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RESEARCH ARTICLE

BIOCHEMICAL STUDIES OF MUSCLE AND LIVER OF *LABEO ROHITA* (HAM.) IN RELATION TO SEASON AND SEX

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ABSTRACT

The present study was carried out to investigate the seasonal variations of moisture, ash protein, lipid and fatty acid (per cent) of muscle and liver of adult male and female *Labeo rohita*. For this purpose seasonally ten live specimen of both sex ranged in total length 34.5 to 42.5 cm. and weight 950gm to 1200gm were considered during study period (2008 to 2010). The amount of protein, lipid and fatty acid level increase during spring whereas moisture content of muscle and hepatic organ increases during summer and rainy season. Seasonal variations of lipid content followed the opposite pattern of the water content. The mean values of these biochemical constituents varied significantly ($p<0.05$) in different season. There was significant negative correlation between moisture and lipid ($r=-.582^{*}$), positive correlation between ash and protein($r=.868^{**}$), protein and lipid ($r=.966^{**}$). Reduced biochemical parameters coincide with that of gonad development and breeding period of the species in the rainy season ($p<0.01$). The female specimen contained more moisture and lipid whereas more protein was found in male. ANOVA was applied to assess the difference among various biochemical parameters. Significant differences were observed in these fish tissues which indicate the quantitative and qualitative nature of fish sample for nutritive purposes.

INTRODUCTION

Fish is known for its high nutritional value. It is one of the most important sources of animal protein and has been widely accepted as a good source of protein and other elements for the maintenance of healthy body (Arannilewa *et al*. 2005). Knowledge of biochemical composition of muscle of major carps is of great help in evaluating not only its nutritive value but also helps in quality assessment and optimum utilization of these natural resources (Abdullah and Lohar 2011). Information concerning the chemical composition of freshwater fishes is useful to ecologists and environmentalists who are interested in determining the effects of changing biological and environmental conditions on the composition, survival and population change within the fish species (Kinsella *et al*., 1978).The main components in the edible portion of fish are water, protein, lipid and ash. The analysis of these four basic constituents of fish muscle is often referred as proximate analysis (Love 1970). Fish (as the cold blooded) is easily influenced by the surrounding water temperature that shows the prominent effect on body temperature, growth rate, feed consumption and other metabolic function (Britz *et al*., 1997). Investigation on various aspects of proximate composition had started earlier. Proximate composition of a number of marine, fresh water and brackish water fish has been reported by Gopakumar (1997).Earlier reports indicate that change in biochemical composition may occur as a result of gonadal maturity (Dygerty 1990). Sankar and Ramachandran (2001) have studied the biochemical composition in Indian major carps in relation to size but very little information available on the biochemical changes in flesh quality of major carp in relation to sex and season (Chandrasekhar *et al*., 2008). In general, it has been observed that a number of physical, abiotic and biotic factors affect the body composition. These factors maybe morphological, physiological, environmental and genetic in nature (Ali *et al*., 2001). Variation in the biochemical composition have been correlated with many parameters such as body growth (Groves, 1970), the state of maturation (Bull, 1928), water temperature (Elliot, 1976). Spawning migration (Idler and Bitmers, 1960), summer storage of fat (MacKinnon, 1972) and captivity purposes (Shearer, 1994). The spawning cycle and food supply are the main factors responsible for this variation (Love *et al*., 1980). This study was under taken to assess the chemical composition of muscle and liver of the Indian major carp *Labeo rohita* and their variations within season and sex.

