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Organoleptic Assessment of Tilapia (*Oreochromis niloticus*) Stored in Different Temperatures

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A B S T R A C T

The current study was conducted to assess the freshness and pattern of spoiling of Nile tilapia (*Oreochromis niloticus*) stored at various temperatures. Nile tilapia purchased from NAQDA - Dambulla with same harvest and size; transported to the laboratory in ice boxes. Fish were randomly divided into four equal groups and stored in 4°C (n=6), -4°C (n=6), -10°C (n=6) & -20°C (n=6) temperatures. Basically, samples were evaluated for 41 days; daily for first five days & then once in two days for six days, once in three days for nine days & finally once in a week for 3 weeks. Organoleptic and demerit points were calculated. From the results, there were significant differences ($p<0.05$) in freshness of tilapia stored in four different temperatures. However, freshness deterioration in -10°C and -20°C were relatively slow but in 4°C it was rapid. In Sensory evaluation rejection was held at after 3 days (4°C), 14 days (-4°C), 27 days (-10°C) and 34 days (-20°C). Significantly positive correlation was observed between freshness deterioration and storage period r=0.99 (4°C), r=0.98 (-4°C), r=0.90 (-10°C) and r=0.92 (-20°C).

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INTRODUCTION

Tilapia is one of the most favourite fish cultured in the world, and production is growing very rapidly (Josupeit, 2005). Tilapia is together with carp one of the widest spread farmed fish species in the world, with production carried out in 75 countries (Tveteras, 2013). Tilapia was praised as the "fish of miracles", the fish that would solve all the protein problems of developing countries 50 years ago and the increasing demand for fish in the developed world. Then some problems with its farming led to long years of silence, from which tilapia came back as the fish of the decade, or the fish of the millennium, at the end of 90s' (Josupeit, 2005).

While tilapia was well known in many areas of Asia and Africa since centuries, developed countries have discovered tilapia only two decades ago. Since the white flesh is very tasty, the tilapia recently entered the top ten among US preferred fish species (Josupeit, 2005). The product coming from tilapia has a very nice colour, white or slightly pink, and the flesh is firm, and says unchangeable in the preparation and cooking. Tilapia farming is popular in the Middle East & some parts of the Africa for a long time. It has become a widespread industry in Asia, Central and south parts of America. In 20th century, tilapia has been introduced to many other countries and at the present it is popular worldwide. Developing countries are the main producers of tilapia, and production is on the increase in many countries across all regions.

China is by far the most important tilapia producing country; with a production estimated at 1.3 million tonnes in 2011, accounting for about 40% off the global production (Tveteras, 2013). Egypt also reported an impressive increase in production between 1990 and 2013 (600 000 tonnes in 2011), while in the same period, production in Indonesia and the Philippines was relatively stable (Tveteras, 2013). US is the world's largest importer. Several species of the tilapia are popular in the world as cultured species. *Oreochromis niloticus* or Nile tilapia is the most important species for both capture and aquaculture. This species can grow up to 60 cm of length and to a weight of 3.6 kg (Josupeit, 2005).This species grows very fast, and is more replacing the second major species, *Oreochromis mossambicus* or Mozambique Tilapia in the aquaculture business. The latter species can reach 40 cm of length and a maximal weight of 3.2 kg. The third major species is O. aureus or blue tilapia. This species can grow to 30-35 cm with a weight of around 1.8 kg. This species is very salt tolerant. Successful hybridization of the above and other minor tilapia species created the best tilapia, easy acceptable to the consumer, salt tolerant – living in salty water increasing the tastiness of the tilapia , quick growing with little animal protein intake (Josupeit, 2005). Sri Lanka has started tilapia farming as a good protein supplement for the people in the rural areas. North Western Province constituting of Anuradhapura & Polonnaruwa districts dominates the inland fisheries sector, contributing nearly 39% of the total production. Tilapia constitutes more than 57% of the inland and aquaculture fish catch of Sri Lanka.

