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Quality Changes during Storage of Smoked 'Cubes' and 'Fillet Steaks' Prepared from Marine Perch *Lethrinus lentjan* (Lacepede)

S. Sindhu, S. Krishnakumar, D.D. Nambudiri and Alphi Korath
Department of Processing Technology
College of Fisheries, Panangad, Kochi - 682 506

The study evaluated keeping quality and storage life of cubes and fillet steaks from a marine perch King Emperor (*Lethrinus lentjan*, (Lacepede). Smoked cubes and fillet steaks were prepared using a brine concentration of 10% and brining time of 15 min, draining at +10^{0}C for 30 min, pre-drying in mechanical drier for 30 min at 50^{0}C and smoking at 80^{0}C for a period of 3 h. Smoked cubes and fillet steaks prepared using a standardised procedure were subjected to storage studies for a period of four months under different packings *viz.*, (i) packed in PE bags (C) (ii) dried at 50^{0}C for 1h and packed in PE bags (S1) and (iii) dried at 50^{0}C for 1 h and packed in paper bags (S2). Quality changes during the storage period were monitored every 15 days time intervals for parameters *viz.*, moisture content, per cent free fatty acids, thio barbituric acid value, total plate count, total fungal count and sensory quality. Samples packed in paper bags remained acceptable only upto 60 days of storage while samples packed in PE bags were acceptable upto 90 days.

Key words: Cubes, fillet steaks, perch, storage study, shelf life

Shelf life of smoked fish depends on many factors, namely the species, the initial quality of raw material, the concentration of salt and corresponding water activity, the temperature regime during smoking, the content of smoke components, the type of packaging, the hygienic standard of the premises, the storage temperature and also the bacterial load. Smoking is described as a method to enhance the shelf life by improving the organoleptic qualities and reducing the bacterial levels (Balachandran *et al.*, 1989; Kazimerz *et al.*, 1999). The antioxidative action and bacteriostatic properties of smoke are critical in determining the shelf life of smoked products. Poor quality control of smoked seafood items is a major factor holding back the rapid market expansion of smoked products and development of innovative items in this area (Balachandran *et al.*, 1989; Pigott & Tucker, 1990).

In this context the determination of microbial quality as well as quality changes during storage are very important. The major quality changes during storage of smoked fish are fat oxidation, lipolysis, microbial spoilage due to high moisture content etc which limit its shelf life. (Hardy, 1980; Lakshmanan, 2002). Lean varieties are expected to show better storage life due to low fat oxidation. In addition, lower levels of water activity, temperature of storage and bacterial load are quite critical (Troller & Christian, 1978; Thomas & Balachandran, 1989). Lipid hydrolysis leads to the accumulation of free fattyacids and undesirable off odours. Smoking, drying and heating, due to an exothermic fat oxidation initially, may catalyse furthur oxidative changes in marine lipids (Woolfe, 1975; Khayat & Schwall, 1983; Lilabati *et al.*, 1997). Total plate count increases with increase in the humidity of the environment and the moisture content of the fish as reported by Lilabati *et al.*, 1999. Here fungal growth was the major cause of spoilage at RH levels above 70%. Smoked fish products deteriorate showing growth of moulds if the water content is approximately 15% (Kaneko, 1976; Meyer, 1976). Spoilage changes include colour and flavour changes, lipolysis, proteolysis and production of mycotoxins (Varma, 2002). The present study was undertaken to determine the shelf life of

smoked cubes and fillet steaks prepared from a marine perch *Lethrinus lentjan* (Lacepede).

Materials and Methods

Smoked cubes and fillet steaks were prepared as per the method standardised by Sindhu (2004). The products were packed in three different forms *viz.* (i) smoked and packed in polyethylene bags (control, *viz.* C) (ii) smoked, dried at 50°C in mechanical drier for 1 h and packed in polyethylene bags (treatment 1, *viz.* S1) (iii) smoked, dried at 50°C in mechanical drier for 1 h and packed in paper bags (treatment 2, *viz.* S2) (Fig.1). The PE bags were heat sealed and the paper bags were clipped. The PE bags had a water vapour transmission rate (WVTR) of 3.08 g/m²/24 h. at 90% RH and 37°C and oxygen transmission rate of 3500 cc/m²/24 h at 1 atmos. pressure difference. Kraft paper bags had Cobb's 1' value of 28.0 g/m². The samples were stored in 5 ply corrugated fibreboard boxes. Sampling was done every two weeks for all the three samples. One pouch from each of the three lots was drawn at every sampling for

