International Journal of Agriculture and Food Science Technology.
ISSN 2249-3050 Volume 5, Number 2 (2014), pp. 105-116

http://www.ripublication.com

Quality Characteristics and Shelf Life of Sutchi Cat Fish (*Pangasianodon Hypophthalmus*) Steaks During Refrigerated Storage

Viji P[1]., Tanuja S[2]*., George Ninan[3], Zynudheen A.A[4], and Lalitha, K.V.[5]

[1,3,4,5]*Fish Processing Division, Central Institute of Fisheries Technology, Matsyapuri P.O, Willington Island, Cochin, India*
[2*]*Directorate of Research on Women in Agriculture, Opp Kalinga studio, Baramunda Post, Bhubaneswar, India 751003,*

Abstract

Fish is more vulnerable to deterioration than chicken and red meat as it contains relatively larger amounts of free amino acids, a higher water activity and a higher final pH, limiting the shelf life of the product. Hygienic handling practices can control the deterioration of fish quality during storage and distribution. The quality changes and shelf life of iced (0^0C) and chill (4^0C) stored sutchi catfish (*Pangasianodon hypophthalmus)* steaks was assessed by evaluating the changes in biochemical, textural, microbiological and sensory attributes during storage. The study revealed that all the biochemical quality indices studied like pH, TVBN, TBA and PV were within the acceptable range for both the treatments throughout the storage period. However, the chill stored steaks showed higher degree of textural deterioration than the ice stored steaks. Total mesophilic and Enterobactereaceae counts were lower in ice stored steaks compared to chill stored steaks. Based on the sensory and microbiological analysis, the shelf life of chilled and ice stored sutchi catfish steaks is determined as 14 and 17 days, respectively, during storage.

Keywords: Sutchi catfish, refrigerated storage, quality, shelf life, steaks

1. Introduction

Freshness of fish is the most important and fundamental criterion for judging the quality of the final product. Fish is more vulnerable to deterioration than chicken and red meat as it contains relatively larger amounts of free amino acids, a higher water activity and a higher final pH, limiting the shelf life of the product. Spoilage of fish occurs concurrently and independently, their relative importance varying with species of fish (size, lipid content, stage of maturation etc.), environmental conditions (feed availability, temperature, microbial load etc.), method of slaughter and post-mortem handling, storage procedures and processing conditions (Isabel et al., 2009). Since fish is a rapidly growing commodity of the modern diet, freshness of these products is becoming more and more important. Various food preservation techniques have been utilized to improve the microbial safety and to extend the shelf life of fish in general, including icing, freezing, chemical preservation, salting and smoking. Presently, in tropical countries, icing and mechanical refrigeration are the most prevalent techniques to control the microbial and biochemical spoilage in freshly caught seafood during distribution and marketing.

The inland aquaculture in India is predominantly a carp farming entity. It is popular in states like Andhra Pradesh, West Bengal, Punjab and Haryana where commercial culture is practiced. Presently catfish farming is gaining importance among Indian farmers as alternative to carps in different parts of the country. The main species of catfishes recently adopted for culture with Indian major carps is sutchi catfish (*Pangasianodon hypophthalmus*). Sutchi catfish is also known as Siamese shark or striped catfish and is native to the Chao Phraya River in Thailand and the Mekong in Vietnam. It was first introduced to India in West Bengal in 1995. Because of its remarkable growth rate (almost one kg in 90 days), there has been much enthusiasm among fish breeders and farmers. Moreover, high nutritional qualities and excellent sensory properties have made this species preferable among the consumers. The fish is in high demand in many part of the country due to the absence of intramuscular bones and its delicate flavor without any fishy odour. Very little information is available on literature regarding the preservation aspects of this fish. In this context, the present study has been undertaken to evaluate the shelf life of sutchi catfish steaks under chilled storage conditions.

2. Materials and Methods

2.1.Preparation of samples

The raw fish was de iced, washed and gutted. The gutted samples were thoroughly washed and cut into steaks of 2-3 cm thickness weighing 100-200 gm each. One steak each was then packed in polyethylene pouch and was divided into two batches; one batch for iced storage (0^0C) in an insulated box and other batch for storage in a cold store maintained at 4^0 C. The ratio of fish to flake ice was 1:1 and the melted ice was replaced daily to maintain the ratio to achieve a temperature of $1\text{-}2^0$ C. Samples from both the batches were withdrawn at regular interval to determine the extent of spoilage by biochemical, physical and sensorial analysis. Sampling was done in triplicate and the mean values were taken.