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MATERIALS AND METHODS

Animal sample collection

For the present study, fish samples were collected seasonally from a fresh water pond of Khurda District, Bhubaneswar, India (19º 40" N to 20º 25" N Latitude and 24º 55" E to 36º 05" E Longitude; area - 2889 Sq. kms.) during July 2008 to June 2010.This pond was chosen considering tropical climate and the physico-chemical features of pond water was analyzed as per APHA (1998) Test fishes were then killed by using the concussive blow to their head. After morph metric measurements (Total length=34.5 to 42.5 cm. and weight 950gm to 1200gm) each fish was descaled, gutted, eviscerated,

washed, muscle and liver were collected. Moisture content was reported as per AOAC, 1970**.**Ash was determined by incineration in a muffle furnance at 550°C for 10 hours (Egan *et al*., 1997). Protein content was estimated by Lowry's *et al*.,(1951) method using folin cio calteu reagent. Total lipid and fatty acid extracted considering advices of Folch *et al*., (1957) which take place in Christie's (Christiansen *et al*., 1989), Kandemir and Polat (2007). These parameters were reported in percentage on wet weight basis.

Statistical analysis

Biochemical data resulting from the experiment were subjected to one way analysis of variance (ANOVA) by using the SPSS, 17.5 for windows. Differences between means determined by Duncan multiple range test ($p<0.05$). The correlation between haematological variables was analyzed by Pearson coefficient for linear correlation (r) at $p<0$ .05.

RESULTS AND DISCSSION

Physicochemical properties of water samples collected from pond during different seasons reflect seasonal changes in water quality (Figure 1). The water temperature ranged from a low of 20.5°C in winter to a high of 30.5°C in summer and pH fluctuated seasonally between 6.8 (rain) to 7.8 (spring) throughout the study period. According to Jinghran **(**1968) temperature range of 28-32°C in tropical waters is congenial for optimal growth of fish. Dissolved oxygen concentration varied from5.8to7.6mgl^{-1}. The maximum value of dissolved oxygen concentration was observed in winter whereas the minimum value found in the summer. Recorded value of dissolved oxygen fell within the ranges documented by Boyd (1979), Alabaster and Lloyd (1980) for good water quality on fish culture. The observed pH data within the range of values documented by Swingle (1961) and Boyd and Lichtkoppler (1985) as values most suitable for fish production for maximum productivity.

Seasonal estimate of total hardness showed significant increase in the month of winter (145.5 mg l^{-1}) declining trend with the minimum values in the month of autumn(119.6 mg l^{-1}) (Figure1). Similar findings were observed by Chatterjee and Raziuddin (2007). The value of total dissolved solid showed higher value in summer (268.2 mg l^{-1}) and lower value in the rain (175.4mg l^{-1}). The highest value of total alkalinity was recorded during summer (148.7mgl^{-1}) whereas the lowest values were recorded during autumn (119.6mg l^{-1}). In this investigation biochemical parameters of muscle and liver were observed seasonally. The major component of fish fillets was moisture. It was found that moisture content in the muscle (Table 1) of male and female fish was varied from 75.2 per cent to 76.85 per cent and 75.52 to 78.13 per cent respectively whereas amount of moisture in liver (Table 6) varies between 69.23 to 72.11 per cent and 68.71 to 72.74 per cent in male and female respectively. Seasonally there was increased value in rain (27.50°C) and summer (30. 5°C) when the water temperature was higher whereas minimum was in spring.

It has been noticed that in rainy season moisture content was maximum whereas other constituents were lower .Moisture content was more at spawning time and reaching highest during rain. Negative correlation (Table 5) was also observed between moisture and lipid ($r= -.582^{*}$ at $p\leq0.05^{*}$), moisture and protein (r=-.473), fatty acid and moisture (r=-.497). Increased moisture during spawning time also observed in *Anabas testudineus* (Nargis, 2008). In the analysis of liver of female fish negative correlation (Table 10) was also well marked between moisture and lipid ($r=.-.823^{**}$ at $p\leq0.01$). Dawson and Grimm (1980) concluded that energy reserve in stickle back fish decreases during growth and gonad maturation. Ash is the total mineral content of the fish sample. Ash content of muscle (Table 1) was ranged from 0.92 to 1.121 per cent in male and 0.87 to 1.14 per cent in the female fish whereas in liver (Table6), it varied from 0.60 to 0.67 per cent and 0.59 to 0.66 per cent in male and female respectively.

