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Seasonal Variation of Quality and the Total Viable Count of Lean and Fatty Fish

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ABSTRACT

This study was conducted to determine and compare the organoleptic quality and the bacterial load of lean fish (*Oreochromis niloticus*) and fatty fish (*Pangasianodon hypophthalmus*). Empirical data were collected from four fish markets in Northeast Bangladesh (Sylhet and Sunamganj) considering two seasons. The total viable count (TVC) of fatty fish (pangus) ranged from 6.213±0.633 to 7.315±0.570 log cfu g^{-1} in winter and 6.907±1.114 to 8.044±0.563 log cfu g^{-1} in summer, whereas tilapia (lean fish) ranged from 5.281±0.690 to 6.251± 0.435 log cfu g^{-1} in winter and 6.025±0.560 to 7.929±0.562 log cfu g^{-1} in summer. The sanitary conditions and fish storage facilities in the region were found to be poor and didn't comply with ICMSF standards. In summary, a number of suggestions can be maintained for the quality of products, including temperature control starting from harvesting by fishermen till handling and consumed by the customers, chilling fish following market conditions, providing safety equipment, and training market workers.

INTRODUCTION

Fish and fishery resources play a vital role in regards to developing the nutritional and socio-economic status of Bangladesh **(Sunny *et al*., 2020; Kuddus *et al*., 2022)**. Fish have been one of the main food staples for humans for many centuries, and it still constitutes an important part of the diet for many people **(Abdul *et al*., 2020; Rahman *et***

***al.*, 2022)**. Fish represent an important source of animal protein in the diet of the people of most Asian countries, which include Bangladesh **(Islam *et al*., 2018a; Sunny *et al*., 2021a; Chakma *et al*., 2022)**. Fisheries resources support 60% of the animal protein demand, which accounts for 4.37% of the Gross Domestic Product (GDP) of Bangladesh **(Islam *et al*., 2016)**. Fish provide valuable nutrients such as protein, minerals, and vitamins and help in the growth of people and have become an ideal food for humans of any age from infants to the elderly **(Shamsuzzaman *et al*., 2017; Islam *et al*., 2018b; Sunny *et al*., 2018)**. Health-conscious people prefer to fish for low-fat content food, specifically in countries with high cardiovascular mortality. Additionally, they prefer polyunsaturated fatty acids in the fatty fish species **(Rodrigues *et al*., 2012)**. Fatty fish such as pangas (*Pangasianodon hypophthalmus*) has been emerging as a highly important aquaculture species economically due to its fast growth, year-round production, and high productivity **(Chowdhury, 2017; FAO, 2020)**. Tilapia (*Oreochromis niloticus*) is also an important lean fish individual that is commonly available in the markets of Bangladesh; it contains low saturated fat, a low-calorie count, phosphorus, niacin, vitamin B12, potassium, and a low amount of carbohydrates **(FAO, 2014; Kuddus *et al*., 2020)**.

Water quality parameters have an immense influence on aquatic environment maintenance **(Rana *et al*., 2018; Sunny *et al*., 2019; Kuddus *et al*., 2021)**. The successes of the fish culture rely on water quality, which is greatly influenced by aquatic microorganisms along with other factors **(Hussain *et al*., 2018; Islam *et al*., 2018b)**. Microorganisms are widely distributed in nature. The different types of fish species are affected by microorganisms, especially bacteria **(Baten *et al*., 2018).** Microorganisms exist on the skin/slime, gills, and gut of live and newly caught fish **(Rabby *et al*., 2019)**. The total number of bacterium found in fish skin is about 10^2-10^7cfu/cm^2, and the availability of bacterial flora in the gills and intestines is 10^3-10^9 cfu/gm **(Alam *et al*., 2017)**. The outer and inner surfaces of the fish could be spoiled. After a fish individual is caught, the immune system collapses with its eventual death, and bacteria can freely proliferate on the skin's surface and the stomach. The intestinal walls sufficiently break down for bacteria to move into the flesh through the muscle fiber **(Wang *et al*., 2020)**. People who buy fish from the markets always face the potential risk of unhygienic handling, transportation, and storage. The status of the market is not up to the standards due to dirty, damp, and unhealthy places, as well as unhealthy fish-holding baskets, insufficient amounts of ice, poor water quality, poor storage, and inadequate display and packaging facilities, which cause contamination. The contamination of fish due to unhealthy conditions encourages microbial contamination from different sources **(Hossain *et al*., 2013; Bisht, 2014)**.

The intensity and abundance of bacterial flora depend on the status of the aquatic environment, which includes seasonal temperature variations, and they are expected to influence the intestinal microbiota of the different types of fish **(Hovda, 2012; Bisthoven, 2020)**. Few quality studies assessed the seasonal variations and the bacterial load of fish in the North-Eastern Bangladesh region, and very few studies focused on comparing the bacterial load of the lean and fatty fish from this region **(Kashem *et al*., 2014)**. The present study has been conducted to discover and compare the seasonal variations of the organoleptic quality and the bacterial load of lean *(Oreochromis niloticus)* and fatty fish *(Pangasianodon hypophthalmus)* at a market condition in the North-Eastern region of Bangladesh. These species are the most popular among all classes of consumers in Bangladesh and are found almost all year round. Thus, their quality that changes with the alterations in environmental parameters are a major concern for the consumers.