2.2. Chemical analysis.

For chemical analysis, the fish muscle was taken and ground using a mixer grinder. Proximate composition of the raw fish was determined by AOAC (1998) method. pH of the homogenised sample in distilled water (1: 5 W/V) was determined by using a glass electrode digital pH meter (Cyberscan 510, Eutech instruments, Singapore). Total volatile base nitrogen (TVB-N) was estimated by the microdiffusion method (Conway, 1950). Oxidation stability of the sample was assessed by measuring Thiobarbituricacid (TBA) value (Tarladgis et al , 1960) as well as Peroxide value (Yildiz et al.,2003) of the fish sample. Free Fatty Acid (FFA) value was determined as per AOAC (1989) to assess the hydrolytic rancidity.

2.3 Microbiological analysis.

Twenty-five grams of fish were aseptically weighed and homogenized with 225 ml sterile 0.85% normal saline for 1 min, in a Stomacher 400 lab blender (Seward medical, London, UK). The homogenized sample was serially diluted using 9 ml sterile saline for bacteriological analysis. Counts of *Staphylococcus aureus*, Faecal Streptococci and Enterobacteriaceae (Koutsoumanis & Nychas, 1999) were determined for fresh fish and for fish at the time of sensory rejection. Total viable counts (TVC) were determined in Plate Count Agar by the spread plate method

2.4.Texture analysis.

Texture Profile Analysis (TPA) was measured with a universal testing machine (Lloyd instruments LRX plus, UK), as described by Anderson et al., 1994, equipped with a load cell of 50 N. TPA was performed on raw fish pieces of 2 cm^3, compressed twice by a cylindrical probe having a diameter of 50 mm and a test speed of 12mm/min. The principle of TPA analysis is that, as the cylindrical probe is forced into the muscle, a shearing force acts, which causes the sample to deform or rupture. This produces a curve showing load resulting from deformation. Hardness, cohesiveness, springiness and chewiness were calculated as defined in the texture analyser user manual.

2.5 Sensory analysis.

For sensory analysis, the steaks were cooked in boiling water for 10 minutes and were assessed by a panel of 5 experienced members. Scoring was based on a 9 point hedonic scale as described by Amerine et al, (1965). Various sensory characteristics like colour and appearance, texture, flavour and taste were evaluated by the trained panelists. A score of 4 was considered as the border line for acceptability.

3. Results and Discussions

3.1. Proximate composition

Proximate composition of the fresh catfish meat showed 77 % moisture, 16.5% protein, 4% crude fat and 0.97% ash.

3.2. Chemical analysis

3.2.1. *Changes in pH.:* Changes in pH values with storage time for the IC and CS steaks are depicted in the figure 1. pH of CS and IS steaks increased from an initial value of 6.35 and 6.21 to a final value of 6. 64 and 6.62 respectively. According to Huss (1995), the post mortem pH for most fish is 7 or slightly lower than 7 immediately after catch. The low pH is an indicator of stress which the fish might have encountered during harvesting.(Mohan et al, 2008). The accumulation of lactic acid in the muscle followed by break down of glycogen, the major energy source, through anaerobic pathway leads to the accumulation of lactic acid. Later on the break down products of protein, lipid and carbohydrates serve as substrates for spoilage bacteria, which produce basic compounds such as amines raising the product pH. Over the storage period, no definite trend was obeserved for pH values of steaks stored in iced and chilled condition. There was a significant ($P<0.05$) increase in pH on the 3rd day of both chilled and iced storage. Even though the difference in pH between the treatments were not significant ($P>0.05$), the ice stored steaks showed a lesser pH than chilled stored steaks. The ice stored steaks showed a significant ($P<0.05$) increase in pH only on the 17th day of storage but there was no significant difference in pH ($P>0.05$) between samples of both the treatments. Similar results were reported for farmed sea bass in ice (Papadopoulos et al, 2003) and farmed turbot in ice (Rodriguez et al, 1999). Result of the present study reveals that pH is a poor quality indicator of freshness of catfish under refrigerated storage. But it can be considered as a quality indicator along with other quality indices.

