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Nutritional Values of Wild and Cultivated Silver Carp (*Hypophthalmichthys molitrix*) and Grass Carp (*Ctenopharyngodon idella*)

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ABSTRACT

The proximate composition and amino acid profile of farmed and wild silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) was determined to identify nutritional differences due to habitat changes. Fifty six fishes in total from wild and farm raised population, of two different weight categories (0.5 to 0.1 kg & 1.0 to 1.5 kg), were captured from Head Trimmu and Sher Dil Aquaculture facility District Jhang, Pakistan. Fish samples were chemically analyzed for protein, lipid, moisture and amino acid profile. When chemical composition of two fish species collected from different sources was compared, the differences were substantial. Elevated levels of protein and lipid were observed in farmed fish, while lower in wild fish. Values were, however, other way round for moisture contents. Quantitative estimation of amino acid profile was proportional to the protein contents at species level, higher in farm raised grass carp and lower in wild fish; contrarily, lipids were lower in farmed grass carp while higher in silver carp. In conclusion, grass carp showed significantly higher protein and lipid contents and lower moisture level than silver carp farmed fish is nutritionally better than wild irrespective of the species studied. Minor differences in protein and lipid levels, however, were observed when same nutrients were studied in different size groups. © 2011 Friends Science Publishers

Key Words: Silver carp; Grass carp; Protein contents; Amino acid profile

INTRODUCTION

Both silver and grass carp are Chinese fishes. Grass carp feeds on aquatic weeds and terrestrial grasses and has short intestine. It manures the pond as 50% of its daily food consumed (twice of its body weight) is defecated in semi-digested condition, which serves as an important source of organic manure. Silver carp is surface feeder feeding mainly on phytoplankton (less than 0.025 mm size). It has longer digestive canal as compared to grass carp hence digestion and utilization of feed is complete. Young ones of both species feed on zoo plankton (Santhanam *et al*., 1990).

Fish as a whole has a lot of food potential and can therefore be expected to provide relief from malnutrition, especially in the country like Pakistan. It provides superior quality protein to that of meat, milk and eggs and well balanced essential amino acid profile, necessary minerals and fatty acids (Hossain, 1996). In addition to that fish flesh is tasty and highly digestible. Over and above it minimizes the risk of heart diseases and increases life expectancy (Barlas, 1986).

Like other animals, fish requires variety of different nutrients in sufficient quantities to flourish and maintain other bodily functions. It can synthesize some but not all the essential nutrients which need to be provided from outside sources. Farmed fish is provided with nutrient rich foods in addition to natural productivity in the pond. Wild fish on the other hand has to depend totally on natural food for its sustenance. These variations have direct bearing on body composition, health status and growth of fish. Body composition is therefore, a true reflector of its feeding habits and type of food availability. Tadros *et al*. (2005) reported essential amino acid differences in between wild male and female specifically of aspartic acid, leucine and hydroxy-proline. Major percentage of lysine is found in fish fillets. Hoffman *et al*. (1994) studied the anatomical heterogeneity of sharp tooth catfish, *Clarias gariepinus,* in the percentage of amino acids like glycine, alanine, proline and hydroxyl-proline. Their concentration increased from anterior to posterior of fish body along the musculature.

Importance of understanding the body composition of fish in relation to growth and reproduction has long been

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recognized. Proximate composition is used as an indicator of fish quality. It varies with diet, feed rate, genetic strain and age (Austreng & Refstie, 1979). A few quantitative studies have also indicated that body constituents and energy resources vary with seasonal life cycles (Dawson & Grimm, 1980; Puwastien *et al.,* 1999). Kinsella *et al.* (1978) analyzed several freshwater fishes. They reported that moisture contents, 72.40-80.50, total fats, 0.7-3.8 and total ash contents were 1.0-1.3%. Zeitler *et al.* (1984) in their studies found a decreasing trend in water and protein contents of *Cyprinus carpio* while fat and energy contents showed a significant increase.