MATERIALS AND METHODS

1. Profile of study sites and sampling

This cross-sectional study was conducted in the four fish markets of three Upazilas in the Sylhet and Sunamganj districts, which are shown in Fig. (1). In order to collect empirical data of lean and fatty fish, the Kazir Bazar, Lamakazi, Gobindoganj, and Baluchar Noyabazar fish markets were visited. Two seasons, (The winter season from Dec. 2019 to Feb. 2020, and the summer season from Mar. 2020 to May 2020) were considered for the samples collection. Lean fish tilapia *(Oreochromis niloticus)* and fatty fish pangas*(Pangasianodon hypophthalmus)* were selected to investigate the seasonal variation of the quality and the bacterial load in winter and summer using the organoleptic method and the total viable count (TVC), where the values are calculated as (log CFU/g ± SD). The fish samples were collected from the fish markets by placing samples in airtight polythene bags, which were immediately brought to the laboratory of Fisheries Technology and Quality Control at Sylhet Agricultural University (SAU), Bangladesh. The fish samples were collected, and the bacterial loads were analyzed at seven days' intervals during the experimental period. Microbiological analysis was conducted in the laboratory of Microbiology and Immunology, SAU, Sylhet, Bangladesh.

2. Determination of the organoleptic quality changes of the samples

A total of 48 fish samples were collected from four different fish markets in Sylhet and Sunamganj during the six-month experimental period, which extended from Dec. 2019 to May 2020. A total of eight fish samples were taken per month, with four samples taken for tilapia and four samples taken for pangas. For each species of tilapia and pangas, twenty-four samples were taken. The organoleptic quality changes of the tilapia and pangas samples were immediately determined by examining the defect points and grading the fish according to grade points by a trained panel of 20 male and female panelists (1:1). There were some modifications in regards to the freshness and the grading scheme that is used by the European Economic Community (EEC) to determine the quality of fresh fish according to a numerical scoring system employed, which is shown in Table

(1). A score less than 2 points was considered to be excellent fish, a score from 2 to less than 5 points was judged as good or acceptable fish, and a score that was 5 and above was considered as bad or rejected fish. Defect points were estimated by the following equation: Grand defect mean value/Grade $= \frac{\text{Total Point Gain}}{\text{No. of characteristics}}$

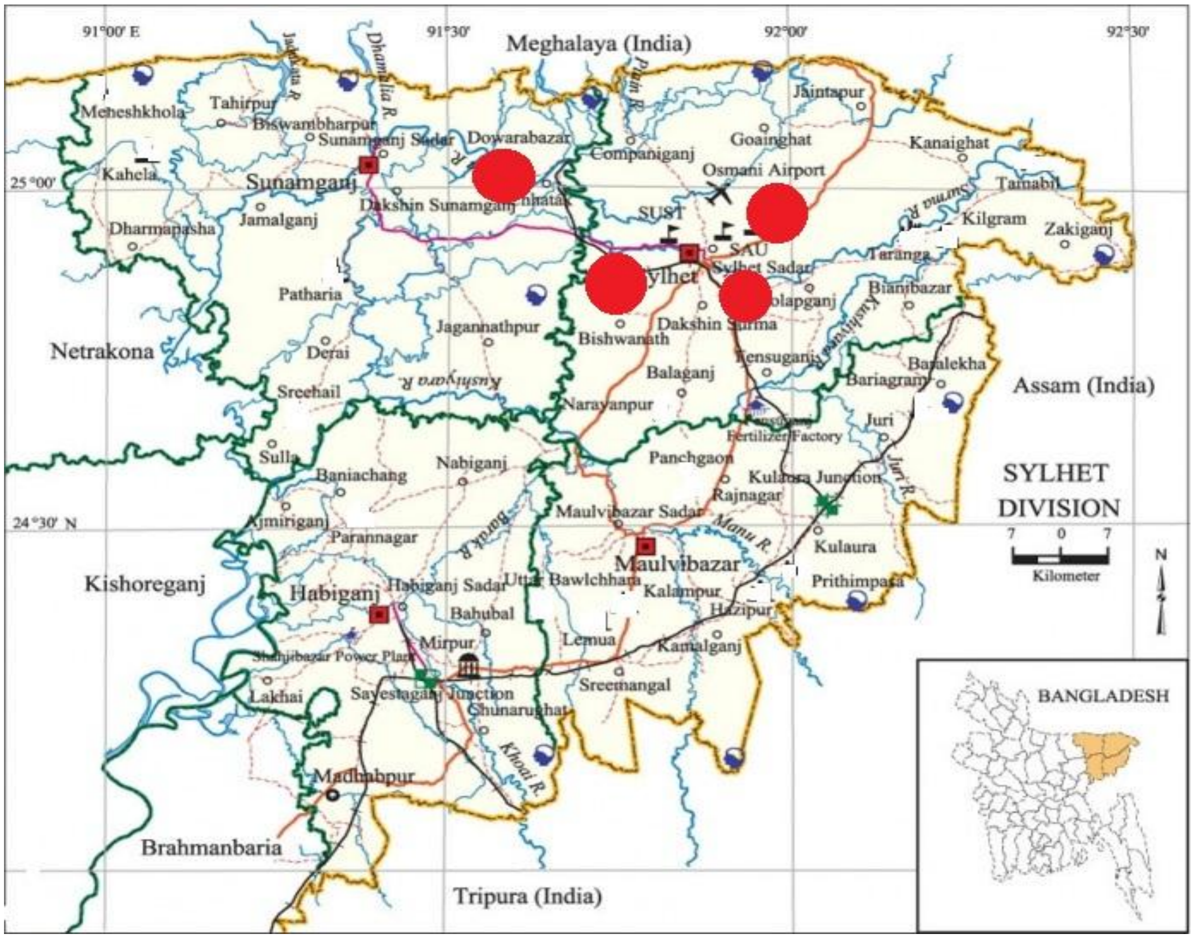

Fig. 1. Location of the study areas

3. Sample preparation

After collecting the samples, they were prepared by dissecting the fish and were determined as 25g of fish muscle. The gills and the intestines were homogeneously mixed with 225ml of distilled water in a Stomacher blender. Each sample was aseptically mixed with sterile distilled water at the ratio of 1:10. In order to make a homogenous suspension, the sample was shaken and tenfold serial dilutions (1:10) were prepared in a range from 10^{-2}- 10^{-9}, according to the recommendation of the International Standardization Organization **(Kashem *et al*., 2014)**. The diluted samples were then placed in a petri dish and mixed well. Finally, the petri dish containing the samples was placed into an incubator to incubate the sample for 24 hours.