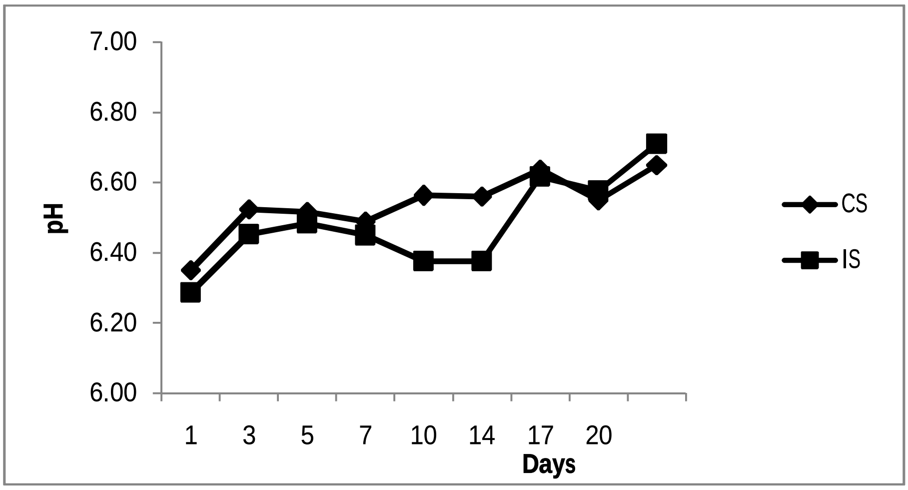


Figure 1: Changes in pH of sutchi catfish steaks stored at chilled (4^0C)and iced (0^0C)condition

3.2.2. *Changes in Total Volatile Base Nitrogen (TVBN):* TVBN levels were monitored as the main parameter of fish muscle freshness. TVBN are produced by decomposition of proteins into simpler substances (ammonia, trimethylamine, creatine, purine bases and free amino acids). Changes in the mean TVBN values of samples are given in the figure 2. On the 1st day of sampling the TVBN values were found to be 7.47 and 7.7 for CS and IS steaks respectively. Other researchers (above) have also reported that the TVB-N content of many fish species at day 1 of storage to be in the range of 5.5– 17.0 mg N/100 g muscle, suggesting that fish muscle possibly underwent some deterioration during handling (Benjakul et al., 2003). The increase in TVBN remained insignificant ($P>0.05$) till the 7^{th} day of storage for both the treatments. But from the 10^{th} day the TVBN values increased significantly ($P<0.05$). Increase in TVB-N with the lapse of storage may be attributed to bacterial spoilage after the bacterial population has grown (Hossain et al, 2005). However, in the present study, TVBN value didn't cross the acceptable limit of 35 mg/ 100 g of fish during the entire storage period of *Pangasianodon hypophthalmus* steaks in ice and chilled condition. Castro et al. (2006) also did not observe an increase in volatile bases until after 20–22 days of storage, when the fish was already considered unfit for human consumption. The lower TVBN content in the cat fish steaks can be due to the absence of trimethyl amine which is the major component of volatile bases in fish meat. Virtually all changes in TVBN are due to TMA component, which is a major constituent of volatile bases. Horner (1997) suggested that TVB-N is insensitive to freshness, which means that it cannot be used as a freshness indicator. However, it relates well with unfitness for human consumption as it is a good spoilage indicator.

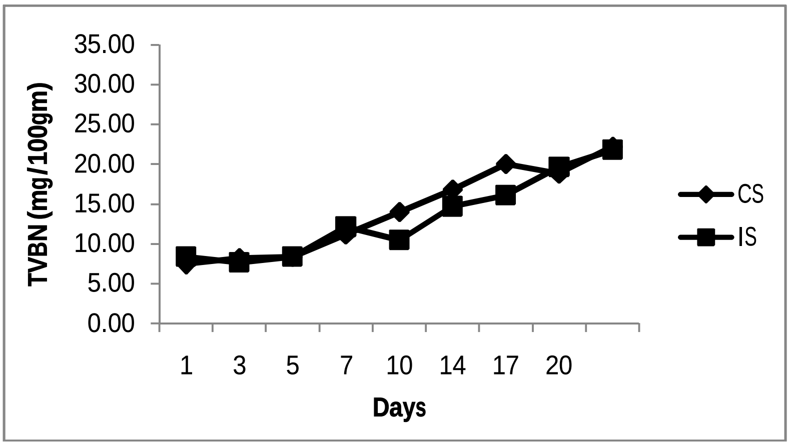


Figure 2: Changes in TVBN of sutchi catfish steaks stored at chilled (4^0C)and iced (0^0C)condition

