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A STUDY ON THE SEASONAL VARIATION OF NUTRITIONAL COMPOSITION AND QUALITY OF SOME IMPORTANT FISHES OF BANGLADESH

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ABSTRACT

This research was conducted to investigate the seasonal variation in nutritional composition, freshness (sensory quality), quality of a migratory fish, an anadromus fish, two rapidly swimming fish and a freshwater minnow of Bangladesh. The selected fish species were *Hilsa ilisha, Channa striata, Mastacembelus armatus, Puntius sarana, Pangasius pangasius*. The parameters for nutritional composition were protein, lipid, ash and moisture. Parameter for freshness (sensory quality) was SDP value, and the parameters for quality were TVB-N and TMA-N value. Nutritional composition, freshness, quality in terms of the mentioned parameters of these five fish species were studied in Autumn, Winter and Summer seasons. Result of this research indicated that nutritional composition of fish significantly varies among the seasons with a few exceptions. Most significant seasonal variation was found in protein and lipid content of the fishes. In *Hilsa ilisha* protein content was 17.15% in Winter, 20.6% in Summer and 22.49% in Autumn; lipid content was 7.2% in Winter, 8.5% in Autumn and 12.3% in Summer. In *Channa striatus* protein content was 16.1% in summer, 16.4% in autumn and 21.44% in winter; lipid content was 0.6% in summer, 2.4% in autumn and 3.4% in winter. In *Mastacembelus armatus* protein content was 16.20% in summer, 17.15% in winter and 19.6% in autumn; lipid content was 1.0% in winter, 1.40% in summer and 2.4% in autumn. In *Puntius sarana* protein content was 15.48% in winter, 19.51% in autumn, 19.95%

in summer; lipid content was 2.1% in winter, 2.5% in summer and 3.25% in autumn. In *Pangasius pangasius* seasonal variation in protein and lipid was less noticeable compared to other fish species of this research, protein content was 18.0% in summer, 18.03% in winter and 19.16% in autumn, lipid content was 4.25% in summer, 4.5% in winter and 5.1% in autumn. Minor seasonal variation in freshness i.e. SDP (sensory quality) value was evident in this research experiment. Significant seasonal variation in quality in terms of TVB-N and TMA-N value of the fishes was obtained in this research. Although the TVB-N and TMA-N values were significantly different in autumn, winter, summer the quality in terms of TVB-N and TMA-N value were within the acceptable limit (TVB-N < 32 mg/100g and TMA-N < 8 mg/100g). From the result of this research it is evident that nutritional composition, freshness and quality of fish significantly different in different seasons.

KEYWORDS: Seasonal variation, nutritional composition, sensory quality, quality, fish, Bangladesh.

INTRODUCTION

Nutritional composition e.g. Protein, Lipid, Ash and Moisture of fish varies in different season i.e. summer, autumn, winter months of the year. Average percentage of these components varies with season. Such variation depends on some factors e.g. species, size, spawning, water temperature, geographical location etc. Fish quality also varies in different season of the year. Because quality deterioration and spoilage rate in harvested fish is accelerated by ambient temperature, sunlight, time elapsed between catch and marketing, number and type of spoilage bacteria, extent of water pollution etc.

It is important to know the seasonal variation of nutritional composition, quality aspect of fish. Such information is very important for the consumers' health. Fish is the major source of animal protein in the diet of the most people of Bangladesh. People of Bangladesh eat fish to fulfill nutritional requirement, energy, good health, dietary satisfaction etc. Fish and fishery products are the main source of animal protein in the diet of the people of Bangladesh. At present it contributes nearly 3.74% to GDP and 4.04% to foreign exchange earnings. Fish and fishery products supply nearly 58% animal protein in the diet of the people of Bangladesh. Apart from protein fish contains lipid, minerals, vitamin, antioxidants etc. Fish lipid contains ω-3 polyunsaturated fatty acids which is effective against coronary heart disease. DHA, EPA and overall bio-factors of fish and fishery products are excellent. This is the reason that fish is a very good food. Fish of Bangladesh water area are famous for

delicious taste. Consumers purchase fish with confidence. Due to changes in climate particularly in aquatic environment the fish are getting contaminated by various types of pollutants, spoilage bacteria, parasites. This makes fish and fishery products unfit for human consumption. Sometimes it causes various health hazards whether temporary or permanent. Domestic consumers suffer from the loss of nutritional benefit as well as health hazard. In the International market such contamination causes loss of reputation and potential financial loss.