Table 1. Determination of defect points of fish

Characteristic	Defect	Defect points	Grade
1. Odor on neck when broken	a) Natural odor	1	Excellent
	b) Faint or sour odor	5	Rejected
2. Odor of gills	a) Natural odor	1	Excellent
	b) Faint or sour odor	2	Acceptable
	c) Slight moderate sour odor	3	Acceptable
	d) Moderate to strong sour odor	5	Rejected
3. Color of gills	a) Slight pinkish red	1	Excellent
	b) Pinkish red or brownish	2	Acceptable
	c) Brown or grey color	3	Acceptable
	d) Bleached, thick yellow slime	5	Rejected
4. General appearance	a) Full bloom, bright, shining, iridescent	1	Excellent
	b) Slight dullness and loss of bloom	2	Acceptable
	c) Definite dullness and loss of bloom	3	Acceptable
	d) Reddish lateral line, dull, no bloom	5	Rejected
5. Slime	a) Usually clear, transparent, and uniformly spread	1	Excellent
	b) Become turbid opaque and milky	2	Acceptable
	c) Thick, sticky, yellowish, or green in color	5	Rejected
6. Eye	a) Bulging with protruding lens, transparent eye cap	1	Excellent
	b) Slight cloudy of the lens and sunken	2	Acceptable
	c) Dull, sunken, cloudy	3	Acceptable
	d) Sunken eye covered with yellow slime	5	Rejected
7. Consistency of flesh	a) Firm and elastic	1	Excellent
	b) Moderately soft and some loss of elasticity	2	Acceptable
	c) Some softening	3	Acceptable
	d) Limp and floppy	5	Rejected

4. Calculation of total viable count (TVC)

A total of 1ml of each tenfold diluted sample was transferred and spread to a plate count agar (PCA) using a sterile pipette and a sterile glass spreader. The incubated plates were then kept in an incubator at 37°C for 24- 48 hours. Two plates that corresponded to one dilution and showed between 30 to 300 colonies per plate were selected. All the colonies on the plate were counted using a colony counter. The number of bacteria per gram of the sample (CFU/g) was calculated using the formula that is provided below according to **Kashem *et al*. (2014)**:

$$\textbf{CFU/g} \quad \frac{\text{No.of colonies on petri dish} \times 10 \times \text{dilution factor} \times \text{Volume of total sample solution}}{\text{Wt.of fish sample (g)}}$$

$$N = \frac{\sum c}{\mathrm{V\ (n1 + 0.01\ n2 + 0.01\ n3)\ d}}$$

Where, N = the total amount of microbes; V = the amount of inoculate mixture that is poured into each petri dish, which is generally 1.0ml; n1= the number of petri dish in the first dilution; n2 = the number of petri dish in the second dilution; n3 = the number of petri dish in the third dilution, and d = the dilution factor of the first dilution.

5. Statistical analysis

The SPSS (Statistical Package for the Social Sciences) version 23 (IBM, New York, USA) was used to statistically evaluate all data. To begin with, all data were recorded in using Microsoft Excel. For the comparisons of the seasonal variations according to the quality and the bacterial load in pangas and tilapia, a student's t-test and a non-parametric pearson's correlation test were applied. All tests were considered significant at 5% ($P <$ 0.05).

RESULTS

1. Changes in the organoleptic qualities

The quality of the fish was graded using defect points, and the fish were graded using different points, which ranged from 1 to 5. The results of the analyses are shown in Tables (2, 3) and Figs. (1, 2). Samples were categorized into different grades. Out of the 48 experimental samples, 24 of the samples were tested in winter, and 24 were subjected to test in summer. In the winter season, grade A, which includes fish in excellent condition was found for 13 samples, which included 8 lean fishes and 5 fatty fishes, whereas grade B, which includes fish in acceptable condition, was found for 10 samples, which included 4 lean fishes and 6 fatty fishes. On the other hand, grade C which included fish in bad condition was found for 1 sample, which was a fatty fish individual. In the summer season, grade A was found for 2 samples, which included 1 lean fish and 1 fatty fish; grade B was found for 14 samples, which included 8 lean fishes and 6 fatty fishes, and grade C was recorded for 8 species, including 3 lean fishes and 5 fatty fishes. The present study revealed that the high temperature with high relative humidity and improper handling during the summer season deteriorated the organoleptic quality more than the winter season. The organoleptic quality mainly depended on the changes in the attributes which occurred according to the species, season, source, and temperature.