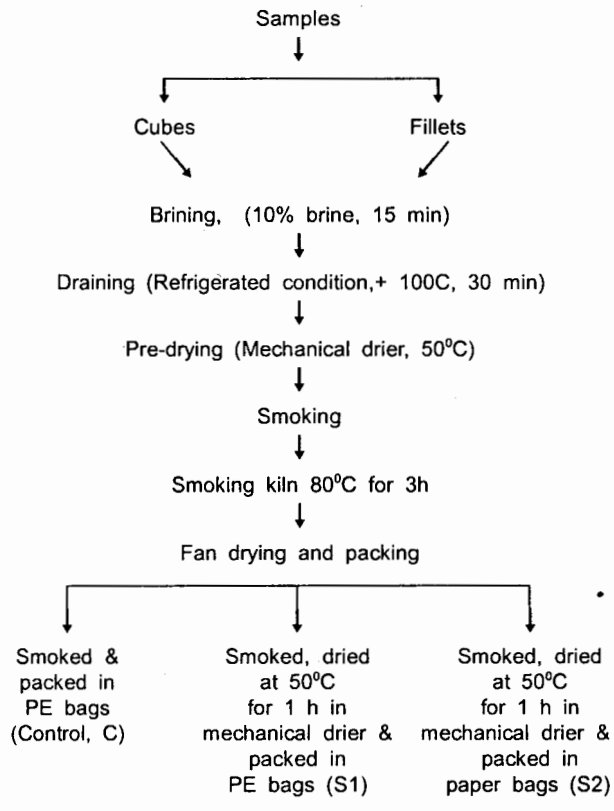

Fig. 1. Flow chart showing storage studies of smoked cubes and smoked fillet steaks

both the cubes and the fillet steaks. Thus the six samples were subjected to various tests *viz.* moisture content (AOAC, 1975), thiobarbituric acid value (Yu & Sinhuber, 1957), total plate count (Maturin & Peeler, 1995), total fungal count (Detroit, 1971), free fatty acid (AOAC, 1998) and sensory evaluation (Kazimerz *et al.*, 1999). Two way analysis of variance was carried out for the test data. Sensory evaluation results were analysed using Friedman test (Sprent, 1989).

Results and Discussion

The moisture content of smoked cubes and smoked fillet steaks were 38.14% and 37.43% respectively at the start of the storage period. For smoked and dried samples, the moisture content was in the range of 34.85% to 35.96% for cubes and 33.26% to 35.63% for fillet steaks. In the case of control (C) moisture content increased to 39.15% and 39.82% for cubes and fillet steaks respectively; whereas in the case of samples S1 the moisture content increased to 36.11% and 36.75% for smoked cubes and fillet steaks at the end of the storage period. For samples S2 moisture content increased to 37.9% and 37.85% for cubes and fillet steaks respectively at the end of the fourth month.

There was a significant difference in moisture absorption between samples. The moisture absorption was in the order C > S2 > S1. The paper bags have poor wet strength and tend to get easily torn and damaged by handling. Besides, they are poor barriers to moisture. PE bags also tend to get damaged due to the sharp edges of the product. The slight changes in moisture observed during storage may be due to absorption of some moisture during the storage period. Disadvantages of PE are, high WVTR and Gas transmission rate (GTR) and susceptibility to damage from sharp spines (Gopal *et al.*, 1998). Packaging of smoked fish poses problems due to irregular shape and sharp protrusions (Thomas & Balachandran, 1989).

Samples packed in paper bags were softer compared to the other two samples.

Friedman test also showed that samples packed in paper bags were significantly different with respect to sensory parameters.

