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QUALITY CHANGES AND SHELF – LIFE OF HOT SMOKED FISH FILLETS

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ABSTRACT

Hot smoked Kapreeta (*Scombromorous sp.*) fish fillets packed in laminated films-double layers (treated foil/ polyethylene) bags sealed under vacuum were used in this study. Data on changes occurring in the quality and shelf–life and spoilage rates during storage at ambient temperature (25-28 °C),chilled storage (0 to 2 °C) and refrigerated storage (10 ± 2 °C) are presented.

A method of presenting the data to allow decisions to be taken on the shelf – life of chilled and refrigerated products is discussed. The results obtained are as follows:

1- Initially the fillets were golden brownish in colour, showed signs of desiccation after <6, 35, 49 days storage at 25-28 °C, 10 °C and 0-2 °C; respectively which increased in further storage and the fillets finally became dull brown with yellow discoloration inside. The firm and juicy texture of the smoked fillets changed to rubbery and soft at the end of the storage period. The rate of spoilage at room temperature (RT), therefore, approximately 5 and 7 times greater than at refrigerated and chilled storage, respectively.
2- The chilled and refrigerated smoked fillets recorded the least, and the fillets stored at room temperature, the highest values of all the indices of quality attributes namely, free fatty acids (FFA), thiobarbituric acid (TBA), peroxide value (PV), total volatile basic nitrogen (TVB-N), trimethyl amine (TMA) and alpha amino nitrogen. Total viable counts, moulds & yeasts, hallophilic and psychrotrophic bacteria number also showed a similar trend.
3- At 0-2 °C, The FFA increased from 0.65% (as oleic acid) to 1.5%, the TVB-N from 6.50 to 33 mg/100g. The TBA, PV and TMA values also showed a similar trend of increasing . However, alpha amino nitrogen decreased from 50.60 to 20mg/100g . The moisture content showed a similar trend.
4- The bacterial metabolic end products (TVB–N and TMA) were less useful as objective measurements of freshness , whereas it could be used as an indicator of the onset of bacterial spoilage.
5- The pH was not a good indicator of early storage changes, TBA, PV and FFA could be used to determine loss of acceptability or end of shelf-life. Moreover , it showed correlation with taste panel results.
6- Smoked kapreeta fish (*Scombromorous sp.*) fillets could be kept in good quality up to 7 weeks if the temperature is maintained below 2 °C. Fluctuating and high temperature in the cold stores are the limiting factors in the quality of fish products.

Keywords: Kapreeta (*Scombromorous sp.*) fish, hot smoking, quality changes.

INTRODUCTION

Fish are an important protein source in many developing countries. It is highly nutritive to man since it contains polyunsaturated fatty acids and protein with all essential amino acids.

Developing new products is of utmost importance, first to extend the range of new products, continue to attract the attention of the consumers and, types of raw material to meet changing tastes and food habits (Kreuzer, 1974). Moreover, monitoring the quality and quality changes during storage of the product to expect and evaluate the shelf-life is very important criteria to study.Proper storage of such product is most essential to get long storage life.

In the domestic trade no attempt has been made so far in evaluating the quality and shelf-life of fish product although much data is available on dried/cured fish, Iyer et al., (1986) and Lakshmanan *et at.*, (1991).Fish and fish products are an extremely perishable food-stuff and, in the high ambient temperatures of the tropics, they will spoil rapidly, often within few days. This is an are in which large losses of valuable protein can occure.

Hiremath *et al.* (1985,1989) increased the storage life of oil sardine, by using optimum curing time and pressure. Limados Santos (1981) reported the use of chilled storage to increase the storage life of salted and pressed sardine. Chakrabarti et al. (1991) found that the storage life of salted and pressed *Psenes indicus* at ambient temperature could be increased by packaging under vacuum. propionic acid and its derivatives control growth of moulds and red halophiles in cured fish (Gupta, S. S. and Chakrabarti R. (1994).

The rate of spoilage at different temperatures relative to the rate of spoilage at 0°C for proteinaceous food products has been studied and a relative rate spoilage curve derived from data in the literature (Olley and Ratkowsky, 1973). This curve may be common to fish, meat and poultry and it is important to know whether it can be applied to tropical fish and shellfish.

It is necessary to introduce diversified products having appealing characteristics and reasonably good shelf-life to increase its utilization.

The effects of holding temperature on the keeping quality of temperate species have been studied in detail. However, data on tropical species is limited. Information on the pattern of spoilage of kapreeta fish and its products during holding at different temperatures is lacking.