The term "quality" with reference to food can have different meanings. It can refer to the sensory characteristics of a product, such as its appearance, flavour, odour and texture, but it can also indicate the nutritional value, safety

and other characteristics. Before buying a food product for the first time, the consumer evaluates its quality based on these characteristics (Jones and Disney, 1996). The success of any effort in the food industry, including fisheries, is highly dependent on getting the product to the consumer in an acceptable condition. Consequently, efforts are required to maintain the quality and acceptability of the fish and fisheries products. Fish product quality has been studied in recent years, because commercial markets require high quality fish as consumers have a strong tendency to select very fresh fish (Luten and Martinsdottir, 1997). Freshness is one of the most important aspects of fish and fish products. For all kinds of fish and fishery products freshness makes a major contribution to the quality of fish and fishery products (Olafsdottir et al., 1997).

However the fresh fish is one of the most perishable types of food (Gram and Huss, 1996). Immediately after its death, the fish undergo a natural and complex decomposition process, that is, microbial, chemical and enzymatic (Huss, 1995). The freshness of fish is reduced by the oxidative rancidity (Azhar and Nisa, 2006), the organoleptic properties are rapidly deteriorated, the nutritional value is reduced and toxic substances are formed (Huss, 1995). These changes can be accelerated or retarded by physical conditions like temperature, physical damage to fish, pollution and bacterial contamination. Temperature is the most significant factor influencing the spoilage since chemical reactions and bacterial multiplication requires an optimal temperature range (Lima, 1981). The shelf life of fish stored under ambient tropical conditions which is generally noted to be less than a day, and will depend on factors like species, sex, nutrition status, season, quality of fishing ground, handling conditions (Jones and Disney, 1996).

Sensory changes occur in appearance, odour, taste and texture during storage of fish. Sensory assessment of the outer appearance of fish and /or the sensory assessment of the sample in the cooked state is the most convenient and successful method for fish freshness determination (Olafsdottir et al., 1997). Spoilage of fish is not clearly defined although obvious signs of spoilage include the formation of off-odours and off flavours, slime formation, gas production and changes in texture (Reay and Shewan, 1949). Loss of freshness and spoilage of fish are complicated processes and various factors such as species and different storage conditions influence the spoilage pattern. Therefore, it has been suggested that no single spoilage or freshness indicator for fish can be used, but rather a combination of selected indicators that represent the different changes occurring during spoilage (Olafsdottir et al., 1997).

Utilisation and interest in sensory analysis in the fish sector is growing (York and Sereda, 1993). Sensory evaluation is used as a tool for grading according to product standards and for studying specific properties of fish species in connection with evaluation of quality, shelf life, storage conditions and product development (Nielsen, 1997). EU Scheme and Quality Index Matrix (QIM) methods are the most commonly used acceptable methods in sensory evaluation. Generally, fish has been widely accepted as a good source of protein and other elements necessary for the maintenance of healthy body (FAO, 1985).

Inadequate storage techniques would implies a substantial shortfall in fish availability thereby affecting the animal protein intake of the people in the tropics whose protein intake from fish ranges between 17.5-50% (FAO, 1985; Willman et al., 1998). Freezing is a common practice in the meat, fish and other animal protein based industry, because it preserved the quality for an extended time and offers several advantages such as insignificant alterations in the product dimensions, and minimum deterioration in products colour, flavour and texture (Obuz and Dikeman, 2003). However, there are some disadvantages associated with frozen storage (Kropf and Bowers, 1992) including freezer burn, product dehydration, rancidity, drip loss and product bleaching which can have an overall effect on the quality of the frozen foods. Various studies have been done in tilapia stored in ice to identify the shelf life. Lake Malawi Tilapia can remain safe for consumption up to 16 days after which the fish are sensorily rejected and bacterial load reaches unacceptable levels (Kapute et al 2013). Oreochromis niloticus was found in edible condition for 15 days in ice storage and 12 hrs at the ambient temperature (Adoga & Funso 2010). This study based on the identification of spoilage pattern of the tilapia stored in different temperature. Therefore the current study was carried out to evaluate the freshness of the tilapia stored in different temperatures and to determine the spoilage pattern of the tilapia stored in different temperatures in Sri Lankan condition.