In the present study FFA content was found progressively increasing within the storage period. FFA content of smoked cubes and fillet steaks were 1.96% and 2.25% respectively during the start of storage. The values of C increased to 24.33% and 30.68% respectively at the end of 120 days. For smoked and dried samples FFA contents of cubes and fillet steaks were 1.98% and 1.64% respectively. These values increased to 30.97% and 32.33% for cubes and fillet steaks at the end of the storage period for samples S1 whereas for S2, the FFA contents increased to 29.33% and 34.66% within 120 days (Fig. 2 and Fig. 3). The change in FFA content during storage was in the order C > S2 > S1 for both cubes and fillet steaks.

Higher temperature involved in smoking could result in low phenolic absorption. Temperature above 71°C reduces the rate of phenolic absorption (Kingston *et al.*, 1999). The phenol contents of the products were very low ranging from 4 to 4.5 mg%. However, control sample was found significantly different from the other two samples. Upto the 60th day of storage, no significant difference was noted. Friedman test also showed no significant difference. Odour scores up to the 60th day of storage were subjected to Friedman test. FFA content increased at a higher pace in case of smoked and dried samples compared to control samples. Highest value was noted in the case

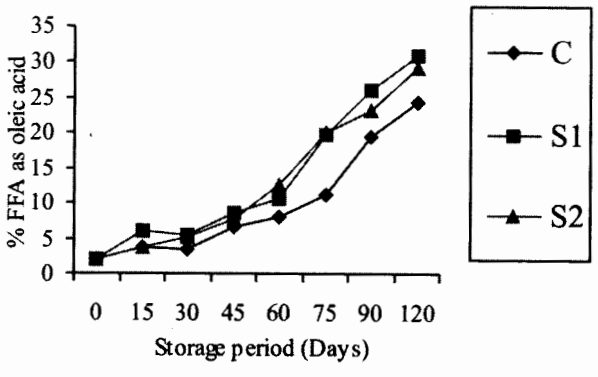

Fig. 2. Changes in % FFA of smoked cubes under different packing conditions

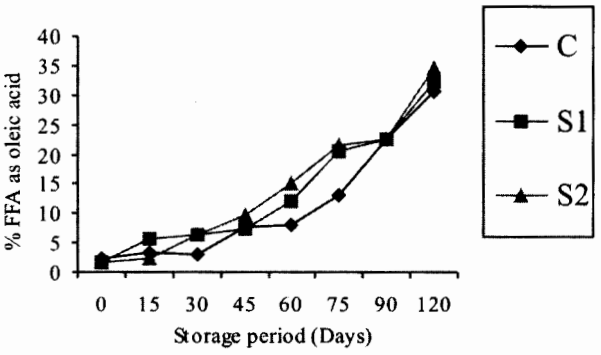

Fig. 3. Changes in % FFA of smoked fillet steaks under different packing conditions

of samples packed in paper bags. Smoking and drying serve to catalyse oxidative changes in marine lipids (Woolfe, 1975).

For cubes and fillets samples, TBA values of C increased from initial 0.78 mg of malonaldehyde/kg and 0.81mg malonaldehyde/kg to 5.07mg of malonaldehyde/kg and 5.85 mg malonaldehyde/kg respectively, at the end of storage period. For S1, the values increased from initial 1.75mg malonaldehyde/kg and 1.56 mg malonaldehyde/kg to 5.85 mg malonaldehyde/kg and 5.00 mg malonaldehyde/kg respectively. For S2, the TBA values of cubes and fillet steaks increased from 1.78 mg malonaldehyde/kg and 1.56 mg malonaldehyde/kg to 6.63 mg malonaldehyde/kg and 6.82 mg malonaldehyde/kg during storage (Fig. 4 and Fig. 5).

Heating undoubtedly causes oxidation of lipids in fish (Aitken and Connell, 1979). In the storage of smoked cubes and fillet steaks the three packings were significantly different. Highest value was noted in the case of samples packed in paper bags. The fat content of samples was also high, above 6%, and this led to the oozing of fat from the product, which got absorbed in the paper bag. This fat in turn was more exposed to oxygen and led to rapid oxidation of samples. Fat oxidation being a chain reaction, the rate of oxidation was high compared to other samples (Olcott, 1962). Fat soluble vitamins also undergo oxidation. Impurities in the salt or the salt itself acts as a prooxidant and this may be the reason