Though extensive studies have been conducted on smoked curing of fish and its storage characteristics in various contouries, only limited work has been carried out in Egypt (Etman 1980, El-Akeel 1988, El-Nemr *et.al.*, 1995, Bassiouny *et al.,* 1999, and Moustafa *et al.,* 2000)

Fresh bloody muscle kapreeta (*Scombromorous sp.*) fish; a one of the genous of so-called dark-fleshed fish, constituting about 8-10% of the total marine fish landing each year of our country was used for the production of hot smoked fillets and fish finger with high quality attributes (Abu-Tor, 2002).

This study was conducted to the relative shelf-life and spoilage rates of smoked fillets of tuna-like shelf-life and spoilage rates and to monitor the changes in the quality of smoked fillets of kapreeta (*Scombromorous* sp.) fish, packed in a treated flexible foil having good keeping quality parameters (Abu-Tor *et al*, 2001), stored at different storage temperatures; ambient temp., 2°C and 10°C. In addition to this, the need for an objective method for quality assessment has long been recognized. Therefore, various physical, chemical and bacteriological tests were used to monitor spoilage during the trial; their potential as quality control indices for this species was evaluated.

MATERIAL AND METHODS

Materials:

Prepared hot smoked fillets of kapreeta (*Scombromorous* sp.) fish (Abu-Tor, 2002) were packed in treated flexible foil having good keeping quality parameters. Four fish fillets (~200g) were placed in each pouch of 30x15 cm, heat sealed and stored in chilled storage (CS:0 °C), refrigerated storage (RS: 10 ± 2 °C) and at room temperature (RT: 25 °C ± 2 °C) for assessing the quality. After packaging the samples were taken for initial analysis. Periodic analysis of the samples were conducted at intervals of one week.

Methods:

The edible part of fish (fillets) were passed twice through an electric meat-chopper type "Moulinex". The minced samples were kept in airtight glass jars in frozen state (at - 18°C) till analysis. All chemical determinations were carried out in triplicate.

1- Chemical methods:

Moisture content using hot air oven at 105°C to a constant protein weight, non protin nitrogen (NPN) and pH with spicol pH meter were determined according to the A.O.A.C. (1990) procedures. Peroxide value (PV), Free fatty acids (FFA), Salt content (as NaCl) by Mohr's titration , total volatile basic nitrogen (TVB-N) by Conway microdiffusion method, trimethyl amine nitrogen (TMAN), alpha amino nitrogen, thiobarbituric acid (TBA), were determined according to the methods of (Woyewoda *et.al.,* 1986).

2- Microbiological methods:

colony forming units (CFU), halophilic, psycrotrophic bacteria, molds and yeasts of smoked fish fillets were carried out according to the methods given by Kiss (1984).

3- Organoleptic evaluation:

Colour, taste, odour, texture, general appearance and over -all acceptability of smoked fish fillets were determined using ten trained panelists. The acceptability was determined on a hedonic scale ranging from (1) to (9) as mentioned by Rangana (1977).

4- Statistical analysis:

The standard deviation was calculated using the method described by Sendecor and Cochran (1967).

RESULTS AND DISCUSSION

Table (1) and Fig. (1) showed the quality changes in orgnoleptic characteristics and overall score of smoked kapreeta fish during storage at different temperatures. Products stored at room temperature deteriorated quickly and became unacceptable within 4-6 days; while the products stored at lower temperature (chilled and refrigerated) had longer shelf life and still acceptable and in good conditions till 56 and 35 days; respectively. Organolepticaly the samples did not show any sign of development of rancidity or off flavour up to these periods of storage. Some days later the smoked fish had developed spoilage characteristics which were disliked by the panel and became inedible. Thus, the shelf-life was affected by storage conditions. The unacceptability of the product after its mentioned keeping quality period was due to textural softening, off-flavour, development of rancidity and the growth of microorganisms.

The bacterial and chemical changes occurring during storage at different temperatures are presented in Table (2) and Figs. (2 to 8).

Table (2) and Figs. (2 to 8) show that product stored at room temperature (RT) deteriorated quickly with growth of moulds and bacteria after 4-6 days and became unacceptable, while the product stored at CS and RS remained in acceptable condition for 49 and 35 days; respectively. The fillets were only on the threshold of spoilage at these periods. The products were unacceptable after these storage periods due to textural softening and the development of off flavour. Comparing with the taste panel results both results are in agreement to each other. In general, fillet spoilage was due to textural softening, off-flavour, development of rancidity and the growth of microorganisms. (Ravesi *et. al* 1985). The time of rejection ≡ The shelf – life, again, was affected by storage conditions. The longer shelf - life ≡ higher keeping quality, the lower temperature of storage.