3.3.3. *Changes in Free fatty acid content (FFA):* The FFA values ranged from 0.91% to 5.07% for chilled steaks whereas for iced steaks the FFA values ranged from 0.53% to 3.65% (Table 1). The FFA increase is very low when compared to its build up in farmed turbot as reported by Ozagul et al (2006). The FFA values fluctuated in the steaks stored by both CS and IS but there was no significant difference in FFA values in both the treatments during the final day of storage. Aidos etal has reported that the formation of FFA is independent of the storage temperature. The formation of FFA proceeds during storage probably due to the action of lipases and phospholipases. The progressive increase in the %FFA values over the storage time showed the progressive breakdown of lipids in fish muscle with time in ice. Accumulation of FFA in fish flesh is undesirable due to secondary reactions leading to quality deterioration. Gandotra etal (2012) has reported an increase of FFA from 0.5 to 8.17% during 14 day storage of Mystus seenghala.

3.3.4. *Changes in Thiobarbituric Acid value (TBA):* TBA index is a widely used biochemical quality indicator for assessing the level of lipid oxidation in food. TBA index gives a measure of malonaldehyde formed in the muscle as a result of oxidation of lipid peroxides. Mean values of TBA of the samples over the storage period are shown in the Table 1. The initial values of TBA of steaks stored under chilled and iced condition was 0.048 and 0.037mg malonaldehyde/ kg sample respectively. For both chilled and iced steaks, the TBA values increased with storage period. Significant increase ($P<0.05$) in TBA was evident from the 7th day of storage in both the treatments. But the CS steaks attained the highest peak of TBA much earlier than that of IS steaks. Both the CS and IS steaks showed a significantly low ($P<0.05$) TBA values on the final day of storage probably due to the losses in secondary oxidation products formed, particularly the low molecular weight volatile compounds. IS steaks had a significantly lower TBA value on the 17th day of storage than that of the CS steaks. A TBA value in the range 1–2 mg malonaldehyde/kg of fish sample is usually taken as the limit of acceptability (Lakshmanan, 2000). In the present study the TBA values were well within the acceptable limit throughout the storage period for both the treatments, although considerable fluctuations were shown. It has been stated by Stansby (1963) that lipids in fresh fish tissue held on ice or under refrigeration exhibit a small tendency towards oxidative rancidity.

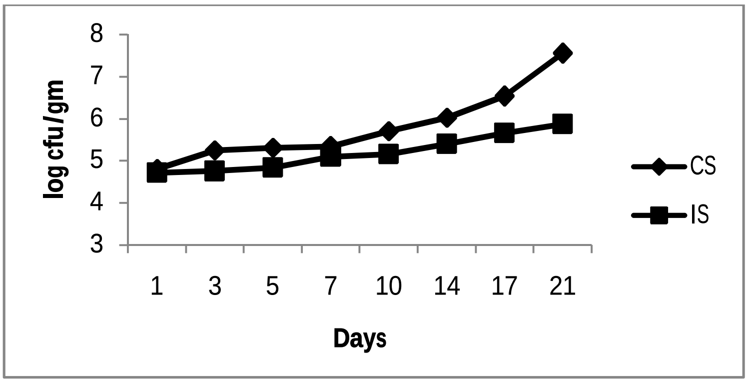
3.3.5. *Changes in Peroxide value (PV):* Significant increase in PV values occurred from the 3rd day of storage of chilled and iced steaks (Table 1). PV of chilled steaks were significantly higher ($P<0.05$) than the iced steaks on the 3rd day of storage indicating that the onset of lipid oxidation is getting delayed by the contact of ice. Although the PV value reduced from the 5th day of storage in both the treatments the change was not significant. On the 7th day again the PV values peaked for both the treatments thereafter showing a decreasing trend. The PV values never crossed the acceptance limit of 20meqO_2/kg oil throughout the period of study. Hydroperoxide formed as primary oxidation products at higher levels might undergo the decomposition into secondary oxidation products. A decrease in the level of primary oxidation products is related to hydroperoxide degradation, producing secondary lipid peroxidation products (Boselli et al., 2005). IS steaks had a significanlty higher PV value on the 17th day of storage than that of the CS steaks indicating lesser formation of secondary oxidation products. Reduced lipid deterioration was reported in black-skipjack (*Euthynnus linaetus*) when stored in ice for 24 days and also noticed that the acceptability of fish was upto 18 days of storage (Mazorra-Manzano , 2000).