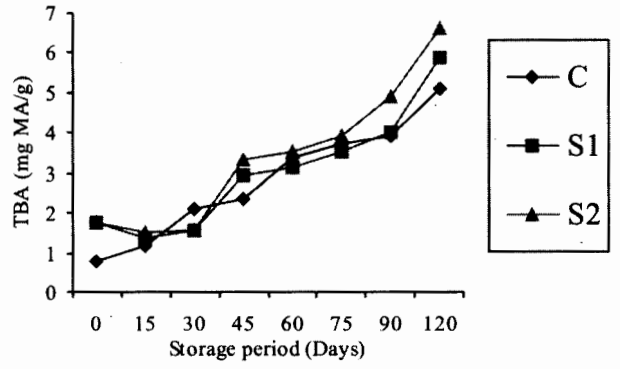

Fig. 4. Changes in TBA value of smoked cubes under different packing conditions

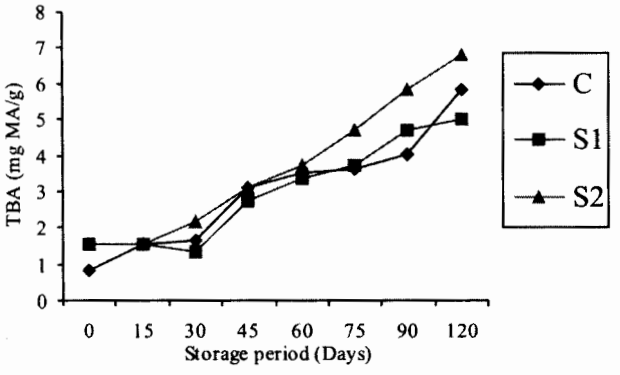

Fig. 5. Changes in TBA value of smoked fillet steaks under different packing conditions

for higher TBA values of smoked fish samples (Castell *et al.*, 1965; Tarr, 1969; Nambudiri, 1980; Bhuniyan *et al.*, 1986). In the present study the rate of fat oxidation was high in smoked and dried samples compared to control. This correlates well with the work of Lilabati *et al.* (1997) where the rate was higher in smoked samples which were sun dried.

Samples S2 were significantly different from others. Friedman test results also showed significant difference for taste. The oozing of fat coupled with poor gas barrier properties resulted in a highly rancid product within two months of storage. The direct exposure of fat even nullified the effect of a barrier and the rate of oxidation was found to be very high. Higher rate of oxidation was reported in unwrapped dried samples due to greater oxygen availability (Howgate and Ahmed, 1972).

Samples packed in PE bags also showed considerable fat oxidation. The high amount of fat ranging from more than 3% in undried (C) to 6% in dried samples (S1 & S2) can be a basic reason. Fat oxidation itself is an exothermic reaction and releases heat (Olcott, 1962; Khayat and Schwall, 1983). Since all the samples were stored in the same carton, the rapid oxidation of samples in the paper bags (S2) might have slightly increased the temperature inside the carton, resulting in considerable fat oxidation of samples stored in PE bags also (C and S1). Besides, cardboard cartons are not air proof. The oxidation is initiated and accelerated by heat, light, the presence of several organic and inorganic components, presence of air, etc (Khayat and Schwall, 1983; Lakshmanan, 2002).

Hot smoking results in partial sterilisation, but post process contamination increased microbial load (Lokesh *et al.*, 1989; Kandoran, 2002). For the control sample, the total plate count of smoked cubes and fillet steaks increased from $6.0x10^1$ cfu/g and $1.0x10^2$ cfu/g to $5.029x10^3$ cfu/g to $4.677x10^3$ cfu/g respectively at the end of the storage period. For smoked and dried cubes and fillet steaks, the count increased from $3.5x10^1$ cfu/g and $4.8x10^1$ cfu/g to $2.630x10^3$ cfu/g and $2.010x10^3$ cfu/g for samples S1 and $4.372x10^3$ cfu/g and $5.060x10^3$ cfu/g for samples S2 (Fig. 6 and Fig. 7).

