid-rich composition typical of freshwater carps.

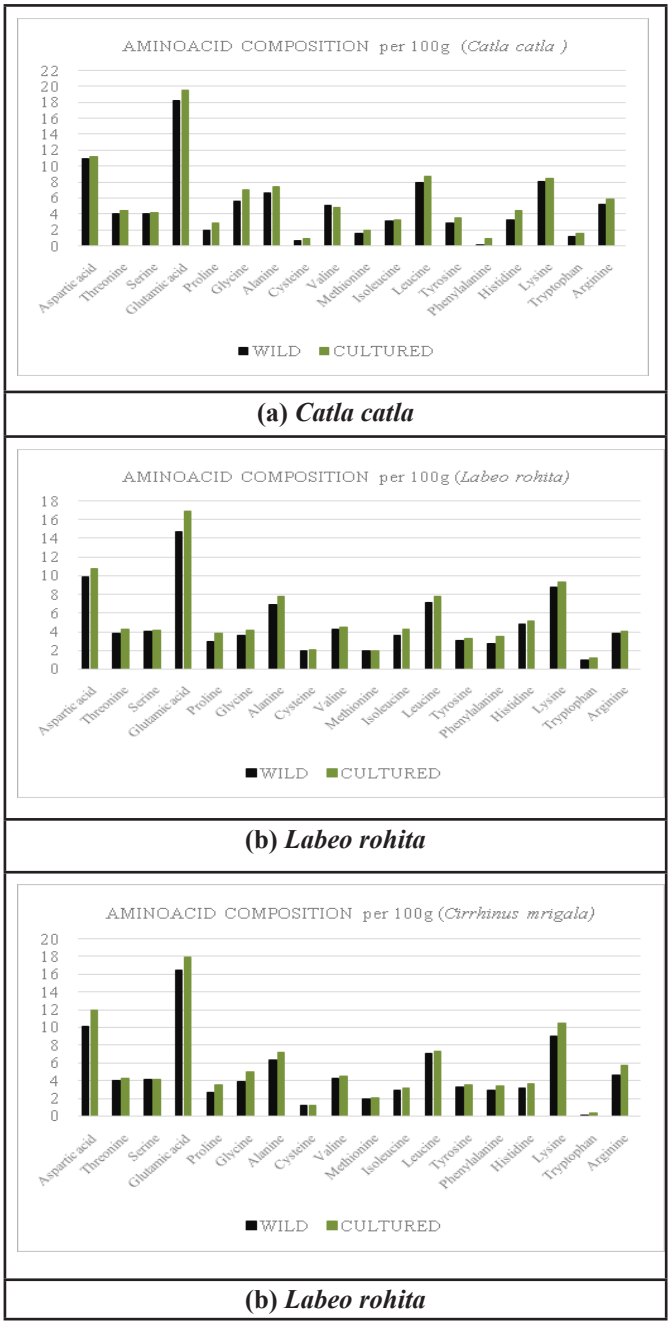

Figure 2. The Amino acid composition (per 100g) in (a) *Catla catla*, (b) *Labeo rohita*, (c) *Cirrhinus mrigala* in Wild group compared to the cultured group

Amino acid profiling showed glutamic acid, aspartic acid, lysine, leucine and alanine as predominant. Glutamic acid and aspartic acid, major non-essential amino acids, play critical roles in nitrogen metabolism, neurotransmission, and energy production. Essential amino acids such as lysine and leucine are crucial for protein synthesis, tissue repair, and growth regulation, while isoleucine supports haemoglobin synthesis and

immune function. Higher amino acid concentrations in cultured fish reflect optimized nutrition, contributing to enhanced growth and overall physiological performance.Overall, cultured fish demonstrate improved nutritional profiles, providing superior protein and amino acid quality, which are beneficial for human consumption and aquaculture productivity.

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