Table 1: Deterioration of fat by autolysis and auto oxidation in (chilled (4^{0}C) and iced (0^{0}C) sutchi catfish steaks

Days	TBA (mg malonaldehyde/kg)		PV m equiO_2/kg oil		FFA (% of oleic acid)	
	CS	IS	CS	IS	CS	IS
1	0.03	0.05	0.90	0.81	0.91	0.53
3	0.09	0.12	6.30	3.49	3.12	1.70
5	0.11	0.16	5.91	1.79	1.59	1.79
7	0.35	0.36	16.10	10.30	1.40	1.08
10	0.68	0.84	11.02	18.52	2.28	2.75
14	0.83	0.86	3.31	6.50	5.02	2.72
17	0.77	0.32	2.53	5.10	3.33	3.65
19	0.43	0.29	1.88	4.02	3.99	6.66
20	0.44	0.28	1.58	3.80	7.39	7.52

3.3.Microbiological analysis

***3.3.1.** Changes in Total Viable Count (TVC):* The initial TVC of CS and IS were 4.80 and 4.71cfu/g respectively. Changes in TVC throughout the storage period are depicted in figure 3. In both the CS and IS steaks, the TVC rose continuously throughout the study and reached 10^6 cfu/g and 10^5cfu/g on the 14th and 17th day of storage respectively, when the steaks were deemed unfit for human consumption as per the sensory score. 10^6counts/g is the maximum microbiological limit for fresh fish recommended by the international commission of microbiological standards for foods (IUMSF, 1978). Cann et al (1984) has reported that salmon stored in ice had a longer shelf life than those stored at 5^{0}C. In another study the storage life of croaker (*Pseudotholitus senegalensis*) in ice was estimated to be 20 days by Ola et al (2004).



.

Figure 3: Changes in TVC of sutchi catfish steaks stored at chilled (4^{0}C)and iced (0^{0}C)condition

3.4. Texture analysis

3.4.1*. Changes in hardness.* Hardness refers to the peak force during the compressive part of the test. Hardness 1 refers to the peak force during first compression and Hardness 2 refers to the peak force during second compression. Hardness 1 and Hardness 2 were found to decrease significantly ($p<0.05$)in both ice stored and chill stored steaks during storage (Fig 4). Decreases in Hardness 1 and Hardness 2 values could be due to the weakening of connective tissue of fish muscle during storage by the proteolysis caused by endogenous and microbial enzymes. The results of the present study are in agreement with those of Manju et al (2007) who studied the effect of sodium acetate dip treatment on the shelf life of pearl spot (*Etroplus suratensis*). Azam et al (1989) have also reported a significant softening of both raw and cooked fillet during 15 days of ice storage using instrumental measurement (Steven's Compression Response Analyser, SCRA). Similarly sardine softening has been correlated with weakening of pericellular tissue by Sato et al. (1997). Similar observations were also made by Hatae et al (1985) who reported a softening of the texture in several fish species stored at 4 ^{0}C for up to 14 days, in a study using the General Foods (GF) texturometer.