Initially the total plate count of hot smoked cubes and fillet steaks were very low and upto the 60th day of storage no significant change was noted. No visible

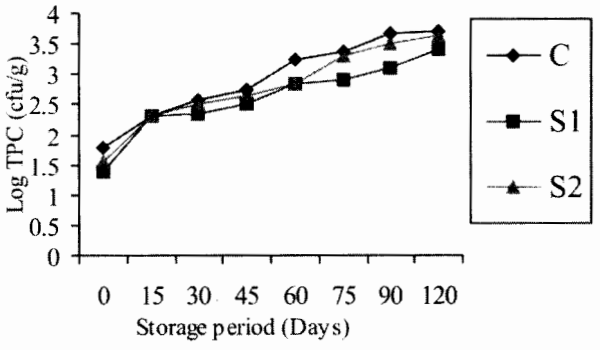

Fig. 6. Changes in TPC of smoked cubes under different packing conditions

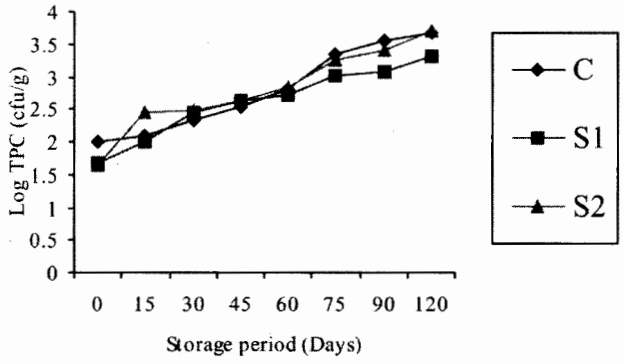

Fig. 7. Changes in TPC of smoked fillet steaks under different packing conditions

colonies were evident even after 120 days of storage. However, the count was found to be slightly higher in sample S2. This may be due to greater moisture absorption by products. Total plate count generally increases with increase in humidity of the environment and the moisture content of the fish (Lilabati *et al.*, 1997; Lilabati and Viswanath, 2001). RH reached a maximum of 96% during the storage period. Drying after smoking also had some effect in decreasing the bacterial count of the smoked products, however the effect of salting (brining) on microorganisms is variable. Some can tolerate greater quantities of salt and some are stimulated by the presence of salt (Pigott and Tucker, 1990).

Moulds are one of the important causes of spoilage of any kind of food (Frazier and Westhoff, 1978). Changes in total fungal count of smoked cubes and fillet steaks during storage are given in Fig. 8 and 9

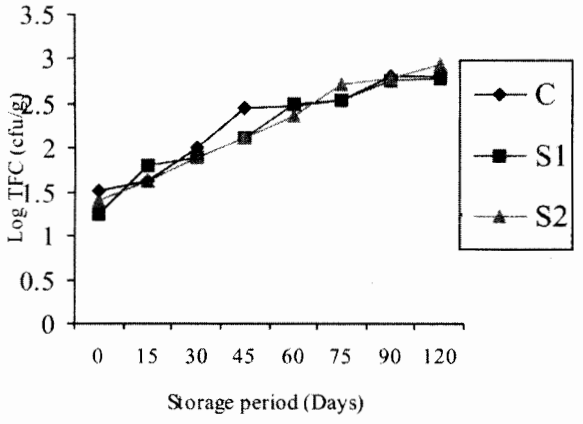

Fig. 8. Changes in TFC of smoked cubes under different packing conditions

respectively. For smoked cubes and fillet steaks packed in PE bags the count increased from $3.3x10^1$ cfu/g and $6.3x10^1$ cfu/g to $6.59x10^2$ cfu/g and $7.22x10^2$ cfu/g respectively. For smoked and dried cubes the count increased from initial $2.5x10^1$ cfu/g to $6.25x10^2$ cfu/g for samples S1 and $8.80x10^2$ cfu/g for samples S2. For smoked and dried fillet steaks the count increased from initial $3.2x10^1$ cfu/g to $6.8x10^2$ cfu/g for samples S1 and $9.15x10^2$ cfu/g for samples S2 (Fig. 8 and Fig. 9).