Other than these factors, ethical factor plays pivotal role in the selection of fish. It is commonly conceived that wild fish has better texture and nutritional value than farmed fish. People always demand for river fish and ignore farmed rose when they visit fish market, though wild is seldom available in the present state of affairs. It has also been observed that people prefer grass carp over silver carp thus undermining the consumer preference and low price than all the other culturable herbivorous fish species. These studies were therefore, planned to clarify these misconceptions and to provide useful and authenticated information for the guidance of consumers during meat selection among various fish species when he or she intends to buy. Therefore, the primary objectives of these studies were to identify nutritional elements of differentiation, which characterize wild and farmed grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*) and to convey an appropriate and authenticated message to the consumer about the nutritional quality of these fishes.

MATERIALS AND METHODS

Procurement of fish: Fifty-six silver carp (*H. molitrix*) and grass carp (*C. idella*), 28 of each from the farm and wild, of two different weight categories (0.5-0.7 kg, 1.0-1.2 kg), were engaged for current nutritional evaluation studies. Wild fish were captured form Trimmu Headworks while farmed fish were provided by Sher Dil Aquaculture facility District Jhang, Pakistan.

Sample preparation: Fishes were transported alive to the Fisheries Research Laboratory, Department of Zoology, G.C. University, Faisalabad, Pakistan. All the fishes were kept in running de-chlorinated tap water for two days for complete defecation of stomach contents. Fishes were then slaughtered and dressed. To determine nutritional differences between species different groups were managed and analyzed separately. The analysis was conducted on ventral, dorsal and tail white muscles of the fish body.

Proximate analysis: Fillets were minced and freeze-dried at -30□C. Duplicate fresh minced fish samples were immediately dried at 105□C in convection oven for 24 hours to determine moisture contents (AOAC, 1995). Crude protein was determined by Microkjeldahl method (AOAC, 1995). The amino acids were analyzed by Pico-Tag method (Bennett & Solomon, 1986) that involves protein hydrolysis (Ng & Pascaud, 1987) and pre-column derivatization of the amino acids followed by reverse phase HPLC (O'Hare *et al*., 1987). Lipid fraction was extracted by the Bligh and Dyer (1959) method as modified by Kates (1986).

Statistical analysis: The values obtained by the analysis of different fish samples (farmed + wild) of the two species are given as the means ± SE. The differences between the mean values of the studied parameters were calculated by Student “t” test and single factor analysis of variance. When statistically significant differences between groups were confirmed ($p< 0.01$), Duncan’s Multiple Range Test was applied, where required to distinguish the significance of various means. Calculations were done with SPSS Statistical Package Version 16.

RESULTS

Moisture contents: When moisture contents of individual fish species were compared between two habitats there were no differences (Table I) but when moisture contents were compared between two species moisture contents were significantly higher in silver carp than grass carp ($p<0.01$) (Table II). However, when moisture contents were compared between sizes, 1 kg grass carp had significantly ($p<0.05$) lower moisture contents than 1.5 kg irrespective of their habitat. Similar trend was observed in silver carp, low moisture contents in small size, while higher in bigger fish (Table III).

Crude protein: The protein contents of farm raised grass carp and silver carp were significantly higher than those caught from the wild (Table I). Similarly when protein contents were compared between two species, values were far higher in grass carp than silver carp ($p<0.01$) (Table II). Unlike moisture small fish has significantly ($p<0.05$) lower protein contents than bigger fish. This trend was uniform in both species irrespective of nature of habitat (Table III).

