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Annual Variation in Proximate Chemical Composition of Fish Sold in Ludhiana Market: Punjab, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author PNA carried out the specimen sampling and analyzed the data of the study and wrote the manuscript. Author SND conceptualized the theme, assisted during the sampling, evaluated the results and wrote the manuscript. Authors AS and PS helped in sampling and analysis. All authors read and approved the final manuscript.

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ABSTRACT

A study was carried out to investigate the nutritional composition of four different fish species (*Wallago attu*, *Labeo rohita*, *Pangasianodon hypophthalmus*, and *Rastrelliger kanagurta*) sourced from the inland and marine sector comprising both culture and capture fisheries marketed in Ludhiana fish market from September 2021 to August 2022, encompassing four distinct seasons: post-monsoon, winter, pre-monsoon, and monsoon. The proximate parameters including protein, lipid, carbohydrate, ash and moisture content were analysed following the standard methods. The moisture content across the four species ranged from 72.48% to 81.08% in selected fish. Lowest

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moisture content was recorded during the pre-monsoon season, contrasting with their highest levels during the monsoon season. Protein levels ranged from 9.72% to 18.36% across different seasons. Specifically, *P. hypophthalmus* displayed the lowest protein content (9.72±0.18%), while *R. kanagurta* exhibited the highest (18.36±0.18). *W. attu*, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta* exhibited their lowest lipid content in flesh during the monsoon season, measuring at 0.69%, 1.59%, 9.33%, and 2.47%, respectively, contrasting with their highest levels during the winter season at 1.07%, 2.05%, 11.04%, and 4.05%, respectively. Across different seasons, carbohydrate content varied from 0.23% to 2.04%. *R. kanagurta* exhibited the lowest carbohydrate values; while *L. rohita* displayed the highest. Across different species, ash content varied from 1.62% to 4.34%, with the lowest observed in *P. hypophthalmus* and the highest in *W. attu*. Overall in fish muscle, water content reached its peak levels while muscle protein content decreased during the monsoon. The decline in protein and the rise in water content of the muscle were attributed to gonadal development and maturation, which depleted muscle protein reserves during the monsoon season. Inverse relationship between moisture and fat content in fish were observed, suggesting that fatty fish typically exhibit relatively lower moisture content. Lower levels of carbohydrate content are found in the total proximate composition of fish muscle, indicating that most of the glycogen in freshwater fish does not significantly contribute to body reserves.

Keywords: Fish market; commercially important fish; proximate composition; Nutrition.

1. INTRODUCTION

Fish emerges as a remarkably valuable source of high-quality animal protein and stands as one of the most abundant reservoirs of essential minerals. The fishery and aquaculture sector exhibit immense potential in addressing concerns related to food security and nutrition [1]. As of the latest data for the year 2021-22, India's total fish production reached an impressive 162.48 lakh tonnes. Furthermore, it is worth noting that per capita fish consumption in India currently stands at 6.31 kg, a figure that highlights the significance of further interventions, particularly in regions like Punjab, where the per capita consumption stands at a mere 0.4 kg, significantly lower than the national average [2]. In the landscape of Asian countries, fish protein alone contributes a substantial 31% to the pool of animal protein sources [3].

The comprehensive analysis of the proximate composition of fish muscles offers valuable insights into the composition of different species. This allows for meaningful comparisons of nutritional differences both within and among species. Fish, as a dietary source, presents a rich array of essential nutrients, including noteworthy quantities of protein, vitamins, minerals, and healthy fats. It is renowned as a globally accepted source of low-fat, high-quality protein and minerals, in addition to being a rich source of polyunsaturated fatty acids (PUFA) [4,5].

Ensuring the nutritional integrity and safety of fish available in the market relies heavily on maintaining the highest standards of product quality. A multitude of factors come into play, including the duration between harvesting and consumption, as well as the meticulous control of temperatures during all stages of handling, processing, and storage. These factors exert profound influences on the biochemical composition, microbial load, and sensory attributes of the fish [6]. The objective of this research endeavor was to conduct a comprehensive examination into the nutritional composition of four diverse fish species, namely *Wallago attu*, *Labeo rohita*, *Pangasianodon hypophthalmus*, and *Rastrelliger kanagurta*, procured from the Ludhiana fish market to discern the variations in fish muscle composition across different seasons.