There are some factors which may reduce the quality of fish. Among which three factors are important. Fish caught near waste dump area of rivers or open water; Fish caught from the dirty area in or near sewerage disposal; Fish caught near Industrial effluent discharge area. Fish quality loss takes place by the following three causes: Bacterial activity, Enzymatic activity, Oxidative rancidity or combination of these three causes. Rate of deterioration, is influenced by temperature, biological agent, chemical reaction, bio-chemical reaction.

The significance of seasonal variation is complex. It is almost impossible to distinguish surely between the effects of many factors which play a part. The main factors are the stage of gonad development and feeding conditions. Appreciable variations are sometimes encountered. The Atlantic sardine contains 2% lipid in the spring and 8.6% in fall. In this species protein content varies between 16% in March and 20% in July. Similar variations are found in many pelagic species which get their nourishment from plankton, the abundance and composition of which vary greatly. Connell (1980)[1] stated that in all species of fish seasonal changes in certain bodily characteristics occur. At certain times of the year ordinary fish appear thinner, flabbier and less lively than at others, the flesh being more watery and softer and containing less protein and fat. Fish of this kind is said to be in poor condition or out of season, such fish has poor sales appeal and gives lower yield. Spawning and feed availability in water greatly influence in occurrence of poor condition in fish. Seasonal, cyclical changes in comparison are observed in all species though less noticeable in some shellfish. Poor condition seriously affect the texture of white fish muscle i.e. on the sensory quality of fish, in extreme cases the fish becomes unusable. In the fatty pelagic species poor condition particularly low fat content usually produce poor quality product. There is a close relationship between heavy feeding and susceptibility to damaging condition known as belly burst. Such condition has secondary influence on the spoilage rate of chilled lean fish too. Such seasonal variation in fish composition has marked influence on the flesh pH, gaping, void free blocks of frozen cod fillets, chalkiness (Bonnell, 1994).[2] Love (1992)[3] stated that unlike pure

chemical substances, which always have the same composition, the musculature of a fish enfolds a variety of constantly changing interactive systems. The balance between these systems can vary widely without causing the death of the fish but, after capture and killing, the variations are often found to have influenced the acceptability of the flesh as food for human consumption. They can also affect its suitability for processing. In Bangladesh seasonal variation in nutritional composition and quality of Eurasian catfish and Indian major carp has been reported by Mansur et. al (2018d; 2019c).[4,5] Fat content in the British coast herring (*Clupea harengus*) of North Sea was estimated as 18% in summer immediately before spawning, 9% in autumn immediately after spawning, and only 2% in winter starvation (Mansur, 1995).[6]

Data on seasonal variation in nutritional composition and quality aspect of fish are not sufficient in Bangladesh. A good number of research have been conducted in the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh on Proximate composition of fishes (Mansur, 1989; Mansur *et. al.*, 1990; Hoq *et. al*., 1995; Kamal *et. al*., 1996; Rahman *et. al*., 1999; Mansur *et. al*., 2000; Mansur *et. al*., 2013; Mansur *et. al*., 2014; Mansur, 2015; Mansur *et. al*., 2017; Mansur *et. al*., 2018a; Mansur *et. al*., 2018b; Mansur *et. al*., 2018c).[7-19] At present we are conducting research on seasonal variation on the composition and quality of fishes in the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh. Enough data, correct and accurate reliable data on seasonal variation of nutritional composition, quality are necessary for quality control and safety measure. It is necessary for quality assurance and health safety of the consumers. This will help to take quality control measure or action, which will keep the bio-factors of fish and fishery products unchanged, will save the bulk catch from spoilage, will help to continue the export of fish and shrimp for earning valuable foreign currency, for new product development, will keep the fish and fishery products safe for human consumption. Result of this research on seasonal variation of nutritional composition and quality will also be helpful for selection of best fish for consumption, product development and selecting best fishing season.

MATERIALS AND METHOD

Source of fish

Reasonable quantity of each species of the following list was purchased from K. R. Market located in the Bangladesh Agricultural University, Mymensingh, Bangladesh. The fishes

were in chilled condition during purchase. The raw chilled fishes were taken in polyethylene bag and rapidly transported to the laboratory of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh. The raw materials (raw fish/chilled fish) of this research were purchased from the same source in each season i.e. autumn, winter, summer for a better comparison of result. Average size and weight of the experimental fishes in different seasons are mentioned in the following list. Such information is necessary to have a general idea about marketable size of these fishes, also for better comparison of result, and to have confidence on the acceptability of result.