Table 2. Organoleptic quality changes of pangas and tilapia for the market condition during the winter

Month	Date	Temperature	Species	Defect (Average)	Point grade	Overall quality
December 19	04.12.19	30.5	Pangas	4.57	B	Acceptable
			Tilapia	3.64	B	Acceptable
	11.12.19	30.5	Pangas	4.42	B	Acceptable
			Tilapia	3.14	B	Acceptable
	18.12.19	27.0	Pangas	1.71	A	Excellent
			Tilapia	1.65	A	Excellent
	26.12.19	26.0	Pangas	1.64	A	Excellent
			Tilapia	1.61	A	Excellent
January 20	02.01.20	22.8	Pangas	1.14	A	Excellent
			Tilapia	1.00	A	Excellent
	09.01.20	27.5	Pangas	1.85	A	Excellent
			Tilapia	1.57	A	Excellent
	16.01.20	27.2	Pangas	1.74	A	Excellent
			Tilapia	1.67	A	Excellent
	23.01.20	28.6	Pangas	2.14	B	Acceptable
			Tilapia	1.78	A	Excellent
February 20	06.02.20	31.5	Pangas	5.00	C	Bad
			Tilapia	4.07	B	Acceptable
	13.02.20	30.6	Pangas	4.21	B	Acceptable
			Tilapia	3.80	B	Acceptable
	20.02.20	28.1	Pangas	3.50	B	Acceptable
			Tilapia	1.82	A	Excellent
	26.02.20	28.6	Pangas	3.71	B	Acceptable
			Tilapia	1.92	A	Excellent

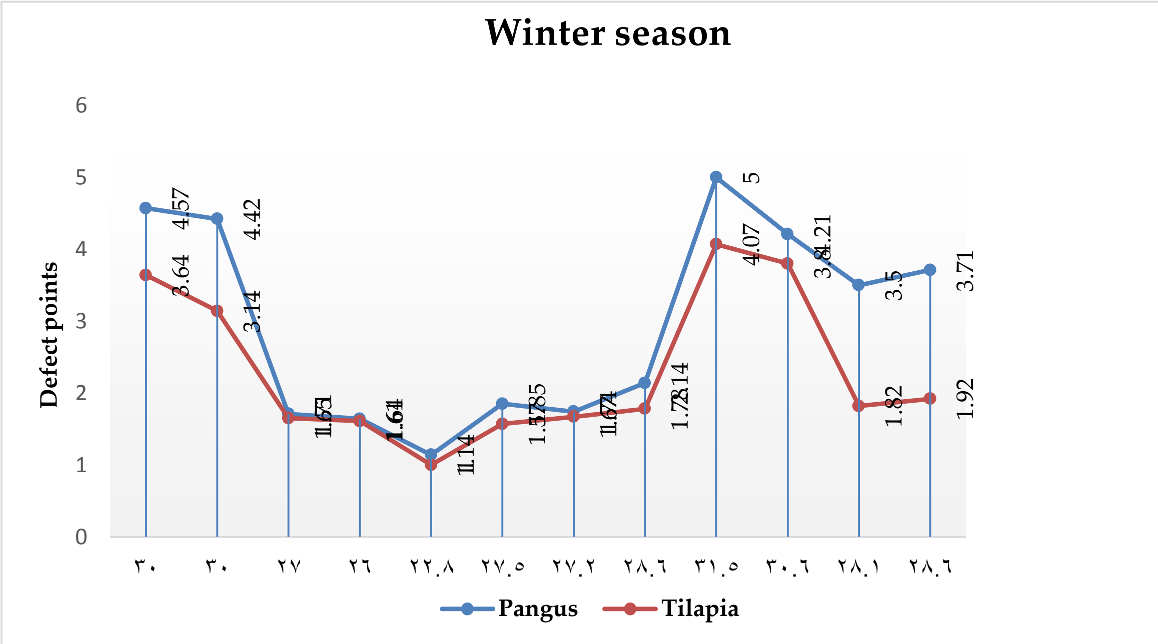

Fig. 2. Defect points of pangas and tilapia in the winter season

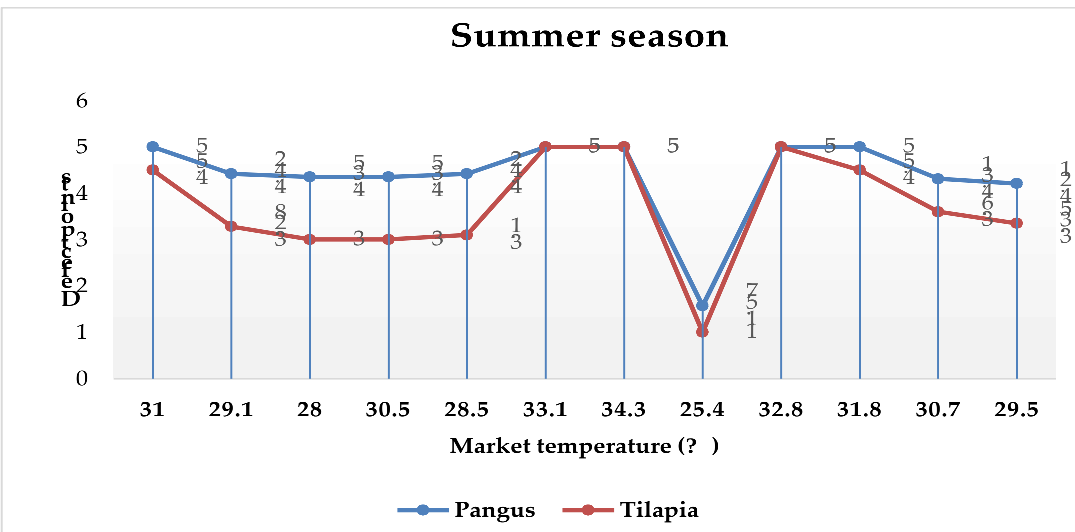

Fig. 3. Defect points of pangas and tilapia during the summer season

2. Bacterial load analysis

2.1. Seasonal variation of the bacterial load in pangas and tilapia

The mean bacterial load was calculated as Log CFU/g±SD. The bacterial load of pangas and tilapia was determined during the summer and winter seasons. Fig. (3) shows that the mean Log CFU/g±SD of the bacterial load was higher (7.37±0.99 and 6.91±1.32) in the summer season for both species. On the other hand, the same bacterial load was lower (6.85±0.62 and 5.93±0.40) in the winter season for both species. The numerical data was statistically significant ($P<0.05$), and the bacterial load was higher in both seasons.