METHODOLOGY

Experimental Animal

Tilapia was chosen to be evaluated for the present study. Required tilapia was collected from NAQDA, Dambulla and immediately transported to the laboratory of Farm Animal Department and Health in ice boxes. 260 fish with same size and age were selected from the same harvesting batch for the experiment in order to prevent bias results.

Experimental Design

Four temperatures (4°C, -4°C, -10°C & -20°C) were selected to store the fish for nearly 6 weeks which is the duration of the whole experiment. Selected fish were cleaned and washed thoroughly with clean water. Then, in the laboratory fish were randomly divided in to four groups as each group with 65 fish and stored in previously determined four different temperatures.

Sampling & Evaluation

Whole study was carried out for 6 weeks. Initially the samples were evaluated daily for five days (5 times), then once in two days for six days (3 times), once in three days for 9 days (3 times) & once in a week for three weeks(3 times).

Six samples from each group were evaluated at a time according to the criteria in Table 1 by a panel consisting of six final year veterinary students. All the evaluators were educated about the evaluating criteria prior to the evaluation. Demerit points were given according to the criteria mentioned in

Table 1 and the mean demerit point for each criterion was considered in calculating the QIM score.

Grading the Quality of the Fish

Mean demerits points for the samples in each temperature were taken in calculating the QIM value. Then the quality of the fish is graded from A- D according to the QIM value (Table 2). Samples with A grade have excellent Quality while the samples with D grade were bad in quality.

Table 1. Demerit points based on the Quality Index Matrix (QIM) method for Tilapia (Oreochromis niloticus)

Quality Parameter		**Description**	**Score**
Appearance	Skin	Shiny gray	0
		Dull grey	1
		Discolored (near gill & abdomen)	2
		Discoloured all over the body	3
	Scales	Firm	0
		Loose	1
Texture	Backside	In-rigor (firm & elastic)	0
		Finger mark disappear rapidly	1
		finger mark leaves 1-2sec	2
		Finger mark leaves over 3 sec	3
	Belly	Firm	0
		Soft	1
Eye	Cornea	Clear & transparent	0
		Slightly opaque	1
		Opaque	2
	Pupil	Clear black	0
		Grey	1
	Form	Convex	0
		Flat	1
		Concave/ sunken	2
Gills	Colour	Blood red	0
		Pale red	1
		Brown	2
	Mucus	Transparent	0
		Cloudy	1
		Milky	2
		Brownish Red	3
Odour		Fresh	0
		Neutral	1
		Sour	2
		Strongly sour	3
Quality Index (QI)			0 – 21

Table 2. Quality Index Matrix (QIM) Used to Grade the Freshness of the Fish

Grade	QI value	Degree of freshness
A	< 2	Excellent
B	>2 -7	Good
C	>7-14	Acceptable
D	>14-21	Rejected

Statistical analysis

Data were analysed using Microsoft Excel 2007 and Minitab 14. A linear regression analysis of sensory changes against storage time in ice was performed on the sensory quality data in each storing temperature in Microsoft Excel 2007 to identify the relationship between the storing time and the QIM score. One way ANOVA was performed in Minitab 14 to identify difference in the freshness deterioration in samples stored in all four temperatures.

RESULTS

Evaluation of the Freshness Stored in Different Temperatures

Freshness of the samples from all four temperatures was reduced in overall with the storage period. Comparative changes of the QIM score of the samples stored in 4°C, -4°C, -10°C & -20°C (Figure 1). It was interestingly seen that quality of the tilapia significantly differ between the storage temperatures ($p<0.05$). Tilapia stored in -10°C and -20°C was significantly better in quality than in other two temperatures (4°C and -4°C) ($p<0.05$). Furthermore the deterioration of the freshness was significantly quicker in 4°C that of in -4°C, -10°C & -20°C. The rapid freshness deterioration limited the shelf life of the fish stored in 4°C only for 3 days.