Table1: Seasonal variations in muscle parameters of *Labeo rohita*

Season	Sex		Moisture	Ash	Protein	Lipid	Fatty acid
Spring	Male	Mean	75.200	1.121	19.7000	2.3600	62.5100
		S. E.M	0.6916^{ab}	0.084^{b}	0.8443^{c}	0.0466^{c}	0.4381^{d}
	Female	Mean	75.5200	1.149	18.4000	2.75000	63.2800
		S. E.M	0.89859^{a}	0.083^{b}	0.44124^{c}	0.26970^{c}	0.2021^{c}
Summer	Male	Mean	76.1900	1.080	18.5000	2.0600	57.6600
		S. E.M	0.4576^{a}	0.186^{a}	0.206^{b}	0.0989^{b}	0.3295^{a}
	Female	Mean	77.1300	1.050	17.6100	2.31000	56.5100
		S. E.M	0.3426^{ab}	0.087^{a}	0.5306^{b}	0.1636^{b}	0.4576^{b}
Rainy	Male	Mean	76.8500	0.920	17.2100	1.53000	50.0800
		S. E.M	0.93681^{b}	0.069^{a}	0.829^{b}	0.1090^{a}	0.8094^{c}
	Female	Mean	78.1300	0.870	16.9200	1.5000	50.3100
		S. E.M	0.6229^{b}	0.051^{a}	0.1375^{ab}	0.1154^{a}	0.5356^{b}
Autumn	Male	Mean	76.290	0.950	17.8500	1.6100	51.5500
		S. E.M	0.819^{b}	0.077^{a}	0.4454^{b}	0.1723^{ab}	0.627^{b}
	Female	Mean	77.2200	0.970	117.120	1.75000	52.6100
		S. E.M	1.36101^{b}	0.046^{a}	0.2393^{ab}	0.0750^{a}	0.6401^{b}
Winter	Male	Mean	75.8700	0.987	18.4300	1.9300	51.6800
		S. E.M	0.5935^{b}	0.021^{a}	0.308^{a}	0.1327^{a}	0.7866^{c}
	Female	Mean	76.2000	1.005	17.7500	2.2000	56.7100
		S. E.M	0.84293^{b}	0.046^{a}	0.1616^{a}	0.1581^{a}	0.2236^{a}

S.E.M=Standard Error of Mean, a, b, c, d: mean values followed by different letters in the rows are significantly different, $p = \leq0.05$

Table 2: Analysis of ONE-WAY-ANOVA on muscle parameters by sex and Seasons in *Labeo rohita*

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.
Moisture	season	47.298	4	11.825	4.771	.007
	sex	3.675	1	3.675	1.483	.238
	season * sex	3.030	4	.758	.306	.871
Ash	season	.306	4	.076	8.944	.000
	sex	.001	1	.001	.172	.683
	season * sex	.006	4	.002	.189	.941
Protein	season	29.418	4	7.355	45.303	.000
	sex	18.723	1	18.723	115.332	.000
	season * sex	.402	4	.100	.619	.654
Lipid	season	8.688	4	2.172	36.443	.000
	sex	.003	1	.003	.050	.825
	season * sex	.852	4	.213	3.574	.024
Fatty acid	season	595.158	4	148.789	80.126	.000
	sex	44.652	1	44.652	24.046	.000
	season * sex	96.558	4	24.140	13.000	.000