List of Fish

Sl. No.	Local name	English name	Scientific name	Average length and weight		
				Autumn	Winter	Summer
1	Pangas	Schilbeid catfish	*Pangasius pangasius*	L: 38 cm W: 460 g	L: 52 cm W: 1445 g	L: 53 cm W: 1470
2	Shoyl	Snake headed fish	*Channa striata*	L: 46.83cm W: 940 g	L: 40 cm W: 700 g	L: 39 cm W: 313 g
3	Shor Puti	Minnow	*Puntius sarana*	L: 16.03cm W: 81.3 g	L: 21.08 cm W: 120 g	L: 20 cm W: 119 g
4	Baim	Mastacembeleid eel	*Mastacembelus armatus*	L: 57 cm W: 42.5 g	L: 33.1 cm W: 94 g	L: 48.3 cm W: 210 g
5	Ilish	River shad	*Hilsa ilisha*	L: 52 cm W: 1450 g	L: 37 cm W: 879 g	L: 33 cm W: 790 g

L = Length; W = Weight.

Laboratory analysis

On receipt of fishes in the laboratory, sensory quality analysis (SDP value) and quality parameters (TVB-N and TMA-N) were estimated immediately. The rest of the samples were subjected to laboratory analysis for estimation of nutritional composition (Protein, Lipid, Ash, Moisture).

Sensory quality analysis: Sensory quality analysis (estimation of SDP value) of the raw chilled fishes was conducted in the laboratory by organoleptic test according to the method of Howgate et. al. (1993).[20] This method is most widely used but very easy and simple method of estimating the degree of freshness of fish i.e. sensory quality (estimation of SDP value).

Biochemical analysis: Nutritional composition (Protein, Lipid, Ash, Moisture) was estimated according to the method of A. O. A. C. (1980).[21] Quality parameters e.g. TVB-N and TMA-N were estimated according to the methods of A. M. C (1979).[22]

RESULTS

Seasonal variations in freshness or sensory quality (SDP value) of the fishes are mentioned in Table 1. Data in Table 1 indicates that the freshness of these fishes were excellent (SDP < 2) in different seasons of the year except *Puntius sarana* in autumn season. There was slight difference in SDP value in different seasons but remained within the acceptable limit.

Table 1: SDP value of different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	SDP		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	1.14	1.14	1.86
2	*Channa striata*	1.14	1.14	1.14
3	*Puntius sarana*	2.14	1.43	1.85
4	*Mastacembelus armatus*	1.73	1.14	1.9
5	*Hilsa ilisha*	1.85	1.56	1.9

Seasonal variations in protein content in the fishes of this research are mentioned in Table 2. Most significant seasonal variation in protein content was estimated in *Channa striata, Puntius sarana, Hilsa ilisha.* Seasonal variations in protein content in *Pangasius pangius* and *Mastacembelus armatus* was also noticeable. Protein content in *Channa striata* was 18.81% in autumn, 21.44% in winter and 16.01% in summer. Protein content in *Puntius sarana* was 19.51% in autumn, 15.48% in winter and 19.95% in summer. Protein content in *Hilsa ilisha* was 22.49% in autumn, 17.15% in winter and 20.60% in summer. However seasonal variations in protein content in *Pangasius pangasius* and *Mastacembelus armatus* was less significant but noticeable. Protein content in *Pangasius pangasius* was 19.16% in autumn, 18.03% in winter and 18.00% in summer. Protein content in *Mastacembelus armatus* was 19.60% in autumn, 17.15% in winter and 16.20% in summer.

Table 2: Protein content in different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	Protein (%)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	19.16	18.03	18.00
2	*Channa striata*	18.81	21.44	16.01
3	*Puntius sarana*	19.51	15.48	19.95
4	*Mastacembelus armatus*	19.60	17.15	16.20
5	*Hilsa ilisha*	22.49	17.15	20.60

Seasonal variations in lipid content in the fishes of this research are mentioned in Table 3. Most significant seasonal variation in lipid content was estimated in *Hilsa ilisha*. Seasonal variation in lipid content in *Pangasius pangasius*, *Channa striata*, *Puntius sarana*, *Mastacembelus armatus* was also noticeable but the range was less than that of *Hilsa ilisha*. Lipid content in *Hilsa ilisha* was 8.50% in autumn, 7.20% in winter and 12.30% in summer. However the seasonal variations in lipid content in the other four species were less significant compared to *Hilsa ilisha* but clearly noticeable. In *Pangasius pangasius* lipid content was 5.10% in autumn, 4.50% in winter and 4.26% in summer. In *Channa striata* lipid content was was 2.40% in autumn, 4.50% in winter and 4.25% in summer. In *Puntius sarana* lipid content was 3.25% in autumn, 2.10% in winter and 2.50% in summer. In *Mastacembelus armatus* lipid content was 2.40% in autumn, 1.00% in winter and 1.40% in summer.