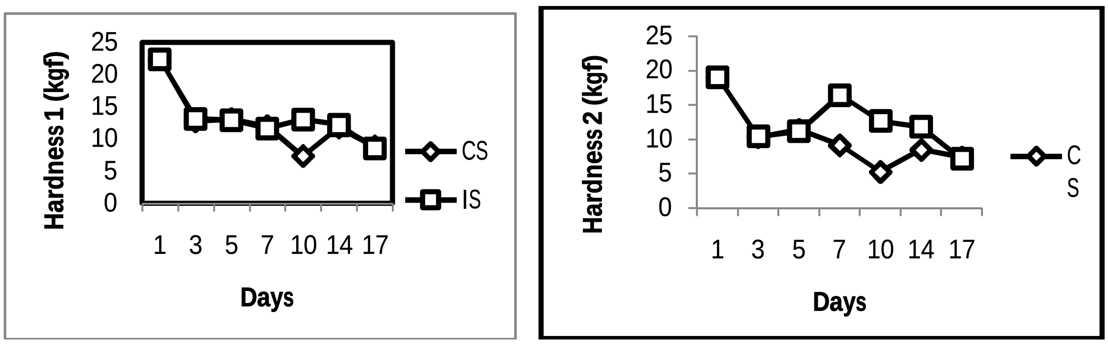


Figure 4: Changes in Hardness 1 and 2 of sutchi catfish steaks stored at chilled (4^0C)and iced (0^0C)condition

3.4.2.*Changes in springiness and chewiness:* Springiness is the elastic or recovering property of the fish muscle during compression. The springiness decreased from 5.611 to 4.04 and 3.81 on the 17th day of storage for the CS and IS steaks respectively (Fig 5). The values indicate that the fish muscle is losing its elasticity during storage. Chewiness refers to the work done. The value for chewiness decreased from 3.51 to 1.47 and 1.193 for CS and IS steaks respectively by the end of storage period. The decrease in chewiness indicates that the meat is getting soft during the storage. the chewiness of both IS and CS sutchi catfish steaks even after 17 days of storage is found to be better than that of pearl spot as reported by Manju et al, (2007)

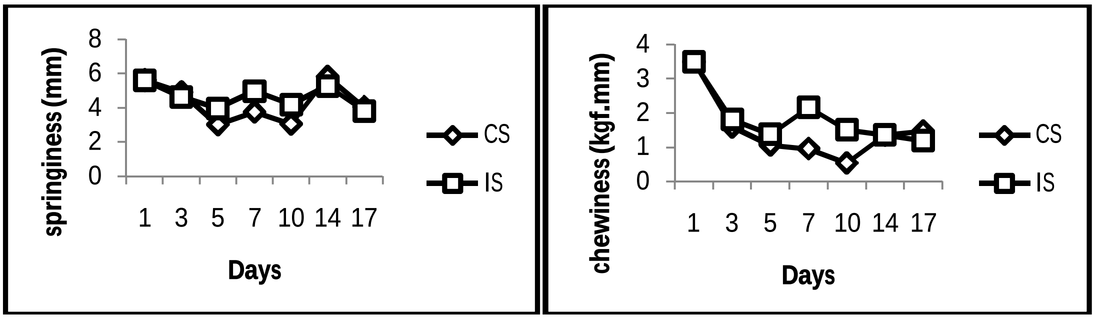


Figure 5: Changes in springiness and chewiness of sutchi catfish steaks stored at chilled (4^0C)and iced (0^0C)condition

3.5. Sensory analysis

There was significant decrease in the sensory score (Fig 6) throughout the storage period for steaks stored in both chilled and iced condition. Fish samples were considered to be acceptable for human consumption until the sensory score reached 4. Fish spoilage gave rise to the subsequent development of strongly fishy, rancid and putrid odours, and fish was clearly rejected for consumption by the taste panel. The data shows that the steaks stored in iced condition had a significantly higher sensory score than the chilled stored steaks throughout the storage period. Huss (1995) found significant positive correlations between TBA values and sensory analysis (r = 0.82-0.98). This holds true for the present study where the IS steaks had a significantly lower pH, FFA and TBA value than its CS counterparts towards the end of the storage period. The sensory score of chill stored steaks reached 3.34 by the 14 th day of storage, whereas the ice scored steaks reached the rejection limit of 3.66 only by the 17^{th} day. Bazard et al (1994) has reported that tilapia fillets packed under 100% air spoiled after 9 days at 4^0C. Manju et al (2007) has reported an acceptability of only upto 8 days for pearl spot packed under air. The study reveals the better shelf life of sutchi cat fish steaks in ice .