Table 3. Organoleptic quality changes of pangas and tilapia for the market conditions during the summer season

Month	Date	Temperature (℃)	Species	Defect point(Average)	Grade	Overall quality
	07.03.20	31.0	Pangas	5.00	C	Bad
			Tilapia	4.50	B	Acceptable
	14.03.20	29.1	Pangas	4.42	B	Acceptable
			Tilapia	3.28	B	Acceptable
	21.03.20	28.0	Pangas	4.35	B	Acceptable
March 20			Tilapia	3.0	B	Acceptable
	28.03.20	30.5	Pangas	4.35	B	Acceptable
			Tilapia	3.00	B	Acceptable
	03.04.20	28.5	Pangas	4.42	B	Acceptable
			Tilapia	3.10	B	Acceptable
	10.04.20	33.1	Pangas	5.00	C	Bad
			Tilapia	5.00	C	Bad
	17.04.20	34.3	Pangas	5.00	C	Bad
April 20			Tilapia	5.00	C	Bad
	24.04.20	25.4	Pangas	1.57	A	Excellent
			Tilapia	1.00	A	Excellent
	02.05.20	32.8	Pangas	5.00	C	Bad
			Tilapia	5.00	C	Bad
	07.05.20	31.8	Pangas	5.00	C	Bad
			Tilapia	4.57	B	Acceptable
	15.05.20	30.7	Pangas	4.31	B	Acceptable
May 20			Tilapia	3.10	B	Acceptable
	22.05.20	29.5	Pangas	4.21	B	Acceptable
			Tilapia	3.35	B	Acceptable

2.2. Market-wise seasonal variations of the bacterial load of pangas and tilapia

The studied samples were collected from four fish markets, viz. Kazir Bazar, Lamakazi, Gobindoganj, and Baluchar Noyabazar, in the Sylhet and Sunamganj districts, and the bacterial load was determined. Remarkable differences were found in the cases of the bacterial loads between pangas and tilapia in the winter season. It was evident that the bacterial load was higher in pangas than tilapia in the summer season. A higher bacterial load was found in pangas compared to tilapia during both seasons at every fish market. Table (4) and Fig. (5) show a market-wise seasonal variation of the bacterial load of fatty fish pangas and lean fish tilapia.

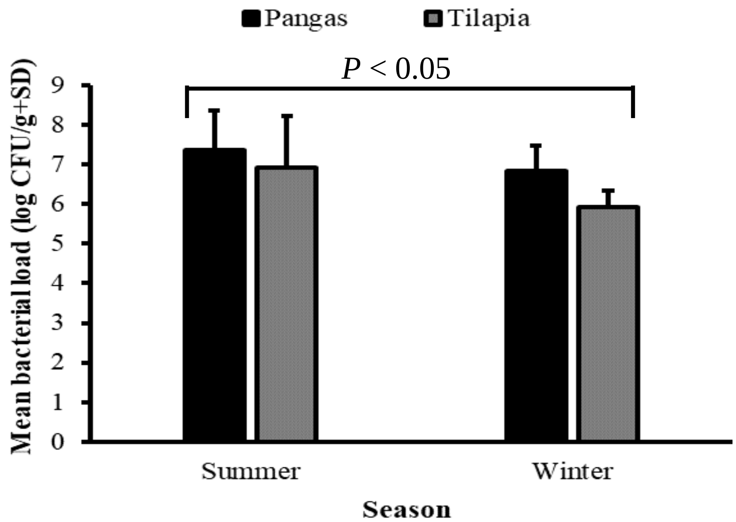

Fig. 4. Seasonal variation of the bacterial load in pangas and tilapia

Table 4. Market-wise seasonal variation of the total viable count (TVC) of pangas and tilapia

Market Name	**Sample name**	**Total viable count (TVC)**		**Log (TVC)**		**Mean± SD**		***P*- value**	
		Winter	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Kazir Bazar	Pangas	4.5×10^5	4.5×10^6	5.653	6.653	6.270±0.535	6.918±0.496	<0.05	<0.05
		3.6×10^6	4.1×10^6	6.556	6.612				
		4.0×10^6	3.1×10^7	6.602	7.491				
	Tilapia	3.5×10^5	4.8×10^5	5.544	5.681	5.634±0.083	6.025±0.560	<0.05	<0.05
		4.5×10^5	5.3×10^5	5.653	5.724				

		5.1×10^5^	4.7×10^6^	5.707	6.672				
Lamakazi	Pangas	3.0×10^7	3.0×10^7	6.477	7.477	6.213±0.633	6.907±1.114	<0.05	<0.05
		3.1×10^5	4.2×10^5	5.491	5.623				
		4.7×10^6	4.2×10^7	6.672	7.623				
	Tilapia	3.9×10^5	4.3×10^6	5.591	6.633	5.281±0.690	6.296±1.380	<0.05	<0.05
		3.1×10^4	6.0×10^4	4.491	4.778				
		5.8×10^5	5.5×10^7	5.763	7.477				
Gobindoganj	Pangas	3.6×10^7	3.7×10^7	7.556	7.568	7.221±0.690	7.958±0.534	<0.05	<0.05
		3.3×10^6	3.7×10^8	6.518	8.568				
		3.9×10^7	4.2×10^7	7.591	7.740				
	Tilapia	2.5×10^6	2.1×10^7	6.397	7.322	6.167±0.482	7.838±0.587	<0.05	<0.05
		4.1×10^5	3.0×10^8	5.612	8.477				