Table 3: Correlation analysis of muscle parameters by seasons in *Labeo rohita*

Season	Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Spring	moisture	1	.989**	.544	.613	.568
	ash	.989**	1	.573	.601	.546
	protein	.544	.573	1	-.309	-.373
	lipid	.613	.601	-.309	1	.996**
	Fatty acid	.568	.546	-.373	.996**	1
Summer	moisture	1	.927**	.118	.860*	.362
	ash	.927**	1	.333	.714	.129
	protein	.118	.333	1	-.396	-.883*
	lipid	.860*	.714	-.396	1	.779
	Fatty acid	.362	.129	-.883*	.779	1
Rain	moisture	1	.801	.230	.570	.457
	ash	.801	1	.733	.948**	.873*
	protein	.230	.733	1	.893*	.970**
	lipid	.570	.948**	.893*	1	.963**
	Fatty acid	.457	.873*	.970**	.963**	1
Autumn	moisture	1	.952**	-.316	.300	.477
	ash	.952**	1	-.029	.571	.710
	protein	-.316	-.029	1	.800	.682
	lipid	.300	.571	.800	1	.977**
	Fatty acid	.477	.710	.682	.977**	1
Winter	moisture	1	.832*	-.106	.546	.726
	ash	.832*	1	.462	.917*	.224
	protein	-.106	.462	1	.767	-.756
	lipid	.546	.917*	.767	1	-.180
	Fatty acid	.726	.224	-.756	-.180	1

** Significant at P≤ 0.01. * significant at the P≤0.05.

The higher amount was observed in the spring when environmental parameters were suitable for fish growth and lower in the rainy season in both the sexes. There was no remarkable variation of ash content was found in male and female. Significant positive correlation **(**Table 4**)** of ash with protein (r=.868** at p≤0.01), lipid (r=0.963** at p≤0.01), moisture and fatty acid(r=0.691** at p≤0.01) and negative correlation with moisture (r= -.329) were observed. Its mean value fluctuated with environmental temperature and food availability. Similar type observation was noted by Geri *et al*. 1995 in the biochemical analysis of *C. Carpio*. It was observed that Protein content (Table 1) of muscle was ranged from 17.21 to 19.7 per cent in male and 16.92 to 18.4 per cent in female and in liver(Table 6)**,** for male variation range was 11.45 to 13.5 and for female 10.65 to 12.88 per cent. Through the passage of time the protein content of muscle increased gradually to reach the highest in spring in both the sex of test fish but the lowest value was in the rainy season. It has been found that the spawning period of fish was the rainy season (Figure 2 & 3). Analysis of correlation matrix (Table 4) indicated that protein content of male muscle showed significant correlation with ash (r=.868** at p≤0.01), lipid(r=.963** at p≤0.01), fatty acid (r=0.724** at p≤0.01) and negative correlation with moisture (r= -.329).Correlation matrix (Table 5) also indicated that protein content of female muscle showed significant correlation with ash(r=.898** at p≤0.01), lipid(r=.966** at p≤0.01), fatty acid(r=.950** at p≤0.01).Negative correlation (Table10) was found in the liver protein and moisture (r=-.753** at p≤0.01) and positive correlation with lipid (r=.989** at p≤0.01). Similar trend has also been noted in the lipid content (Table 1) of muscle which was fluctuated from 1.53 to 2.36 per cent in males and 1.50 to 2.75 per cent in females. For liver tissue (Table 6), variation was fluctuated from 3.4 to 4.54 per cent and 3.02 to 5.16 per cent in male and female respectively. In both the sexes maximum value was noted in spring when the water temperature (26.0°C) and food availability were favorable for growth and development and minimum in the rain in both the sexes when gonad was fully mature for spawning (GnSI14.20 per cent, Figure 3).Energy depot was used for gamete development. Correlation matrix (Table 4) indicated that lipid content of male muscle showed significant correlation with ash(r=.923** at p≤0.01), protein (r=.963** at p≤0.01), fatty acid(r=.610* at p≤0.05), negative correlation with moisture (r= -.142). Significant correlation (Table 5) was also found in the lipid of female muscle with ash(r=.811** at p≤0.01), protein