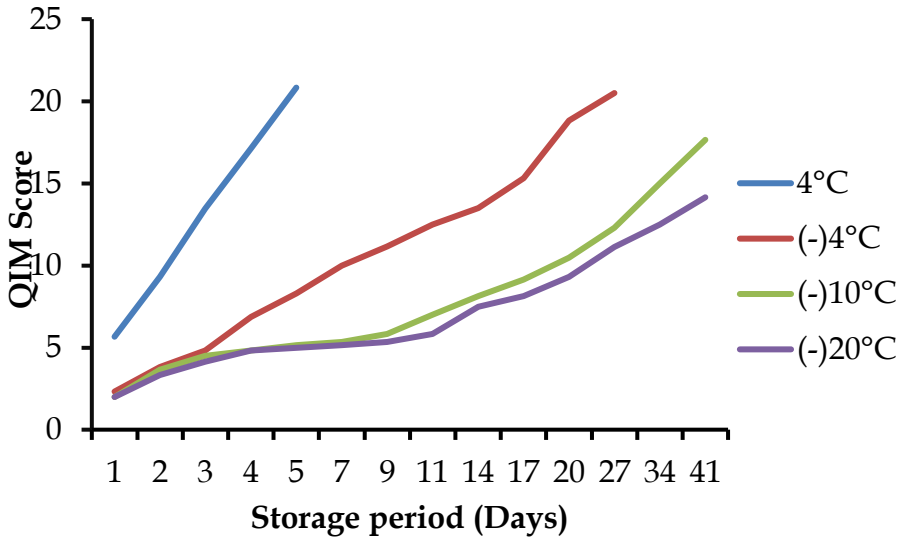
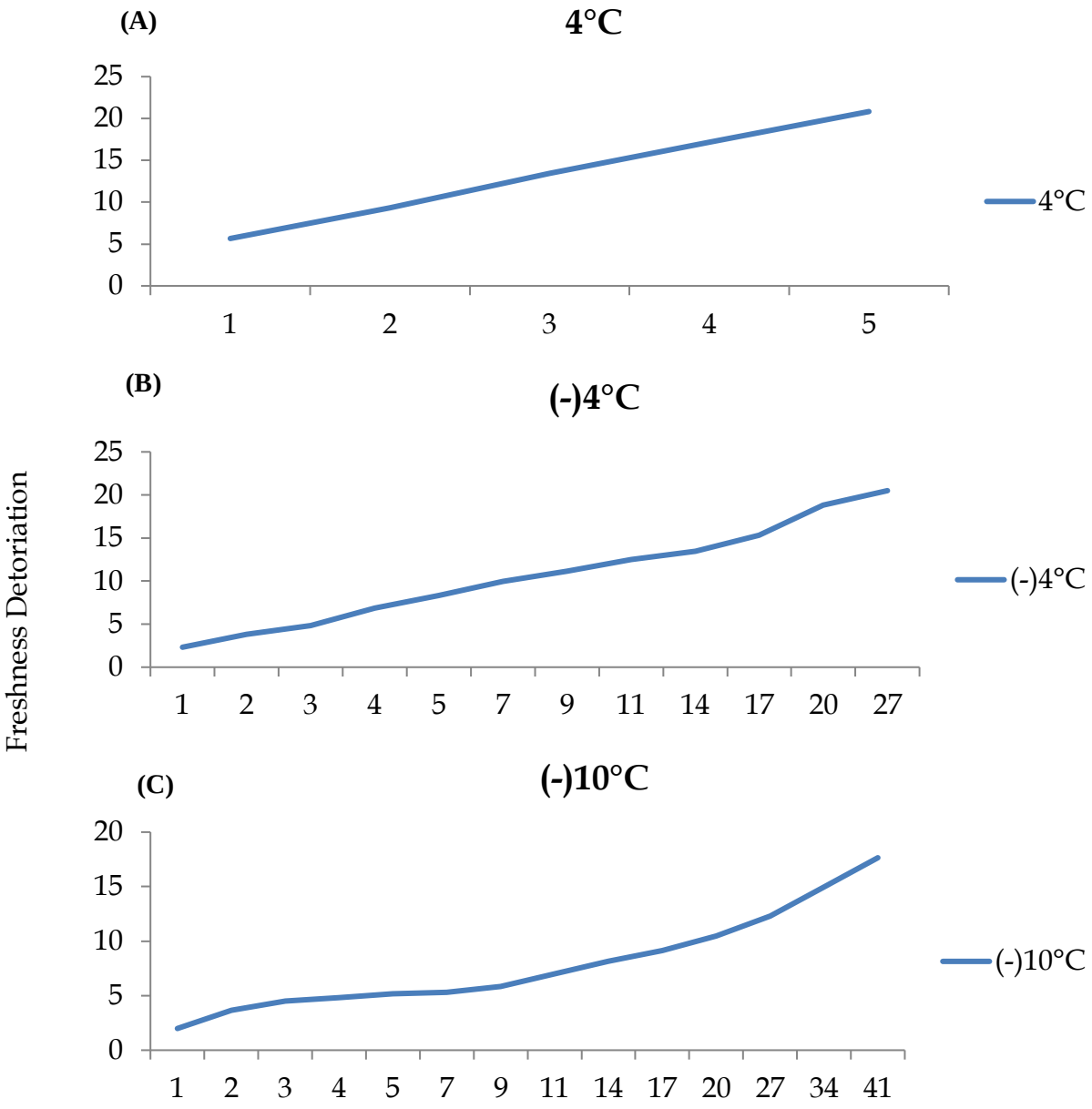