		3.1×10^6	5.2×10^7	6.491	7.716				
Baluchar Noyabazar	Pangas	3.7×10^7	4.9×10^7	7.568	7.690	7.315±0.570	8.044±0.563	<0.05	<0.05
		4.6×10^6	4.9×10^8	6.662	8.694				
		5.2×10^7	5.6×10^7	7.716	7.748				
	Tilapia	2.7×10^6	3.2×10^7	6.431	7.505	6.251±0.435	7.929±0.562	<0.05	<0.05
		5.7×10^5	3.7×10^8	5.755	8.568				
		3.7×10^6	5.2×10^7	6.568	7.716				

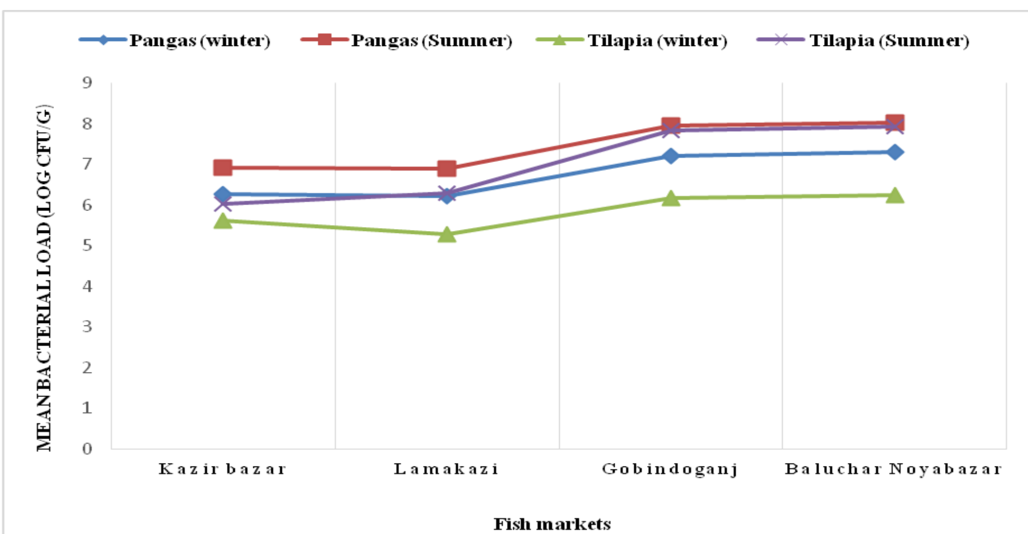

Figure 5. Seasonal variation of the bacterial load in the experimental markets.

2.3. Effect of the seasonal variations of the bacterial load with temperature in pangas and tilapia

The temperature ranged from 22.8- 31.5ºC during the experimental period from Dec. 2019 to Feb.2020. The effects of the temperature on the bacterial load occurred on both species. The improved growth of the bacteria depended on the availability of food, temperature, and other environmental conditions. The highest bacterial load was observed at the temperature of 31.5ºC and the lowest was observed at 22.8ºC for both species in this study. In Fig. (5), the correlation between the bacterial load and the temperature was evident in the winter season. The temperature was positively correlated with pangas (r = 0.959) and tilapia (r = 0.980). The temperature was highly correlated with both species, which was found to be statistically significant (*P*<0.05). In the summer season, occurring from Mar. to Mat, the temperature was higher and remained between 25.4-34.3ºC. A higher temperature is responsible for bacterial growth. The higher bacterial growth was observed at the temperature of 34.3ºC. The highest temperature and bacterial load were recorded in April 2017 in this study. In Fig. (6), the ambient temperature was correlated with the bacterial load of pangas (r = 0.951) and tilapia (r = 0.973), which was statistically significant (*P*<0.05). A higher bacterial load was found in pangas than in tilapia during the summer and winter seasons, as elucidated in Table (5).

Table 5. Seasonal variations of the bacterial load with temperature in pangas and tilapia

Winter												
Temp. (^{0} C)	30.5	30.5	27.0	26.0	22.8	27.5	27.2	28.6	31.5	30.6	28.1	28.6
Pangas	7.568	7.556	6.477	5.653	5.491	6.556	6.518	6.662	7.716	7.591	6.602	6.672
Tilapia	6.431	6.397	5.591	5.544	4.491	5.653	5.612	5.755	6.568	6.491	5.707	5.793
Summer												
Temp. (^{0} C)	31.0	29.1	28.0	30.5	28.5	33.1	34.3	25.4	32.8	31.8	30.7	29.5
Pangas	7.690	7.477	6.653	7.568	6.612	8.568	8.694	5.623	7.748	7.740	7.623	7.491
Tilapia	7.505	6.633	5.681	7.322	5.724	8.477	8.568	4.778	7.716	7.623	7.477	6.672