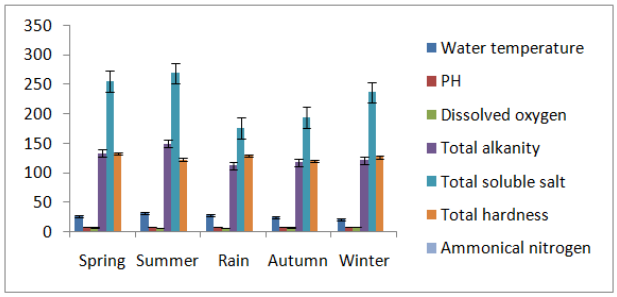

Fig.1. Seasonal variations of different water parameters

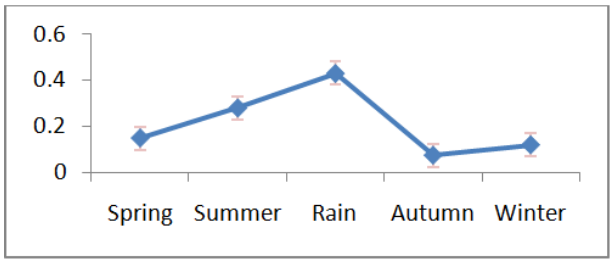

Fig.2. Seasonal variations of Gonadosomatic index (GnSI)of male *Labeo rohita*

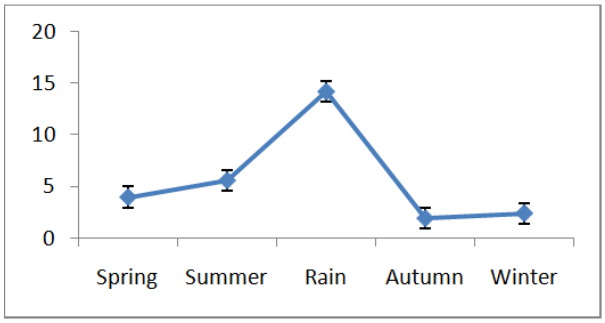

Fig.3; Seasonal variations of Gonadosomatic index (GnSI) of female *Labeo rohita*

(r=.966**at p≤0.01), fatty acid (r=.928**at p≤0.01) and negative correlation with moisture (r=-.582*at p≤0.05). Liver lipid was negatively correlated (Table10) with moisture (r=-.823** at p≤0.01) and positive correlation with fatty acid (r=.944**at p≤0.01).

Table 4: Correlation analysis of muscle parameters for male *Labeo rohita*

Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Moisture	1	.055	-.329	-.142	-.130
Ash	.055	1	.868**	.923**	.691**
Protein	-.329	.868**	1	.963**	.724**
Lipid	-.142	.923**	.963**	1	.610*
Fatty acid	-.130	.691**	.724**	.610*	1

** Significant at P≤ 0.01., * significant at the P≤0.05.

Therefore lipid content was significantly affected by the season (Table 2 & 7) in *Labeo rohita*. Such type of seasonal variations also noted in *Glossogobius giuris* (Islam and Joadder 2005). More or less similar observation was also marked in *Catla catla* by Chandrasekhar *et al*., (2008). Season and sex-wise analysis indicated variation range of fatty acid (Table 1) in the muscle of male 50.08 to 62.51 per cent and female 50.31 to63.28 per cent. The average value in liver (Table 6) was ranged from 50.18 to 62.71 per cent for male fish and for female variation was ranged from 50.01 to 64.28per cent. Season wise maximum value was noted in the spring in both the sexes. The amount of total lipid, fatty acid and protein in muscle and liver increased in winter and reaching maximum during spring and minimum was in rainy season which is the breeding season of the fish (Figure 2 & 3). Such type of observation also marked by Kandemir and Polat (2007) on the muscle and liver of rainbow trout (*Oncorhynchus mykiss*). The biochemical characteristics observed in this study shows marginal differences in comparison with that of muscle of carp analysed by ChandraShekhar *et al*. (2008) and Ali *et al*. (2006). The liver is an important storage depot in the Cyprinoid fish, therefore special attention was also given in this analysis. Noted value of moisture and lipid content of the liver of *Labeo rohita* agree with the observation of Hassan *et al*. (2010) on Indian major carp, *Catla catla*. According to the observation table, the amount of fatty acid in muscle and liver more or less, follow gonad development pattern(Fig.2 & 3) as well as feeding habit. During the breeding season, fishes have been found to be active and agile which lead to the utilization of muscle energy reserve and there is a significant variation ($p < 0.01$) in this season in protein, lipid and fatty acid level. Strong impact of season and sex also felt in the liver also ($p < 0.01$).