Figure 1. Comparison of the Mean QIM Score with Storage Period

Significantly strong positive correlation was observed with the storage period & freshness deterioration in 4°C (r= 0.99), -4°C (r= 0.98), -10°C (r= 0.90) and -20°C (r= 0.92).



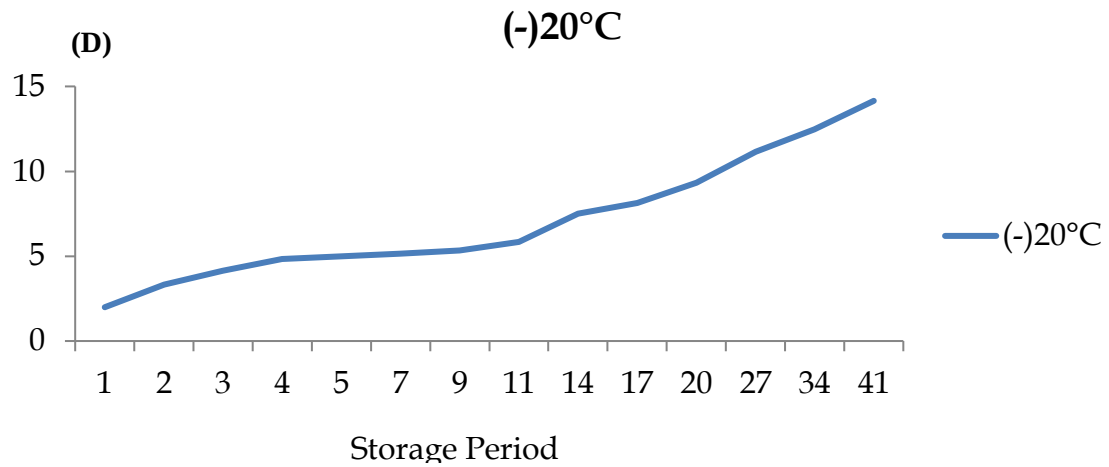


Figure 2. Correlation of mean QIM Score and storage period in 4°C (A), -4°C (B), -10°C (C) & -20°C (D)

Each sample stored in four tested temperatures was graded & their acceptability was decided according to the mean QIM Score (Table 3 - 6).

Freshness of the tilapia stored in 4°C gain the grade B after 24hrs which implies the good quality of the fish. Gradually the quality of the tilapia has reduced within 5 days of the storage period and acquired the highest QIM value rather quick. Fish was acceptable for 3 days and then it was rejected (Table 3).