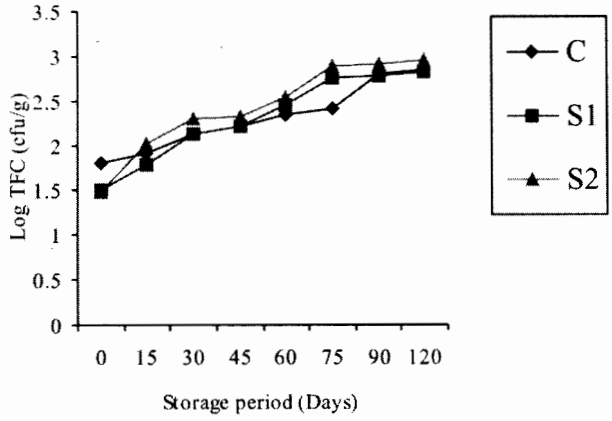

Fig. 9. Changes in TFC of smoked fillet steaks under different packing conditions

The increase in fungal count was very low initially and significant change was noted only after 60 days of storage. There were no visible fungal colonies even upto 120 days of storage. The highest count was found in samples packed in paper bags.

According to Kaneko (1976) smoked fish products deteriorate by growth of moulds if the water content is approximately 15% (Meyer, 1976). There is a direct relationship between the microbial count and humidity and also the moisture content of the sample. Fungal growth was the major cause of spoilage at RH levels above 70 % (Lilabati *et al.*, 1999). The storage period for the product in this experiment was during the monsoon season during which period the percent RH showed a minimum and maximum level of 70% and 96% respectively. This also might have influenced the fungal count of the samples. Growth of moulds on

foods has been reported over the temperature range of 10°C to 45°C.The production of enzymes which hydrolyse macromolecules such as protein, lipids, polysaccharides etc may give moulds an advantage of initiating their own growth in food. Spoilage changes include colour changes, odour/ flavour changes, lipolysis, proteolysis and production of mycotoxins (Varma, 2002).

According to Ryder *et al.* (1993) sensory evaluation is the most reliable test for raw material and processed fishery products. Organoleptic changes involved in fish are the results of the various microbial and chemical changes taking place during storage. Sensory evaluation being a subjective method, it is best coupled with other methods to form an important quality index (Gill, 1992; Nunes *et al.*, 1992).

Colour of smoked food is due to browning involving carbonyl amino reactions, phenol deposition and subsequent oxidation (Kazimerz *et al.*, 1999). Coconut saw dust which is one of the best sources of smoke in terms of colour (Solanki *et al.*, 1970) was used in the present study.

In the present study no significant difference was noted for colour. A slight darkening was noted towards the end of the storage period and this may be the reason for slight decrease in the colour scores towards the end. The gloss of the product also contributes to colour. The species selected being lean, the contribution of oil to gloss formation may be negligible and gloss is mainly due to brining and subsequent drying. A slight reduction in gloss was noted during the course of storage.

The flavour of smoked foods results from the composite action of smoke constituents, heat and salt, as all the factors induce physical and chemical changes in the products (Daun, 1979; Poulter, 1988; Moorjani, 1998, Kazimerz *et al.*, 1999). The odour scores did not show significant difference with Friedman test. Eventhough rancid odour was marked, the smoke flavour masked the intensity of the rancidity. Some of the panelists judged slight rancid odour as acceptable odour. Borderline of acceptability was fixed at 4. Eventhough average scores obtained were higher than 4, the products were judged unacceptable by majority of the panelists. Taste scores subjected to Friedman test showed significant difference. Rancid taste was more easily detectable than odour. Fungi have a proteolytic and lipolytic action which also could have contributed to the underisable taste (Varma, 2002).

Properly smoked fish is firm and springy to touch. Smoke curing has a tenderising action on the meat and heat denaturation of proteins makes the fish completely cooked (Anon, 1981). Smoke components like formaldehyde cause some toughening also (Kazimerz *et al.*, 1999).

Texture scores analysed by Friedman test showed significant difference. Products dried and packed in paper bags showed greater moisture absorption and a marked difference in texture when compared to the other two samples. These samples got easily crushed on finger pressure. Overall score is important in terms of overall acceptability of product by the consumer. However, overall scores obtained showed no significant difference. Lowest scores were obtained for products packed in paper bags. Eventhough polyethylene bags are expected to have better barrier properties compared to paper bags, rancidity development did not show expected results. While samples packed in PE showed acceptability up to 90 days of storage, the products packed in paper bags were acceptable only up to the 60th day of storage.

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