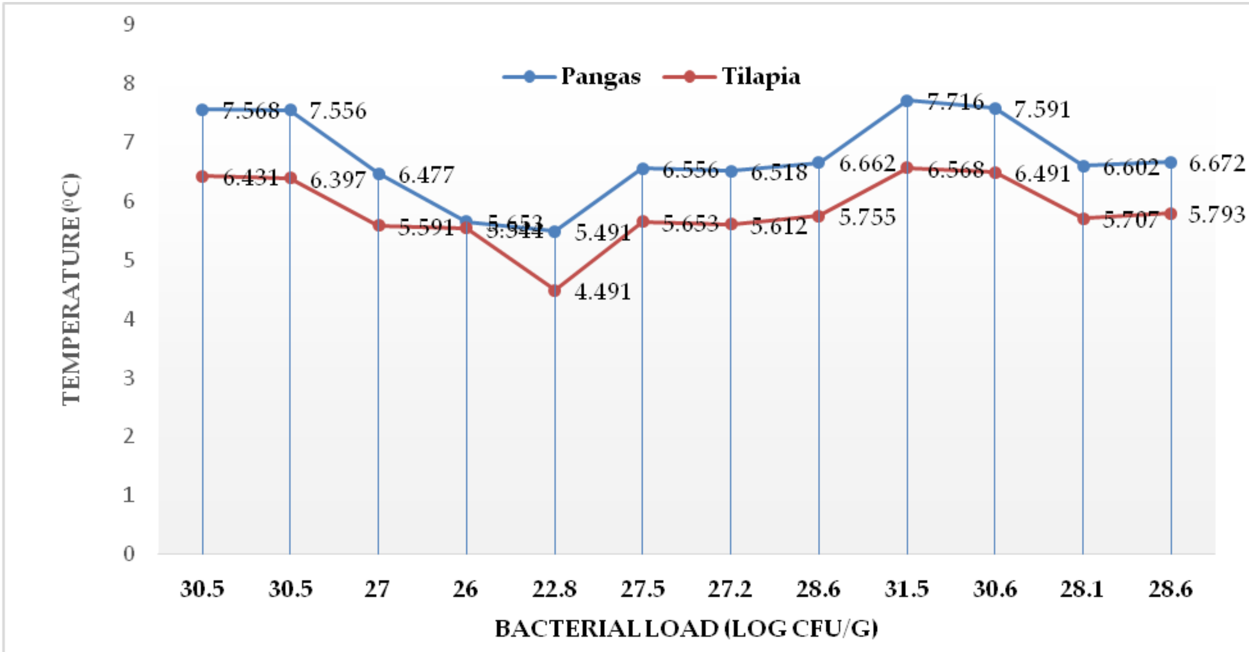

Fig. 6. Fluctuation of the bacterial load with ambient temperature in winter for pangas and tilapia

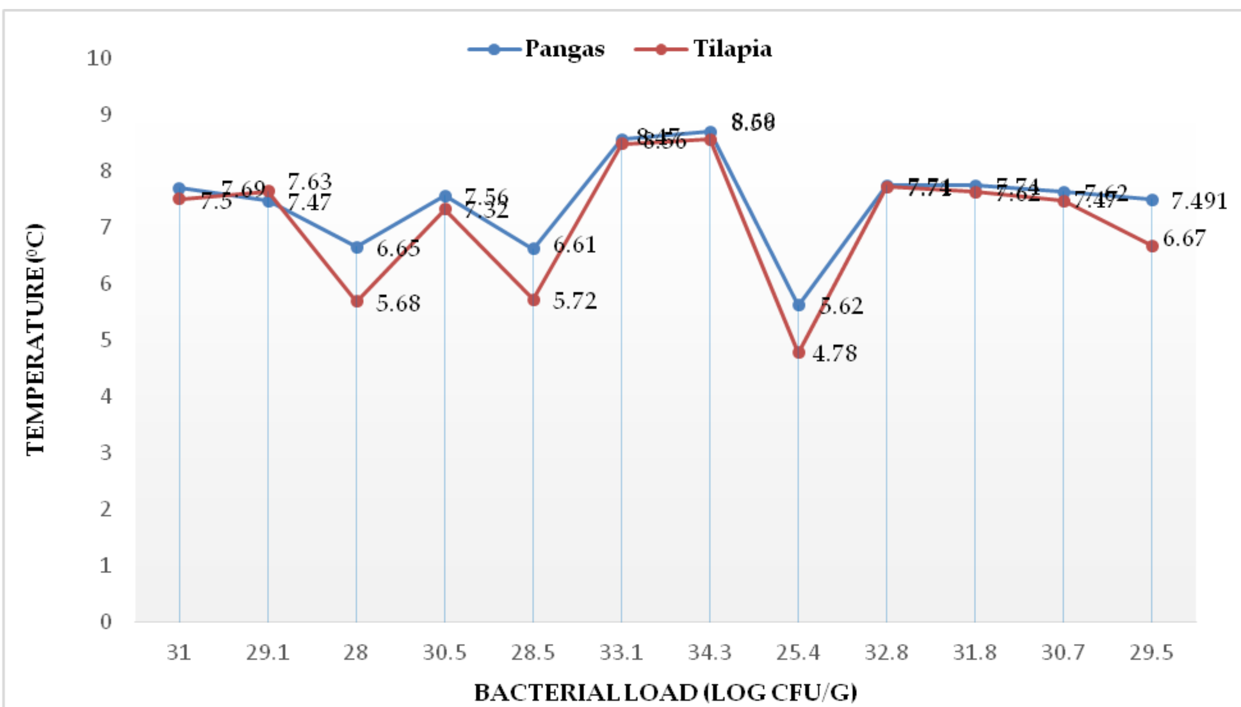

Fig. 7. Fluctuation of the bacterial load with ambient temperature during summer for pangas and tilapia.