Lipid contents: Lipid content also called ether extract represents all the compounds which are soluble in organic solvents. Lipid composition rather showed different trend. Significantly ($p<0.05$) higher lipids were present in wild grass carp than farmed (Table I). Unlike grass carp higher ($p<0.01$) lipids were found in farmed silver carp than wild (Table II). When lipid contents were compared among different fish size groups, results were quite variable. One kg grass carp has significantly higher lipids than 1.5 kg fish when it was raised under captivity. Values were other way round when the wild fish was analyzed where lipid levels increased significantly with increase in size (Table III). Lipid values had quite unique variation trend in silver carp and totally differed from that of grass carp. Small sized (0.5 kg) farm raised silver carp had significantly low lipids than bigger sized fish (1 kg) (Table III). Totally opposite values were observed in wild samples, where lipid contents were significantly lower in bigger fish (1.0 kg) than smaller fish (0.5 kg) (Table III).

Amino acid profile: Values of aspartic acid, alanine, glutamic acid, isoleucine, methionine, cysteine, histidine, proline and threonine were similar in farmed and wild grass carp. Significantly ($p<0.05$) higher values of phenylalanine, valine, arginine, lysine and tyrosine were found in farmed fish than wild fish (Table IV). Contradictory to these values, only alanine, glutamic acid, phenylalanine and valine were higher in farmed silver carp than wild. When both these species were compared between themselves values of aspartic acid, isoleucine, methionine, phenylalanine, valine, lysine, cysteine, histidine, proline, tyrosine and threonine were significantly ($p<0.05$) higher in grass carp than silver carp (Table IV).

Table I: Comparison of inter-habitat (farmed and wild) nutritional differences in grass carp and silver

Parametrs (%)	Grass carp		Silver carp	
	Farmed	Wild	Farmed	Wild
Moisture	74.30 ± 0.07^a	74.79 ± 0.14^b	77.89 ± 0.06^a	78.79 ± 0.11^b
Protein	20.00 ± 0.15^a	19.46 ± 0.24^b	16.11 ± 0.15^a	15.50 ± 0.16^b
Lipids	2.52 ± 0.01^a	2.71 ± 0.08^b	2.23 ± 0.03^a	2.19 ± 0.09^b

Table II: Comparison of interpecific nutritional differences in Grass carp and Silver carp

Parameters (%)	Grass carp	Silver carp
Moisture	74.56 ± 0.09^a	78.33 ± 0.02^b
Protein	19.73 ± 0.15^a	15.80 ± 0.12^b
Lipids	2.63 ± 0.05^a	2.12 ± 0.48^b

Note: Figures with different superscript letters are significantly different from each other at $p<0.01$

DISCUSSION

Results of the current studies have revealed that culture habitat of fish has direct bearing on its nutritional quality. The proximate composition of fish flesh of wild silver (*H. molitrix*) and grass carp (*C. idella*) *showed* significantly higher moisture contents (78.79 vs 77.89 & 74.79 vs 74.30) and low protein contents (15.5 vs 16.11 & 19.46 vs 20.0) than their farmed counterparts. Lipids were significantly ($p<0.01$) higher in wild grass carp (2.71 vs 2.52), while lower (2.19 vs 2.23) ($p<0.05$) in silver carp. Tahir (2003) has reported highest lipid contents (4.40%) in farmed *Labeo rohita* when he compared with wild specimens. On the other hand, carbohydrates contents were higher in *H. molitrix* as compared to *C. idella* probably due to its phytophagus nature. Jankowska *et al*. (2007) observed that contents of water, protein and fats in the fillets of cultivated and wild perch (*Perca fluviatilis*) differed significantly ($p< 0.01$).