2. MATERIALS AND METHODS

The present study focused on the selection of fish markets in five districts of Punjab, India, namely Amritsar (31º37′ 50.969″N, 74º52′ 30.93″E), Jalandhar (31º20′ 2.605″N, 75º34′ 13.205″E), Ludhiana (30º55′ 17.501″N, 75º54′ 5.642″E), Mohali (30º43′ 49.67″N, 76º42′ 2.46″E), and Bathinda (30º12′ 29.399″N, 74º 57′ 56.785″E). The data collection spanned a period of one year, from September 2021 to August 2022, with sampling conducted at regular intervals corresponding to different seasons, including post-monsoon, winter, pre-monsoon, and monsoon. The selection process took into consideration the marketing of fish obtained from both culture and capture fisheries in Punjab, as well as fish imported from other states. *L. rohita*

(culture fishery), *P. hypophthalmus* (culture fishery), *W. attu* (capture fishery), and *R. kanagurta* (capture fishery) muscle samples were collected in fresh condition from markets in sterile containers and transported in an insulated box to the Department of Fisheries Resource Management, College of Fisheries Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab. The collected samples were stored at -20^{0}C for further analysis. Analysis of the proximate composition, encompassing parameters such as moisture, protein, lipid, carbohydrate, and ash content was performed using fish muscle after thawing at room temperature.

All the proximate parameters were analysed following the standard methods [7]. Moisture content was recorded by the standard hot air method using the hot air oven. The crude protein level of the fish meat was recorded by estimating total nitrogen by the Kjeldahl method using an electrically heating digestion and distillation unit. The crude lipid content of the fish meat was recorded by the Soxhlet extraction method using the Soxhlet fat extraction unit. The total carbohydrate content of the fish meat was recorded by the Anthrone method using the spectrophotometer. Ash content of the fish meat was recorded by the dry method at high temperature (550 ± 25ºC) using a muffle furnace. One way ANOVA (p=0.05) was performed using Tukey`s-b Post Hoc multiple comparisons method to evaluate the relationship among proximate composition and quality parameters. Statistical analysis was performed by using SPSS ver. 20 software package.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Selected Fish Species

3.1.1 Moisture content in fish flesh

Among the four selected fish species, namely *W. attu*, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta*, their lowest moisture content was recorded during the pre-monsoon season (79.18%, 77.01%, 73.02%, and 72.48%, respectively), contrasting with their highest levels observed during the monsoon season at 81.08%, 79.92%, 74.96%, and 74.94%, respectively. These fluctuations highlight the pronounced influence of seasonal variations on fish moisture levels in the market. The moisture content across the four species ranged from 72.48% to 81.08% across different seasons (Table 1). Significant variations in average moisture content were observed across seasons ($p<0.05$) among the selected species, *R. kanagurta* recorded the minimum and *W. attu* the maximum moisture content. According to FAO [8], fish fillets typically exhibit an inverse relationship between moisture and lipid content; with their combined sum constitute approximately 80% of the proximate composition, while the remaining 20% comprises other components.

Naher et al. [9] determined the moisture levels of *W. attu* samples in fresh and frozen storage conditions collected from the Mymensingh district, Bangladesh. The moisture content recorded for *W. attu* under fresh and frozen conditions was determined to be 79.00 ± 0.45% and 75.00 ± 1.01%, respectively. Similarly, Dayami and Sarojnalini [10] estimated an average moisture content of 79.18 ± 0.43% in *L. rohita* sourced from Loktak Lake, Manipur, which closely corresponds to the findings of the current investigation. Moreover, Dayami and Sarojnalini [10] noted the highest moisture content in *P. hypophthalmus* during the monsoon season compared to other periods. Sonavane et al. [11] reported moisture content of 72.24% in *R. kanagurta* and emphasized the inverse relationship between moisture and fat content in fish, suggesting that fatty fish typically exhibit relatively lower moisture content.

3.1.2 Protein content in fish flesh

During the study period, *W. attu*, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta* exhibited their lowest protein content in flesh during the monsoon season, measuring at 14.62%, 14.35%, 9.72%, and 16.48%, respectively, whereas their highest levels were recorded during the pre-monsoon season, reaching 16.49%, 16.05%, 11.59%, and 18.36%, respectively. These fluctuations underscore the significant impact of seasonal variations on protein levels among diverse fish species. Notably, protein levels ranged from 9.72% to 18.36% across different seasons (Table 2). Furthermore, the average protein content values exhibited significant variations across various seasons ($p<0.05$) within the four selected species. Specifically, *P. hypophthalmus* displayed the lowest protein content, while *R. kanagurta* exhibited the highest. The observed increase in protein contents during the post-monsoon season suggests a recuperation of fish from the rigors associated with breeding activities.

Table 1. Moisture content of selected fish during seasonal interval

Season	*W. attu*	*L. rohita*	*P. hypophthalmus*	*R. kanagurta*
Post-monsoon	80.44^{ab}±0.28	78.23^{b}±0.29	74.61^{ab}±0.28	73.41^{b}±0.29
Winter	79.53^{b}±0.25	77.32^{b}±0.29	73.66^{bc}±0.25	72.79^{b}±0.27
Pre-monsoon	79.18^{b}±0.29	77.01^{b}±0.32	73.02^{c}±0.28	72.48^{b}±0.27
Monsoon	81.08^{a}±0.32	79.92^{a}±0.29	74.96^{a}±0.30	74.94^{a}±0.33
Average	80.05±0.25	78.12±0.36	74.07±0.26	73.40±0.31

The values (mean ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly within the seasons from different sites (in a column).