DISCUSSION

Temperature is the most important factor in biological science. It influences the animals' growth, reproduction, and nutrition **(Uddin *et al*., 2004; Sunny *et al*., 2020)**. It also influences the growth and reproduction of microbes, especially the bacteria of the fishes. A lean fish (tilapia) and a fatty fish (pangas) are affected by the bacteria, and bacteria also infect them during post-harvest management **(Kawser *et al*., 2022)**. The present study is in line with the study of **Al- Harbi and Uddin (2007)**, who postulated that, the total viable count (TVC) in hybrid tilapia was higher ($3.9\pm 1.7 \times 10^6$ to $1.1 \pm 2.4 \times 10^7$ CFU/g) in summer than in winter ($1.9\pm 2.0 \times 10^5$ to $1.2 \pm 2.9 \times 10^6$ CFU/g) [29]. **Al- Harbi and Uddin (2004)** studied the seasonal variations of the total viable count of bacteria in the intestines and recorded ranges from $6.8\pm1.9\times10^6$ to $7.5\pm1.4\times10^7$ in the early summer, from $1.6\pm2.0\times10^6$ to $5.1\pm2.5\times10^7$cfu/g in summer, and from $8.9\pm1.8\times10^5$ to $1.3\pm0.9\times10^7$cfu/g in the winter **(Sinkafi *et al*., 2019)**. **Bisht *et al.* (2014)** focused on the bacterial load that was associated with the season, and they found that the intestinal bacterial load was 100 times higher (6.67 $x10^5$cfu/g) during the winter season and 1000 times higher (2.33 $x10^6$cfu/g) during the summer compared to the superficial skin of fish during the winter and summer (3.39 and 8.87 $x10^3$ cfu/cm^2). On the other hand, **Shinkafi and Ukwaja (2010)** investigated the bacterial microflora that was associated with fresh tilapia (*Oreochromis niloticus)*, and the mean viable bacterial count from each section of the samples were found to be 46.1×10^7cfu/g in the gills, 18.8×10^8cfu/g in the intestines, and 27.3×10^8cfu/g in the skin (**Kawser *et al*., 2022)**. **Hasan *et al*. (2015)** found total viable bacterial counts ranged from $4.32x10^5$ to $5.92x10^6$cfu/g in fatty fish pangas. **Hossain (1993)** observed a total viable count in fish samples 9.9 x 10^6 to 1.423 x 10^7cfu/g, which was recorded as the highest in July in the intestines of adult fish, and it was found to be at its lowest in January. The summer season showed a higher microbial load than the winter season, and it is known that the total viable counts of fish change in conjunction with the environmental changes, which supports the findings of the present study **(Holben *et al*., 2002; Hagi *et al*., 2004)**.

Due to the higher ambient temperature in the water body, the microbial load was found to be higher in the summer than in the winter **(Sunny *et al*., 2021b)**. A different study suggested that the microbial load in fish might increase with the rise of water temperature **(Kawser, *et al*., 2022)**. In this context, the present study was supported by the study of **Al- Harbi and Uddin (2004)**, who observed a higher microbial load (33.0 ± 2.3ºC) in July and a lower higher microbial load in January (14.5±1.5ºC) [38]. **Saadia *et al*. (2017)** investigated samples that could be classified into three categories of quality grades that included, (a) a high-quality grade product, which was stored in ice for not more than 4 days, (b) an acceptable grade product, which was stored in ice for more than 4 days but less than 8 days, and (c) an unacceptable grade product, which was stored in ice for more than 8 days. The overall qualities of the lean and fatty fish were comparatively better in the winter season than in summer, which is quite similar to the present study. **Nabi *et al*.**

(2001) assessed the effect of delayed icing on the quality changes of lean fish tilapia (*O. niloticus*) by keeping them at room temperature (27- 30°C), which became organoleptically unacceptable within 16- 20 hours . The microbiological study showed patterns of the standard plate count (SPC) at the end of the shelf-life study when the fish species became organoleptically unacceptable,which are more or less similar to the sample that was stored under different conditions. The temperature ranged from 22.8 to 31.5ºC from December to February during this experiment forming the winter season. Remarkably, the bacterial load was lower in both samples for all the studied areas in the winter season. The temperature was positively correlated with pangas (r = 0.959) and tilapia (r = 0.980). On the other hand, in the summer season, the temperature was higher (25.4 to 34.3ºC) during the period from March to May. The temperature was higher in the summer season than in winter, which was the main causative factor for the growth of the bacterial load. The ambient temperature was correlated with both pangas and tilapia. It was found that the temperature was highly correlated with pangas (r = 0.951) and tilapia (r = 0.973) in the summer season. It was observed that the lowest bacterial load and better organoleptic quality was at the temperature of 22.8ºC during January, and the highest load and unacceptable organoleptic quality was observed at 34.3ºC during April **(Nabi *et al*., 2001)**. This revealed that the growth of the bacterial load depends on the temperature, which was found to be statistically significant with a *P*-value <0.05 in pangas and tilapia in both seasons. This study coincides with the study of **Al-Harbi (2004)** who found a higher bacterial load at the temperature of 33.0±2.3ºC in October and also recorded a lower bacterial load at the temperature of 14.5±1.5ºC in January . As a result, the impact on the bacterial load and quality according to the temperature was evident. The results of the changes in organoleptic quality and the bacterial load mainly depended on the changes in the attributes that occurred in the species, season, source, and temperature.

CONCLUSION

The present study revealed that the optimum temperature with high relative humidity during the summer season accelerated the growth of the bacterial loads more than in the winter season. Fatty fish pangas contained a higher bacterial load than lean fish tilapia during the study period. In addition, the organoleptic quality of pangas and tilapia was found to be very poor. Icing the fish must be properly achieved for a long handling time at market conditions, which keeps the fish species fresh for selling. The market staff should be well known about the maintenance of good hygienic practices, and they should be provided with properly working and safety equipment. The temperature should be maintained from harvesting to marketing using ice or a refrigeration unit. The government of Bangladesh should take all the necessary initiatives to create awareness among the fishermen and the fish traders about the quality loss of fish, which is due to bacteriological contamination, improve the infrastructure of the markets and develop hygienic conditions. This indicates that if proper cleaning, washing, sanitation, and hygiene maintaining facilities are properly maintained, the consumers will be able to obtain safe and quality fish and fishery products from the markets.

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