Table 3: Lipid content in different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	Lipid (%)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	5.10	4.50	4.25
2	*Channa striata*	2.40	3.40	0.60
3	*Puntius sarana*	3.25	2.10	2.50
4	*Mastacembelus armatus*	2.40	1.00	1.40
5	*Hilsa ilisha*	8.50	7.20	12.30

Seasonal variations in ash (total minerals) content in the fishes of this research are mentioned in Table 4. Most significant seasonal variation in ash content was estimated in *Pangasius pangasius*, *Channa striata* and *Puntius sarana*. Seasonal variation in ash content in *Mastacembelus armatus* and *Hilsa ilisha* was noticeable but comparatively less significant. In *Pangasius pangasius* ash content was 1.14% in autumn, 0.89% in winter and 4.30% in

summer. In *Channa striata* ash content was 4.50% in autumn, 1.00% in winter and 6.48% in summer. In *Puntius sarana* ash content was 3.40% in autumn, 1.03% in winter and 2.80% in summer. But the seasonal variation in ash content in the other two species (*Mastacembelus armatus*, *Hilsa ilisha*) was not as significant as in the first three species (*Pangasius pangasius*, *Channa striata*, *Puntius sarana*) of this research. However the seasonal variation in ash content was noticeable in *Mastacembelus armatus* and nearly unchanged in *Hilsa ilisha*. Ash content in *Mastacembelus armatus* was 1.01% in autumn, 1.85% in winter and 2.90% in summer. Ash content in *Hilsa ilisha* was 1.66% in autumn, 1.39% in winter and 1.41% in summer.

Table 4: Ash content in different fish species (*Pangasius pangasius*, *Channa striata*, *Puntius sarana*, *Mastacembelus armatus*, *Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	Ash (%)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	1.14	0.89	4.30
2	*Channa striata*	4.50	1.00	6.48
3	*Puntius sarana*	3.40	1.03	2.80
4	*Mastacembelus armatus*	1.01	1.85	2.90
5	*Hilsa ilisha*	1.66	1.39	1.41

Seasonal variations in moisture content in the fishes of this research are mentioned in Table 5. Significant seasonal variation in moisture content in almost all species of fish was estimated during this research. In *Pangasius pangasius* moisture content was 74.47% in autumn, 79.60% in winter and 73.01% in summer. In *Channa striata* moisture content was 75.12% in autumn, 79.39% in winter and 76.61% in summer. In *Puntius sarana* moisture content was 75.65% in autumn, 81.39% in winter and 74.47% in summer. In *Mastacembelus armatus* moisture content was 77.97% in autumn, 74.70% in winter and 79.42% in summer. In *Hilsa ilisha* moisture content was 66.70% in autumn, 73.76% in winter and 65.13% in summer. Result stated in Table 5 clearly indicates that there was a significant seasonal variation in moisture content of the fishes in different seasons.

Table 5: Moisture content in different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	Moisture (%)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	74.47	79.60	73.01
2	*Channa striata*	75.12	79.39	76.61
3	*Puntius sarana*	75.65	81.39	74.47
4	*Mastacembelus armatus*	77.97	74.70	79.42
5	*Hilsa ilisha*	66.70	73.76	65.13

The quality parameters TVB-N and TMA-N are mentioned in Table 6 and Table 7 respectively. The most widely used quality parameter TVB-N was significantly different in *Channa striata*, *Puntius sarana*, *Mastacembelus armatus*, *Hilsa ilisha* in different season of the year. In *Channa striata* TVB-N content was 17.0 mg/100g in autumn, 11.91 mg/100g in winter and 7.80 mg/100g in summer. In *Puntius sarana* TVB-N was 7.04 mg/100g in autumn, 5.69 mg/100g in winter and 5.00 mg/100g in summer. In *Mastacembelus armatus* TVB-N was 32.80 mg/100g in autumn, 8.80 mg/100g in winter and 9.10 mg/100g in summer. In *Hilsa ilisha* TVB-N was 5.40 mg/100g in autumn, 13.10 mg/100g in winter and 4.50 mg/100g in summer. But in *Pangasius pangasius* TVB-N content was not much different in different seasons of the year, TVB-N range was 13.00 to 14.20 mg/100g in this freshwater fish.