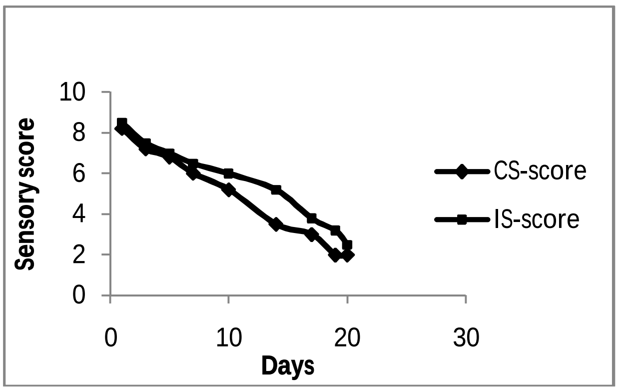


Figure 6: Changes in sensory score of sutchi catfish steaks stored at chilled (4^0C)and iced (0^0C)condition

4. Conclusions

The present study was undertaken to estimate the shelf life of Sutchi cat fish (*Pangasianodon hypophthalmus*) steaks in iced and chilled condition. The sensory analysis revealed that the iced steaks are having an extra shelf life of 3 more days when compared to the chilled steaks. Although the chilled and iced steaks were rejected on the 14th and 17th day respectively by sensory analysis, all the biochemical quality parameters were within the acceptable limit of human consumption even after the rejection.

Acknowledgements

The authors are grateful to the Director of Central Institute of Fisheries Technology (CIFT), Cochin for granting permission to carry out the work and for providing the necessary facilities

References

[1] Aidos I, Van-der-Padt A, Boom R M and Luten, J B (2003). Quality of crude fish oil extracted from herring by-products of varying states of freshness. *J. Food Sci.*, 68, pp. 458-465.

[2] Amerine M A, Pongborn R H and Roescler E B (1965). *Principles of sensory evaluation of food.* New York: Academic Press, pp. 602.

[3] Anderson U B, Stomsnes A N, Thomassen M S and Steinsholt K (1994). Fillet gaping in farmed Atlantic salmon. *Nor. J. Agricul. Sci.*, 8, pp.165–179.

[4] AOAC (1998). *Official methods of analysis (17th ed.).* Washington, DC: Association of Official Analytical Chemists.

[5] AOAC (1989). *Official methods and recommended practices of American Oil Chemists Society*. 5th ed. Champaign, USA: Association of Official Analytical Chemists

[6] Azam K, Mackie I M and J Smith (1989). The effect of slaughter method on the quality of rainbow trout (*Salmo gairdneri*) during ice storage. *Intl J. Food Sci. Technol.* ,24, pp. 69-79.

[7] Benjakul S, Visessanguan W, Thongkaew C and Tanaka M (2003). Comparative study on physicochemical changes of muscle proteins from some tropical fish during frozen storage. *Food Res. Intl.*, 36, pp. 787-795.

[8] Boselli E, Caboni M F, Redriguez-Estrada M T, Toschi T G, Daniel M and Lercker G (2005). Photoxidation of cholesterol and lipids of turkey meat during storage under commercial retail conditions. *Food Chem.*, 91, pp. 705–713.

[9] Cann D C, N C Houston, L Y Taylor, G L Smith, A B Thomson and A Craig (1984). *Studies of salmonids packed and stored under a modified atmosphere.* Torry Research Station, Ministry of Agriculture, Fisheries and Food, Aberdeen.).

[10] Castro P, Carlos J. Penedo Padron, M Caballero cansino, E. Sanjuan Velazques and R. Millan de Larriva (2006). Total volatile base nitrogen and its use to assess freshness in European sea bass stored in ice. Food Control, 17, pp. 245-248.

[11] Conway, E. J. 1950. *Micro-diffusion analysis and volumetric error*, Crosby. London: Lockwood and Son Ltd.

[12] Gandotra R, Sharma S, Koul M and Gupta S (2012) Effect of Chilling and Freezing on Fish Muscle. *J. Phar. Biol. Sci*., 2, pp.05-09.

[13] Hatae K, Tamari S, Miyanaga K and Matsumoto J (1985). Species difference and changes in the physical properties of fish muscle as freshness decreases. *Bull. Japan Soc. Sci. Fish.*, 5, pp.1155-1161.

[14] Horner W F A (1997). Preservation of fish by curing, drying, salting and smoking. In*: Fish Processing Technology.* (G.M. Hall, ed.), Blackie Academic and Professional, London, U.K, pp. 32–74,

[15] Hossain M I, Islam M S, Shikha F H, Kamal M and Islam M N (2005). Physicochemical changes in Thai Pangas (*Pangasius sutchi*) muscle during ice-storage in an insulated ice box. *Pak. J. Biol. Sci.*, 8, pp. 798-804.