Table 1. Changes in the quality of fish in 4°C

Storage period (Days)	QIM Score	Grade	Acceptability
1	5.6	B	Good
2	9.3	C	Acceptable
3	13.46	C	Acceptable
4	17.15	D	Rejected
5	20.83	D	Rejected

The quality of the tilapia stored in -4°C temperature was initially considered as good in quality for 3 days. Freshness of the tilapia has deteriorated to the unacceptable level within 20 days in -4°C in where it crosses the QIM value of the quality rejection (Table 4).

Table 4. Changes in the quality of the fish in -4°C

Storage period (Days)	QIM Score	Grade	Acceptability
1	2.32	B	Good
2	3.81	B	Good
3	4.82	B	Good
5	8.31	C	Acceptable
11	12.48	C	Acceptable
14	13.48	C	Acceptable
20	18.81	D	Rejected
27	20.5	D	Rejected

Fish stored in other two temperatures (-10°C and -20°C) has maintained the excellent quality during the first day of the storage (Table 5 and Table 6). Then the quality was gradually reduced with the storage period and the quality of the fish in both temperatures were recorded as good up to 11th day of the storage in both of the temperatures. Freshness has been maintained acceptable for more than 27 days in -10°C while it is one week ahead (34 weeks) in -20°C.

Table 5. Changes in the quality of the fish in -10°C

Storage period (Days)	QIM Score	Grade	Acceptability
1	1.99	A	Excellent
3	4.49	B	Good
5	5.16	B	Good
9	5.83	B	Good
11	7.00	B	Good
17	9.15	C	Acceptable
20	10.48	C	Acceptable
27	12.31	C	Acceptable
34	14.98	D	Rejected

Table 6. Changes in the quality of the fish in - 20°C

Storage period (Days)	QIM Score	Grade	Acceptability
1	1.99	A	Excellent
3	4.15	B	Good
5	5.00	B	Good
9	5.33	B	Good
11	5.83	B	Good
17	8.14	C	Acceptable
20	10.48	C	Acceptable
27	11.14	C	Acceptable
34	12.48	C	Acceptable
41	14.15	D	Rejected

Determination of the spoilage pattern of the tilapia stored in different temperatures

There was no difference observed in the spoilage pattern of the tilapia in 4°C, -4°C, -10°C and -20°C storing temperatures .The eye convexity and the colour of the pupil were changed with the time in 4°C as expected. However grey discolouration and increase convexity of the eyes were the common changes observed very earlier in the fish stored in -4°C, -10°C and -20°C while the other organoleptic parameters remain unchanged. Basically the gill colour was became pale red and it was maintained for a longer period in very low temperature (-10°C and -20°). Initially all the samples stored in low temperatures (-4°C, -10°C and -20°C) developed a neutral odour. Gradually they developed sour odour as the other parameters get changed. In addition to above mentioned quality parameter changes, other followed the normal spoilage pattern in all studied temperatures. The Comparative changes of the criteria (in 4°C, -4°C, -10°C and -20°C) that were observed in present study has displayed in Figure 3.