Table 6: TVB-N content in different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	TVB-N (mg/100g)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	14.20	13.21	13.00
2	*Channa striata*	17.00	11.91	7.80
3	*Puntius sarana*	7.04	5.69	5.00
4	*Mastacembelus armatus*	32.80	8.80	9.10
5	*Hilsa ilisha*	5.40	13.10	4.50

TMA-N of the fishes are stated in Table 7. TMA-N was significantly different in *Channa striata* and *Mastacembelus armatus* in different seasons of the year. In *Channa striata* TMA-N was 4.50 mg/100g in autumn, 1.30 mg/100g in winter and 2.30 mg/100g in summer. In *Mastacembelus armatus* TMA-N was 5.44 mg/100g in autumn, 1.30 mg/100g in winter and 2.50 mg/100g in summer. But in the other three species of this research TMA-N was not as

much different as in *Channa striata* and *Mastacembelus armatus* in different seasons of the year. In *Pangasius pangasius* TMA-N was 3.20 mg/100g in autumn, 3.11 mg/100g in winter and 2.90 mg/100g in summer. In *Puntius sarana* TMA-N was 2.90 mg/100g in autumn, 2.59 mg/100g in winter and 2.20 mg/100g in summer. In *Hilsa ilisha* TMA-N was 1.50 mg/100g in autumn, 0.40 mg/100g in winter and 0.90 mg/100g in summer.

Table 7: TMA-N content in different fish species (*Pangasius pangasius, Channa striata, Puntius sarana, Mastacembelus armatus, Hilsa ilisha*) in autumn, winter, summer season.

Sl. No.	Scientific name	TMA-N (mg/100g)		
		Autumn	Winter	Summer
1	*Pangasius pangasius*	3.20	3.11	2.90
2	*Channa striata*	4.50	1.30	2.30
3	*Puntius sarana*	2.90	2.59	2.20
4	*Mastacembelus armatus*	5.44	1.30	2.50
5	*Hilsa ilisha*	1.50	0.40	0.90

DISCUSSION

There was slight seasonal variation in SDP value of the fishes, but such variation was not much when compared among the fishes in different seasons of the year. Such variation is expected and may took place due to several reasons. Water temperature, bacterial and enzymatic activity and environment usually different in the different seasons which influenced the freshness i.e. sensory quality (SDP value) of the fishes under this part of research. Such seasonal variation in SDP value in Eurasian catfish and Indian major carps was also estimated in our previous research. However the SDP value in all samples of different seasons remained in excellent condition (SDP <2) except *Puntius sarana* in autumn season.

Remarkable seasonal variation in nutritional composition (protein, lipid, ash and moisture) in almost all fish species of this research was estimated during this research. This is expected because the fishes were rapidly swimming fish with special characteristics in each species e.g. one species was migratory (*Hilsa ilisha*), one species was anadromous (*Mastacembelus armatus*), one species was predatory (*Channa striata*), two species were rapid swimmer (*Pangasius pangasius, Puntius sarana*). For this reason the energy expenditure was high in these fish species in different seasons of the year. The primary causes of variation of nutritional composition of fishes are the food intake of fish, and the degree of energy expenditure. The factors determining the composition of fish are: the season of the year when

fish is caught, the geographical area in which it was taken, difference between species, individual variation, age difference, sex difference, anatomical difference, food habit difference. Also before spawning and during it energy reserves in the flesh, liver are transferred for the development of gonads (eggs and spawn). During spawning and immediately after spawning most fish do not eat. As a consequence of both effects the flesh after spawning becomes severely depleted of protein, carbohydrate and fat, and the fish are accordingly rundown which is known as poor condition. Similar condition can arise when for any reason fish are not eating or eating at a very low level. Seasonal and cyclical changes in flesh condition are observed in all species.

Connell (1980) stated that compositional changes has marked influence on fish. In white fish in poor condition the fish when cooked and eaten is soft, gelatinous. Flavour is weak or insipid. In extreme cases depletion of protein gives rise to a jelly-like completely unusuable state in the fish flesh. In fatty pelagic fish composition and dependent quality changes are most marked. Sardine, sprat, herring, mackerel, anchovies are example of this kind. Fat content of herring flesh can change from 2% in winter starvation to 18% in summer immediately before spawning i.e. active feeding condition. For some special products condition and composition of fish is important. Seasonal variation in nutritional composition has secondary influence on fish. In chilled storage lean fish in poor condition spoil rapidly than the same species in good condition. The reason is probably connected with the higher flesh pH of the former, which arises primarily because the glycogen content is lower. After death the glycogen is converted into lactic acid the concentration of which determines the flesh pH. Lower lactic acid concentration results in higher flesh pH. Bacteria which cause spoilage are more active in flesh of higher pH.