Cultivated perch contained more protein (20.1% vs. 17.6%) and fat (1.3% vs. 0.3%), although the water content in the fillets of cultivated perch was lower than that in wild perch (77.3% vs. 80.9%). Álvarez *et al*. (2009) observed that farmed and wild blackspot seabream (*Pagellus bogaraveo*) led to a wide number of differences. Farmed fish muscle showed a higher ($p<0.01$) total lipid content than its wild counterparts. They opined that the feed offered to farmed specimen had direct impact on its body fat increments. Earlier, Boujard *et al*. (2004) and Gonzáles *et al*. (2006) found similar results on European seabass (*Dicntrarchus labrax*) and wild yellow perch (*Perca flavescens*). These explorations validate our findings that higher moisture and lower protein and fat contents is a characteristic feature of wild fish populations. Previous and our studies warrant that moisture and protein and lipids are inversely related to each other. Situation was however, quite different in grass carp, where increase in lipids was directly proportional to moisture contents. Findings of Periago *et al*. (2005) that higher moisture and protein contents and a lower flesh pH, hydroxyl proline and collagen contents in farmed sea bass, while no difference in total fat between both populations in the wild European sea bass totally contradicts the past as well as current findings. Though low fat contents and higher moisture was present in silver carp (Table I), no absolute differences in wild and farmed fish are really hard to justify in the context of our findings.

When nutritional components of different size groups of these two fish varieties were compared trend was not linear rather curvilinear between both species. Moisture and protein contents increased with size, while lipids decreased in grass carp in captivity, while moisture decreased and fat increased in wild fish (Table III). In silver carp moisture decreased, protein increased with size irrespective of culture habitat but lipids increased in farmed fish with size but decreased in wild with increase in size of fish. Gunther *et al*. (2007) reported that the moisture contents decreased, while protein, lipids, ash and phosphorous increased as weight of lake trout and hybrid F1 (lake trout × brook trout) increased. Oduor-Odote *et al*. (2008) found that lipids in fish vary greatly and this variation is related to feed intake, migratory swimming or sexual changes in connection with spawning. Higher lipids may be due to preparation for spawning. Lipids vary in different parts of fish body and also they show enormous variation in different seasons of the year. Recently, Asma and Ashraf (2010) found a linear relationship between protein and age/size of fish in three carnivorous fish species (*Wallagu attu*, *Mystus seenghala* & *Channa morulius*) but quite inverse in lipids, because there was proportionate decline in this nutrient with increase in size. Our current findings corroborate the previous findings and further authenticate that carnivorous and herbivorous fish species have similar nutrient deposition and retention pattern (Ali *et al*., 2006; Asma & Ashraf, 2010). These studies further verify that changes in moisture, protein and phosphorous are function of body weight, while lipid content appears to be function of body weight and may be simultaneously affected by lipid contents of diet (Javaid *et al*., 1992). Kalay *et al*. (2008) however, totally negated the

Table III: Comparison of interaspecific size wise nutritional differences in Grass carp and Silver carp

Param-etrs (%) ±SEM	Grass carp				Silver carp			
	Farmed fish weight (kg)		Wild fish weight (kg)		Farmed fish weight (kg)		Wild fish weight (kg)	
	1	1.5	1	1.5	0.5	1	0.5	1
Moisture	74.16 ± 0.06[a]	74.45 ± 0.11[b]	75.3 ± 0.05[a]	74.35 ± 0.05[eb]	78.30 ± 0.09[a]	77.47 ± 0.11[b]	79.14 ± 0.06[a]	78.43 ± 0.08[b]
Protein	19.56 ± 0.09[a]	20.44 ± 0.14[b]	18.59 ± 0.05[a]	20.33 ± 0.88[b]	15.61 ± 0.01[a]	16.61 ± 0.08[b]	14.99 ± 0.05[a]	16.01 ± 0.13[b]
Lipids	2.72 ±0.04[a]	2.31 ± 0.1[b]	2.10 ± 0.05[a]	2.51 ± 0.08[b]	2.18 ± 0.06[a]	2.28 ± 0.2[b]	2.45 ± 0.11[a]	1.93 ± 0.05[b]

Figures with different superscript letters are significantly different from each other at $p<0.01$

past and present research findings with respect to the length weight relationship and changes in body composition with age (negative correlation between protein & lipid levels with age/size). They reported decreased in protein contents with age, increase in fat contents with no effect on Cu, Zn, and Fe.