Table 2. Protein content of selected fish during seasonal interval

Season	*W. attu*	*L. rohita*	*P. hypophthalmus*	*R. kanagurta*
Post-monsoon	15.74^{b}±0.11	15.21^{b}±0.10	10.65^{b}±0.11	17.54^{b}±0.11
Winter	15.76^{b}±0.14	15.70^{ab}±0.17	11.20^{ab}±0.15	18.13^{ab}±0.18
Pre-monsoon	16.49^{a}±0.23	16.05^{a}±0.17	11.59^{a}±0.16	18.36^{a}±0.18
Monsoon	14.62^{c}±0.19	14.35^{c}±0.19	9.72^{c}±0.18	16.48^{c}±0.20
Average	15.65±0.22	15.33±0.20	10.79±0.22	17.63±0.23

The values (mean ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly within the seasons from different sites (in a column).

Mishra [12] documented an average protein content of 15.95% during the monsoon season and 16.99% during the post-monsoon season in *L. rohita* sourced from various fish markets in Sultanpur, Uttar Pradesh. The observed increase in protein content during the post-monsoon season suggests a recovery phase for the fish following the demanding breeding activities. Rahman et al. [13] recorded a protein content of approximately 13.58% in *P. hypophthalmus*. They also noted significant distinctions between live and deceased fish specimens, underscoring the impact of extended storage on fish quality, encompassing chemical composition and nutritional attributes. Mishra [12] additionally highlighted the seasonal variability in fish protein content, typically showing lower values during breeding seasons like the monsoon. Sonavane et al. [11] evaluated an average protein content of 19.14% in *R. kanagurta* harvested from the Ratnagiri coast, concluding that mackerel serves as an excellent protein source across diverse societal strata. In the present study, the protein levels of fish were higher during the pre-spawning period (pre-monsoon) and declined during the spawning period (monsoon), mirroring the trend [12]. In fish muscle, water content reached its peak levels while muscle protein content decreased during the monsoon. The decline in protein and the rise in water content of the muscle were attributed to gonadal development and maturation, which depleted muscle protein reserves during the monsoon season [14].

3.1.3 Lipid content in fish flesh

W. attu, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta* exhibited their lowest lipid content in flesh during the monsoon season, measuring at 0.69%, 1.59%, 9.33%, and 2.47%, respectively, contrasting with their highest levels during the winter season at 1.07%, 2.05%, 11.04%, and 4.05%, respectively. The lipid content across different species varied from 0.69% to 11.04% in various seasons (Table 3). Notably, lipid values were minimal in *W. attu* and maximal in *P. hypophthalmus,* with the lowest values recorded during the monsoon and the highest during the winter season. According to FAO [8], moisture and lipid content in fish muscle exhibit an inverse correlation, and escalated moisture content and rapid decline in lipid content in studied fish species could be linked to the spawning season. Ganeshwade and Jadhav [15] conducted a study on seasonal biochemical variations in *W. attu* from the Krishna River near Audumber, Maharashtra and reported a lipid content of 0.64% during the winter, and decreased during the monsoon seoson. Mishra [12] documented high lipid content in *L. rohita* during the post-monsoon season, attributed to active fish feeding. Subsequently, this lipid content declined in the pre-spawning season, indicating its utilization during gonadal development and as an energy source during ovulation and spawning.

Rahman et al. [13] documented a lipid content of approximately 8.0% in *P. hypophthalmus*, while

Murthy et al. [16] reported a lipid content of 3.83% in *R. kanagurta* sourced from various fish outlets in Navi Mumbai, Maharashtra. Sonavane et al. [11] observed an inverse relationship between moisture and fat content, indicating that fatty fish species tend to possess relatively lower moisture content. A similar inverse relationship was noted between *W. attu* and *P. hypophthalmus* in the current study.

3.1.4 Carbohydrate content

Carbohydrate levels in fish flesh reached its lowest points during the monsoon season in all four species, *W. attu*, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta,* measuring at 0.54%, 1.46%, 0.62%, and 0.24%, respectively. Conversely, it peaked during the pre-monsoon season at 0.78%, 2.04%, 1.13%, and 0.36%, respectively (Table 4). Across different seasons, carbohydrate content varied from 0.23% to 2.04%. *R. kanagurta* exhibited the lowest carbohydrate values, while *L. rohita* displayed the highest. Carbohydrate values were minimal during the post-monsoon period and maximal during the pre-monsoon season.