Two universal parameters TVB-N and TMA-N of fish muscle indicate over all quality of fish and fishery products. Considerable attention has been paid to TVB-N and TMA-N of raw fish and a maximum allowable limit is set. This maximum allowable limit determines the acceptability and safety of raw fish on the basis of quality (Connell *et. al*., 1976; Pearson and Muslemuddin, 1969; Wong *et. al*., 1975; Uchiyama *et. al*., 1970; Burt *et. al*., 1976).[23-27] Fresh fish muscle contains a little TMAO but the major portion of TVB-N is considered essentially to be ammonia. In well preserved fish and prawn ammonia originates from amino acids, mainly from glutamine and asparagins (Haaland and Njaa, 1988).[28] Selection of appropriate method for the accurate determination of TVB-N is important. A number of

methods for determination of TVB-N and TMA-N have been proposed by many researchers (Ritskes, 1975; Miller *et. al.*, 1972; Keay and Hardy, 1972; Murray and Gibson, 1972; Gruger, 1972; Ward *et. al.*, 1979; Ruiter and Weseman, 1976; Parris, 1984; Bhotta *et. al*., 1984).[29-37] In this research we have followed extraction with tri-chloro acetic acid and steam distillation method. Steam distillation method was found most reliable which is the recommended general method by Analytical Methods Committee. TVB-N value is the result of bacterial spoilage as well as enzymatic spoilage. But the TMA-N value is the result of bacterial spoilage only. Both parameters are useful for quality assessment of fish.

In this research TVB-N value and TMA-N value were significantly different in different seasons of the year (Table 6 and Table 7) which indicates seasonal variation in quality of fishes. Result of this research also indicates the trend in seasonal variation of TVB-N value and TMA-N value i.e. quality was different in various species of fish.

Connell (1980) stated that there are two major causes of quality deterioration in fish e.g. microbiological and non-microbiological. Non-microbiological cause is two types enzymatic and non-enzymatic. Micro-organisms are present on the external surfaces including slime and in the gut of fish but during life not in flesh/muscle. Normal bacterial population or flora on fish consists of several groups of micro-organisms. On death, the micro-organisms or the enzymes they secrete are free to invade or diffuse into the flesh. They react with the complex mixture of natural substances present. Number of micro-organisms in the flesh grow slowly initially but then increasingly rapidly. Their microbial action results in a well-defined sequence of changes in odoriferous and flavourous compounds. Initially compounds having sour, grassy, fruity, acidic, later bitterness and sulphide or rubberiness appear, finally in the putrid state the character is ammonical or faecal. Not all the genera of micro-organisms originally present in the fish are responsible for these changes. The exact sequence of changes differs between species. In some species of fish ammonia is produced by microbiological activity. In some species of fish TMAO is microbiologically reduced to TMA. Increase in TMA is used as chemical measure of spoilage. At later stages of spoilage micro-organisms through the agency of secreted proteolytic enzymes also attack the structural components, protein, resulting in a gradual softening of the fish flesh.

From the result of this research it is evident that there is seasonal variation in quality in migratory fish, anadromus fish, rapidly swimming fish and freshwater minnow. Data of

present research are supported by the result of our previous research studies (Mansur and Horner, 1997; Mansur *et. al.*, 1997; Mansur *et. al.*, 1998; Mansur and Horner, 1998).[38-41]

This research was conducted to study the seasonal variation of nutritional composition and quality of a migratory fish, an anadromus fish, two rapidly swimming fish and a freshwater minnow of Bangladesh in Summer, Autumn and in Winter season. The selected fish species were *Hilsa ilisha, Channa striata, Mastacembelus armatus, Puntius sarana, Pangasius pangasius*. Result of present research indicates that nutritional composition varies among the seasons. Fish quality also varies among the seasons but remained below maximum allowable limit. Such data are important for Fish Farms, Fish Processing Industries, consumers at home and abroad.

CONCLUSION

From the result of the present research it may be concluded that the nutritional composition of fishes vary in Summer, Autumn and in Winter. Quality by sensory test and chemical test also varies in Summer, Autumn and Winter season but remain in acceptable limit. Such seasonal variation in nutritional composition and quality is related to species too.

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