Table 5: Correlation analysis of muscle parameters for female *Labeo rohita*

Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Moisture	1	-.127	-.473	-.582*	-.497
Ash	-.127	1	.898**	.811**	.871**
Protein	-.473	.898**	1	.966**	.950**
Lipid	-.582*	.811**	.966**	1	.928**
Fatty acid	-.497	.871**	.950**	.928**	1

** Significant at P≤ 0.01., * significant at the P≤0.05.

The seasonal cycle of protein seem to be influenced by the maturation cycle and depletion of the gonad. It is an accepted fact that there exist a strong link between the fat, protein and water. Increase in the proportion of the one of these parameters lead to decrease of the other so that sum remains approximately constant as noted by Jacquet (1961) and Love (1970). Correlation table also expresses similar views as increase of moisture significantly decrease the amount of lipid and fatty acid. Correlation is more significant in the female sex. Season wise, it has been more significantly marked in the rainy season ($p < 0.01$) ,as protein and lipid is removed from fish muscle and liver, the water content rises steadily and this is a useful index of the state of the depletion of the fish. Sivakami *et al***.** (1986) also reported similar mobilization of protein and lipid for the development gonad of *Cyprinus carpio*. Result analysis clearly indicated the fluctuation of fat and water. Medford and Mackey (1978) noted similar observation in the liver and muscle of *Esox lucius* (northernpike). This finding support the main conclusion that major changes in the body composition of fishes brought about by the changes in the pond water in different seasons, nutritional status and breeding period of fish (Reintz, 1983; Weatherly and Gill, 1987; Salam and Devies, 1994 and 1997; Ali *et al*., 2004).

Table 6: Seasonal variations in liver parameters of male and female *Labeo rohita*

Season	Sex		Moisture	Ash	Protein	Lipid	Fatty acid
Spring	Male	Mean	69.23000	0.6700	13.5000	4.5400	62.71000
		S. E. M	0.69705[a]	0.010[b]	0.31815[c]	0.218[d]	0.43859[c]
	Female	Mean	68.71000	0.6600	12.8800	5.1600	64.2800
		S. E. M	0.8476[a]	0.0372[a]	0.19083[d]	0.1274[e]	0.2078[d]
Summer	Male	Mean	71.39000	0.6300	12.6100	4.0800	57.6600
		S. E. M	1.1358[ab]	.02041[b]	0.51743[b]	0.043[c]	0.3287[b]
	Female	Mean	70.83000	0.6400	11.5800	4.57000	56.5100
		S. E. M	0.55663[b]	0.046[a]	0.12898[c]	0.0928[d]	0.45108[c]
Rainy	Male	Mean	72.1100	0.600	11.4500	3.4000	50.1800
		S. E. M	0.7735[ab]	0.0304[b]	0.10124[b]	0.085[ab]	0.8047[a]
	Female	Mean	0.51241[b]	0.5900	10.6500	3.0200	50.0100
		S. E. M	72.7400	0.0161[a]	0.11588[b]	0.0498[b]	0.53047[a]
Autumn	Male	Mean	70.66000	0.6100	11.5600	3.64000	51.55000
		S. E. M	0.3319[b]	0.043[a]	0.23928[b]	0.0944[b]	0.6219[a]
	Female	Mean	71.2100	0.6300	10.8600	3.34000	52.61000
		S. E. M	0.45818[b]	0.0587[a]	0.08351[c]	0.0601[c]	0.64931[b]
Winter	Male	Mean	70.0800	0.6200	11.77000	3.85000	51.68000
		S. E. M	0.4635[c]	0.0172[a]	0.07928[a]	0.0657[a]	0.7801[a]
	Female	Mean	70.5600	0.6300	11.48000	4.1200	56.7100
		S. E. M	1.09241[b]	0.0187[a]	0.15660[a]	0.1069[a]	0.23406[b]