When amino acid profile of both grass and silver carp was compared in two different habitats farmed fishes had better amino acid balance and significantly higher concentrations than their wild counterparts. Concentrations of phenylalanine, valine, arginine, lysine and tyrosine were more prominent in grass carp and those of alanine, glutamic acid, phenylalanine and valine were more conspicuous in silver carp (Table IV). These remarkable differences in the levels of amino acids in grass carp entailed more balanced diets due to its limited feeding scope than silver carp, which feeds on wide variety of phytoplanktons and can meet its amino acid requirements more comfortably. Differences in rest of the amino acids were quite nominal and statistically insignificant ($p>0.05$). Yamamoto *et al.* (2005) and Yang *et al.* (2010) reported that essential amino acid supplementation markedly affected animal growth due to the changed nutritional status. Effect of essential amino acids was more prominent in those fishes fed on low protein diets than those fed on higher protein diets. It appears that body composition of herbivorous fish species is a true reflection of their natural and artificial food but this behavior is only noticeable, where fishes have restricted feed options. Further the mechanism of conversion, qualitative and quantitative synthesis and accumulation of excess protein than taken in the food with limitations in certain fish species necessitate further work. These data suggest that nutritionally grass carp is superior to that of silver carp. In addition, flesh quality of farmed grass carp is better than wild one as well as than that of silver carp for human consumption.

Body composition varies from species to species and from habitat to habitat with its own pre-determined set of principles. These conceptions seem quite valid, because Quinton *et al.* (2007) estimated genetic correlations of whole-body lipid and protein with feed utilization traits to examine potential physiological mechanisms causing variation in gain in weight/feed intake (G: F) and they found that their simultaneous selection for rapid growth and reduced body lipid (%) led to greater genetic response in G: F compared with selection for rapid growth alone.

It can be deduced that genetic factors as well as extrinsic factors such as feeding regimes and/or exercise significant change some structural and flesh quality parameters of different fish species. Thus, there is no hard and fast rule applicable universally to all the fish species.

Table IV: Amino acid composition of wild and farmed grass carp and silver carp

Name of amino acid	Grass carp		Silver carp	
	Farmed	Wild	Farmed	Wild
Aspartic acid	6.18±0.13[aA]	6.0±0.12[a]	7.01±0.82[aB]	6.95±0.1[a]
Alanine	6.17±0.29[aA]	5.99±0.3[a]	6.17±0.29[aA]	5.98±0.2[b]
Glutamic acid	4.83±0.06[aA]	4.83±0.05[a]	4.83±0.06[aA]	4.01±0.02[b]
Isoleucine	7.15±0.10[aA]	6.98±0.10[a]	6.5±0.05[aB]	6.0±0.03[b]
Methionine	4.37±0.17[aA]	4.25±0.10[a]	2.48±0.42[aB]	2.30±0.01[a]
Phenylalanine	7.41±0.05[aA]	5.99±0.10[b]	7.02±0.05[aB]	6.30±0.02[b]
Valine	2.55±0.002[aA]	1.98±0.02[b]	1.59±0.04[aB]	1.49±0.01[b]
Arginine	1.60±0.03[aA]	1.78±0.1[b]	1.60±0.03[aA]	1.60±0.02[a]
Lysine	6.23±0.10[aA]	5.89±0.02[b]	1.92±0.06[aB]	1.90±0.06[a]
Cysteine	1.13±0.03[aA]	1.13±0.02[a]	1.39±0.04[aB]	1.39±0.03[a]
Histidine	2.01±0.09[aA]	2.02±0.01[a]	1.34±0.06[aB]	1.32±0.01[a]
Proline	2.71±0.13[aA]	2.65±0.1[a]	2.29±0.07[aB]	2.25±0.02[a]
Tyrosine	3.44±0.09[aA]	3.01±0.1[b]	2.45±0.10[aB]	2.43±0.07[a]
Threonine	1.91±0.10[aA]	1.80±0.02[a]	1.53±0.08[aB]	1.45±0.04[a]

Figures with different superscript letters are significantly different from each other at $p<0.01$

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