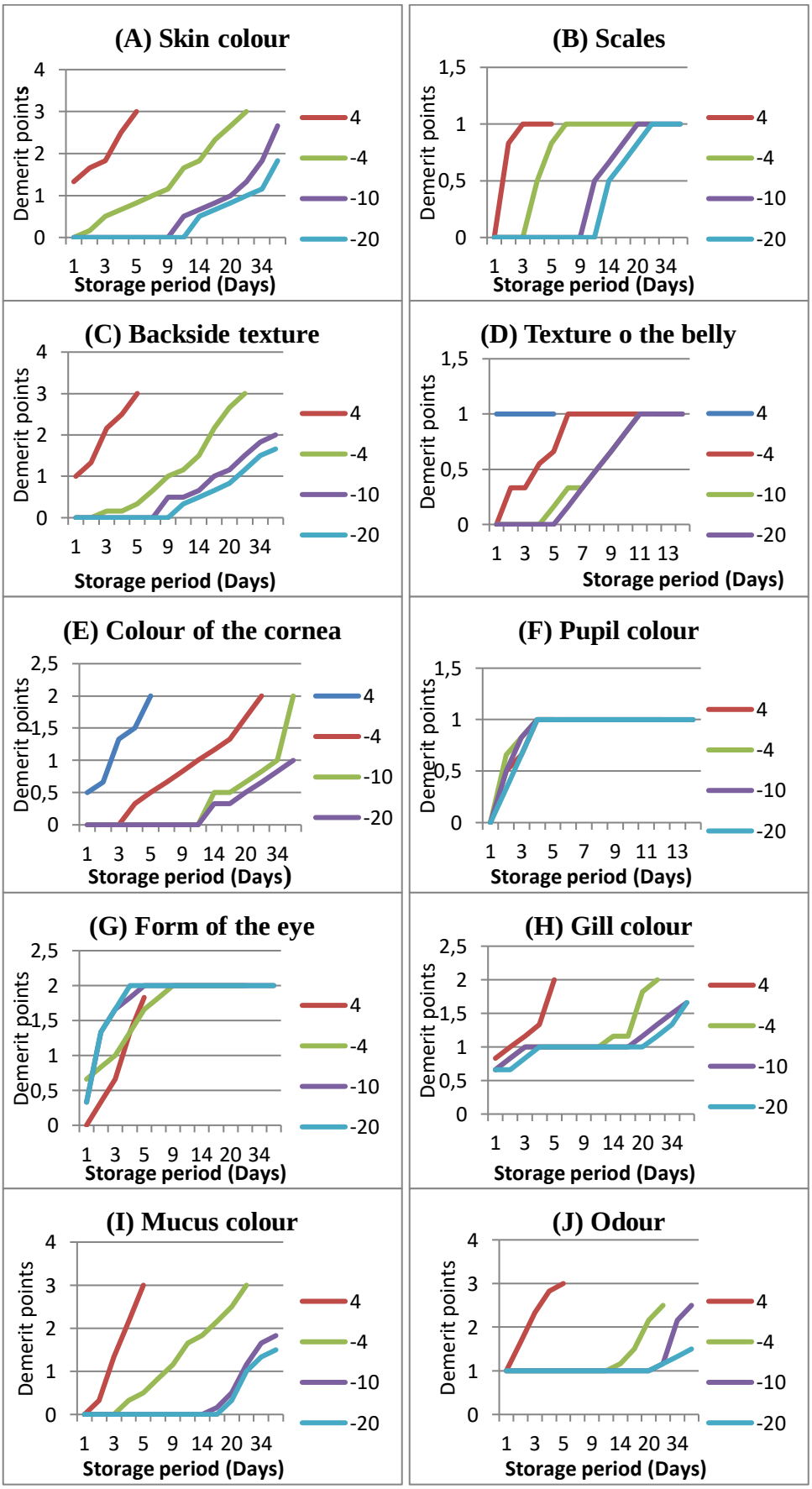


Figure 3. Changes of the each evaluating parameter with the storage period in 4°C, -4°C, -10°C and -20° C

DISCUSSION

The organoleptic assessment of the present study revealed that the freshness of tilapia gradually decreases with the time when it is stored in 4°C, -4°C, -10°C & -20°C temperatures. It was also observed a significant difference in the spoilage rate among four temperatures. Spoilage rate is significantly high in the fish stored in 4°C & thereby the shelf life also reduced. The current study revealed the shelf life of the tilapia in 4°C is limited only for the 3 days. Similar observation was recorded recently that unacceptable major changes in freshness and taste of tilapia occurred when it was stored in 4°C for three weeks (Obemeata and Christopher, 2012). One of the studies on *Oreochromis niloticus* recommended reducing the storage period less than five days under refrigerated temperature to avoid food intoxication (Dergal *et al.,* 2013). However, many studies done in relation to the storage of tilapia to determine the freshness were in 0°C & 30°C (Adoga *et al*., 2010, Kapute *et al*., 2013). The estimated shelf life of the tilapia species in 0°C was in between 13-32 days & in 30°C it was less than the 12 hrs. Tilapia stored in -18°C has been suggested to be used within one week of the capture to harness the fresh quality state of the fish and avoid changes that may be detrimental to the consumer (Obemeata and Christopher, 2012). It has also been found out that the microbial load & chemical content in the tilapia fillets vary depending on the age and the sex. Therefore, the spoilage rate and the shelf life of the fillets of *Oreochromis niloticus* also vary depending on their age & sex (Albeti, 2013).