[16] Huss, H.H. 1995. Quality and quality changes in fresh fish. FAO. In: *Fisheries Technical Paper No 348.* Food and Agricultural Organization of the United Nations, Rome, Italy, pp. 195-202.

[17] ICMSF (International Commission of Microbiological Standards for food). (1978): *Microorganisms in foods, 2. Sampling for microbial analysis. Principles and specific applications*, International Commission on Microbiological specifications for Foods. Torents. Canda, University of Torronto Press, pp. 92 – 100

[18] Isabel M, Jose M Gallardo and Santiago P. Aubourg (2009). Quality preservation in chilled and frozen fish products by employment of slurry ice and natural antioxidants. *Intl J Food Sci Technol.*, 44, pp. 1467-1479.

[19] Koutsoumanis K, Nychas G E (1999). Chemical and Sensory changes associated with microbial flora of Mediterranean Bouque (*Boops boops*) stored aerobically at 0, 3, 7 and 10^0C. *Appl. Environ. Microbiol*, 65, pp.698- 706.

[20] Lakshmanan P T (2000). Fish spoilage and quality assessment. In *Quality assurance in seafood processing,* Cochin: Society of Fisheries Technologists (India), pp. 28–45.

[21] Manju S, Jose L, Gopal T K S, Ravisankar C N and Lalitha K V (2007). Effect of sodium acetate dip treatment and vacuum-packaging on chemical, microbiological, textural and sensory changes of pearl spot (*Etroplus suratensis*) during chilled storage. *Food Chem.*, 102, pp. 27-35.

[22] Mazorra-manzano M A, Pacheco-aguilar R, Díaz-rojas E I and Lugo-sánchez M E (2000). Postmortem changes in black skipjack muscle during storage in ice. *J. Food Sci.*, 65, pp. 774-779.

[23] Mohan C O, Ravishankar C N and Srinivasa Gopal T K (2008). Effect of O2-scavenger on the shelf-life of catfish (*Pangosius sutchi*) steaks during chilled storage. *J. Sci. Food Agric.*, 88, pp. 442-448.

[24] Ola, Joseph B and Oladipo A E (2004). Storage life of Croaker in ice and ambient temperature. *Afr. J. Biomed Res.*, 7, pp.13-17

[25] Ozogul Y, Ozogul F, Kuley E, Ozkutuk A S, Gokbulut C and Kose S (2006). Biochemical, sensory and microbiological attributes of wild turbot (*Scophthalmus maximus*), from the Black Sea, during chilled storage. *Food Chem.*, 99, pp. 752–758.

[26] Papadopoulos V, Chouliara I, Badeka A, Savvaidid I N and Kontominas M G (2003). Effect of gutting on microbiological, chemical and sensory properties of aquacultured sea bass (*Dicentrarchus labrax*). *Food Microbiol.*, 20, pp. 411–420.

[27] Rodrıguez O, Barros-Velazquez J, Pineiro C, Gallardo J M, and Aubourg S P (2006). Effects of storage in slurry ice on the microbial, chemical and sensory quality and on the shelf life of farmed turbot (*Psetta maxima*). *Food Chem.*, 95, pp. 270–278.

[28] Sato K, Ando M, Kubota S, Origasa K, Kawase H, Toyohara H, Sakaguchi M, Nakagawa T, Makinodan Y, Ohtsuki K and Kawabata M (1997). Involvement of type V collagen in softening of fish muscle during short-term chilled storage. *J. Agric. Food Chem.*, 45, pp. 343–348.

[29] Stansby, M.B. 1963. Composition of fish. In: *Industrial fishery technology*. Bobert E. Krieger publishing Co., Huntington, Newyork, p.370

[30] Tarladgis B G, Watts B M, Younthan M T (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Am. Oil Chem Soc.*, 37, pp. 44-47

[31] Yildiz G, Wehling R and Cuppett S L (2003). Comparison of four analytical methods for the determination of peroxide value in oxidized soybean oils. *J. Am. Oil Chem. Soc.*, 80, pp. 103-107.