Rahman et al. [14] reported a carbohydrate content of approximately 0.73% in *P. hypophthalmus*, aligning closely with the values recorded in the present study. Sahu and Parida [17] highlighted the relatively low levels of carbohydrates compared to other proximate compositions in fish, noting a carbohydrate level of 0.51% in *R. kanagurta*. In marine fish, glycogen does not serve as a significant reserve energy source supported the present findings. Lower levels of carbohydrate content are found in the total proximate composition of fish muscle, indicating that most of the glycogen in freshwater fish does not significantly contribute to body reserves [18]. These findings are consistent with the results observed in the current study also.

3.1.5 Ash content

Ash content reached its nadir during the monsoon in all four species (*W. attu*, *L. rohita*, *P. hypophthalmus*, and *R. kanagurta*), measuring at 2.54%, 1.65%, 1.62%, and 1.71%, respectively, and peaked during the pre-monsoon season at 3.78%, 2.28%, 2.04%, and 3.04%, respectively (Table 5). Across different species, ash content varied from 1.62% to 4.34%, with the lowest observed in *P. hypophthalmus* and the highest in *W. attu*. Hasan et al. [19] documented an ash content ranging from 1.04% to 2.95% in *P. hypophthalmus*, with an average value of 1.75%, which closely aligns with the findings of the current study. Sonavane et al. [11] reported an ash content of 1.42% in *R. kanagurta* harvested from the Ratnagiri Coast, Maharashtra. Mishra [12] observed higher ash content during the post-monsoon season and lower levels during the monsoon season. The association between higher ash content and increased mineral metabolism is notable. The availability of food substantially increases during the post-monsoon season following the receding water levels during the monsoon. The findings of the present study also indicate a similar trend, with ash content peaking during the pre-monsoon seasonand reaching its lowest during the monsoon season.

Table 3. Lipid content of selected fish during seasonal interval

Season	*W. attu*	*L. rohita*	*P. hypophthalmus*	*R. kanagurta*
Post-monsoon	0.78^{a}±0.06	1.62^{a}±0.07	9.78^{b}±0.80	3.09^{b}±0.07
Winter	1.07^{a}±0.11	2.05^{a}±0.14	11.04^{a}±0.16	4.05^{a}±0.17
Pre-monsoon	1.02^{a}±0.14	1.94^{a}±0.05	11.00^{a}±0.13	3.98^{a}±0.14
Monsoon	0.69^{a}±0.12	1.59^{a}±0.13	9.33^{b}±0.13	2.47^{c}±0.15
Average	0.89±0.06	1.80±0.07	10.28±0.23	3.40±0.21

The values (mean ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly within the seasons from different sites (in a column)

Table 4. Carbohydrate content of selected fish during seasonal interval

Season	*W. attu*	*L. rohita*	*P. hypophthalmus*	*R. kanagurta*
Post-monsoon	0.60^{a}±0.03	1.64^{b}±0.04	0.72^{b}±0.04	0.23^{a}±0.03
Winter	0.74^{a}±0.07	2.01^{a}±0.06	1.04^{a}±0.08	0.32^{a}±0.06
Pre-monsoon	0.78^{a}±0.08	2.04^{a}±0.07	1.13^{a}±0.07	0.36^{a}±0.05
Monsoon	0.54^{a}±0.06	1.46^{b}±0.08	0.62^{b}±0.07	0.24^{a}±0.06
Average	0.66±0.04	1.79±0.07	0.88±0.07	0.29±0.03

The values (mean ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly within the seasons from different sites (in a column)

Table 5. Ash content of selected fish during seasonal interval

Season	*W. attu*	*L. rohita*	*P. hypophthalmus*	*R. kanagurta*
Post-monsoon	3.61^{b}±0.07	1.79^{ab}±0.07	1.66^{a}±0.08	1.74^{b}±0.07
Winter	4.28^{a}±0.13	2.24^{a}±0.13	1.98^{a}±0.14	2.98^{a}±0.13
Pre-monsoon	4.34^{a}±0.13	2.28^{a}±0.12	2.04^{a}±0.12	3.04^{a}±0.13
Monsoon	3.14^{b}±0.14	1.65^{b}±0.13	1.62^{a}±0.14	1.71^{b}±0.14
Average	3.84±0.15	1.99±0.10	1.83±0.08	2.37±0.20

The values (mean ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly within the seasons from different sites (in a column)

4. CONCLUSION

The Ludhiana fish market presents a diverse array of fish sourced from both the inland and marine sectors comprising the culture and capture sector. An analysis of proximate composition revealed significant variations influenced by species-specific characteristics and seasonal fluctuations. These proximate compositions not only illuminate seasonal variations but also provide a robust framework for ensuring the nutrition of fish consumption, thereby enhancing consumer food security.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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