Present study, furthermore, has revealed that there were significant differences in deterioration of the freshness in all four storage temperatures (4°C, -4°C, -10°C and -20°C). However the freshness deterioration of tilapia is significantly low in the -10°C & -20°C temperatures and the quality also relatively high. This could be due to the influence of the temperature for maintaining the quality of the fish, as it was reported by Lima (1981). Lima (1981) further explained that the temperature is the most significant factor influencing the spoilage since chemical reactions and bacterial multiplication requires an optimal temperature range. However, the spoilage of fish is due to the combination of the enzymatic and microbial activities. Huss (1995) suggested that the reason for spoilage of fresh fish under cold storage is due to the increasing bacterial growth linearly with storage time, resulting declining sensory scores. Similarly, our study also showed that there was strong direct proportional relationship with the deterioration of the freshness & the storage period in all four temperatures. Arannilewa et al. (2005) also have claimed that the frozen tilapia has best quality in first ten days of storage and the quality has reduced with the storage period. Similar reduction of freshness of oyster with the storing temperatures was reported providing further evidence for the reduction of the food quality with the storage temperature (Rong et al., 2009).

Since the temperature is one of the key factors influencing the spoilage, controlling of the temperature plays a major role in food preservation. As it is easy and more practicable than the other preservation methods, it is one of the most common methods in use. Combination of the other methods and the temperature control has been provided best results instead of using one method

alone. Although the current study reveals the shelf life of the tilapia in refrigerated temperature has shelf life less than 3 days, on contrary *Masniyom et al. (2013) has reported that the shelf life of the tilapia stored in refrigerated temperature by* MAP (Modified Atmosphere Packaging) and vacuum packaging was accepted throughout the stored of fifteen and twelve days respectively but samples stored in air had the acceptability only six days of storage.

Changes of the gill colour, softening of the belly and the backside of the tilapia, increasing convexity of the eye, development of the opacity in the cornea, changes of the gill colour, viscosity of the gill mucous & development of the sour odour were the major spoilage changes observed in the study. Especially the gill colour, changes of the gill mucous, changes of the eye & development of the sour odour played a main role in the consumer acceptance. Development of the pale colour in gills, greyish pupil and increase convexity of the eye were observed in first few days of storage in low temperatures. The reduction in the score of the evaluating parameters such as skin colour, backside and belly texture, gill colour and transparency of the gill mucus etc can be attributed to the increasing activities of spoilage agents as found in an recent study (Oriakpono *et al*., 2011) and biochemical changes occurring therein with increasing time. Freshness of fish can be assessed by many other methods such as biochemical, physical (Gill, 1997) and microbiological methods (Gram and Huss, 1996). However, the sensory evaluation or organoleptic method is still used as the most satisfactory method to evaluate the freshness of fish (Hassan and Ali, 2011).

CONCLUSION

The current study concludes that there is a strong relationship in the freshness deterioration and the storage period. Also it concluded that a significant variation in the deterioration of the freshness of the fish among all four temperatures (4°C, -4°C, -10°C and -20°C). Even though there are minor changes in spoilage pattern, the quality of the tilapia was significantly better when it is stored in -10°C and -20°C. However, the storage of tilapia for a long period is discouraged as the quality decreases even in low temperature. The overall quality of the tilapia in each of these temperatures should be further evaluated with the comparison of the microbial & chemical evaluation methods to ensure the food security.

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