S.E.M=Standard Error of Mean, a, b, c, d: mean values followed by different letters in the rows are significantly different, $p \leq 0.05$

Table 7: Analysis of one way ANOVA on liver parameters by sex and seasons in *Labeo rohita*

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.
Moisture	season	72.192	4	18.048	14.475	.000
	sex	3.072	1	3.072	2.464	.132
	season * sex	10.308	4	2.577	2.067	.123
Ash	season	.043	4	.011	3.240	.033
	sex	.027	1	.027	8.157	.010
	season * sex	.003	4	.001	.204	.933
Protein	season	12.678	4	3.169	77.475	.000
	sex	.027	1	.027	.660	.426
	season * sex	1.698	4	.425	10.376	.000
Lipid	season	14.088	4	3.522	248.203	.000
	sex	1.083	1	1.083	76.321	.000
	season * sex	1.512	4	.378	26.638	.000
Fatty acid	season	595.158	4	148.789	80.126	.000
	sex	44.652	1	44.652	24.046	.000
	season * sex	96.558	4	24.140	13.000	.000

Table 8: Correlation analysis of liver parameters by seasons in *Labeo rohita*

Season	Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Spring	Moisture	1	.929**	-.322	-.551	.149
	ash	.929**	1	-.050	-.282	.369
	protein	-.322	-.050	1	.966**	.882*
	lipid	-.551	-.282	.966**	1	.732
	Fatty acid	.149	.369	.882*	.732	1
Summer	Moisture	1	.964**	.012	-.312	.452
	ash	.964**	1	.269	-.053	.662
	protein	.012	.269	1	.944**	.897*
	lipid	-.312	-.053	.944**	1	.702
	Fatty acid	.452	.662	.897*	.702	1
Rain	Moisture	1	.726	.291	.995**	.973**
	ash	.726	1	.869*	.661	.549
	protein	.291	.869*	1	.204	.063
	lipid	.995**	.661	.204	1	.990**
	Fatty acid	.973**	.549	.063	.990**	1
Autumn	Moisture	1	.364	.650	.927**	.713
	ash	.364	1	.937**	-.008	-.392
	protein	.650	.937**	1	.317	-.066
	lipid	.927**	-.008	.317	1	.923**
	Fatty acid	.713	-.392	-.066	.923**	1
Winter	Moisture	1	.944**	.937**	.995**	-.004
	ash	.944**	1	.995**	.929**	-.293
	protein	.937**	.995**	1	.931**	-.347
	lipid	.995**	.929**	.931**	1	-.022
	Fatty acid	-.004	-.293	-.347	-.022	1

** significant at $P \leq 0.01$., * significant at the $P \leq 0.05$.

Table 9: Correlation analysis of liver parameters for male *Labeo rohita*

Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Moisture	1	.012	-.546*	-.535*	-.408
Ash	.012	1	.733**	.704**	.620*
Protein	-.546*	.733**	1	.897**	.784**
Lipid	-.535*	.704**	.897**	1	.956**
Fatty acid	-.408	.620*	.784**	.956**	1

** significant at P≤0.01, * significant at the P≤0.05.

Table 10: Correlation analysis of liver parameters for female *Labeo rohita*

Parameter	Moisture	Ash	Protein	Lipid	Fatty acid
Moisture	1	-.277	-.753**	-.823**	-.727**
Ash	-.277	1	.807**	.735**	.729**
Protein	-.753**	.807**	1	.989**	.923**
Lipid	-.823**	.735**	.989**	1	.944**
Fatty acid	-.727**	.729**	.923**	.944**	1

** significant at P≤ 0.01. * significant at the P≤0.05.

Conclusion

Present investigation can be concluded that impact of season and sex is observed in the biochemical composition of fish muscle and liver. The better biochemical composition is observed in the spring season. The result of the present work can be useful for the fish physiologists, consumers and food industries.

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