Both TVB-N and TMA-N (Figs. 2and 3) increased gradually during storage (The initial value of TMA (2.20 at day zero) in bloody tuna muscle, which is not a low value, may be partially due to its high content of precursor trimethylamine oxide (TMAO).

TVB-N is a measure of the total volatile amine compounds present, and it collectively includes ammonia, monomethyl-amine and dimethyl-amine and trimethy amine (Ravesi *et al.*, 1985). It have been employed as chemical indices of spoilage for many temperate and coldwater fish and the limit of acceptability has been suggested as 30 mg N/100g (Amu and Disney, 1975; Connell, 1975 and the commission of the European Communities, 1995).

Trimethy-amine (TMA) is formed by the action of a bacterial enzyme, triamine oxidase, on the precursor substance trimethyl-amine oxide (TMAO), found in marine species. The optimum pH for activity of this enzyme was reported to be 7.2 – 7.4 in cod (Ravesi *et al.*, 1985). 10 mg TMA N/100g is the recommended limit of acceptability for temperate and cold water fish (Conell, 1975).

There were considerable variations in the TVB –N and TMA values depending on storage temperature (Fig 2, 3). This values of the fish stored at room temperature increased very quickly followed by RS then CS so that by day 6 and 35 and 56, when the taste panel rejected the smoked fillets, the levels were, 173, 45 and 40 mg TVB-N/100g and 40, 15 and 12 mg TMA N/100g (RT, RS and CS, respectively). These are obviously well above the suggested limits. At this limit /time the smoked fillets were rejected by the panelestes, sensory evaluation results, (Table 1 and Fig 1). This increase in TMA and TVB concentrations correlated with the microbiological results (Table 2), emphasizing the use of TMA as an indictor of the onset of bacterial spoilage rather than an indicator of freshness. It is also could suggested that measurement of TVB-N concentration is not a good indictor of freshness. Howgate (1982) stated that TVB-N, like TMA, content is not a sensitive index of freshness because of its high variability and the test is unusually reserved for fish near the limit of acceptability. Additionally it presence originally in fish muscles and in a constant ratio specially in the first period after catch.

Since these amines are produced as a result of microbial activity, one would expect the bacterial growth to reflect a similar temperature dependency. That they can be seen in Table (2) and Fig (2,3), however, there is a notable lag in bacterial increase during the first 40 days at 0-2°C which contributed to the extended shelf life at this lower temperature.

Table (2) and Fig (2,3) illustrate the rapid increase in rate of either bacterial growth or volatile amine production at storage temperatures above about 10°C. Therefore, it behooves the fisherman or processor to maintain low storage temperatures for bloody tuna to retard the production of the volatile amines and other bacterial decomposition products strongly associated with spoilage. Thus extending the keeping quality.

The sodium chloride concentration did not change significantly, was about 7.5%, throughout the storage period at different temperatures while there was slightly increasing in RT sample as seen from table (2). According to Bannerman (1980), 3% salt concentration in the final smoked product has been found effective for hot smoked fish. According to him, this concentration was enough to inhibit the growth of any food poisoning organisms present, particularly *Clostridium botulinum*, without making the product unpleasantly salty to eat. Cann (1984) stated that the concentration required to prevent growth of *Clostridium botulium* at room temperature can vary from as low as 3 ½ per cent to 5 per cent or more, So a product, like hot smoked trout and mackerel should have an minimum concentration of 3 per cent salt, he said. In the present experiment, final salt concentration is above the minimum level in the product (Table 2) and the product is acceptable.

Surendran *et al.* (1983) in their studies the salt tolerance of bacteria isolated from tropical marine fish and prawn demonstrated that more than 80% of the isolated selected cultures were capable of growth in the presence of 1.5 to 3.5% salt (NaCl) and least 25 to 30% of the cultures in each group required 1.5 to 3.5% salt for growth. Moreover, 40% of each of *Pseudomonas* and *Vibrio* stains and 30% each of *moraxella* and *flavobacteria cytophage* strains to related 10% salt. Majority of the cultures of *Pseudomōna, Vibrio, Moraxella, Micrococcus, Acinetobacter* and *Flacobacteria Cytophaga* were slightly halophilic (2 to 5% salt tolerant)

Moisture content did not change significantly throughout the storage period at both (CS) and (RS) while its change was pronounced in the samples stored at (RT) resulting in some toughness of the product (Table 2).

The pH changes with time during storage at different temperatures are shown in Fig. (4). It remained relatively constant (<6) during the initial storage period and began to increase thereafter . The pH increased rapidly (from 5.7 to 7.1) by day 42 and (from 5.7 to 8) by day 6 in the fish at 10 °C (RS) and (RT); respectively while the (CS) fish were only pH 6.6 on day 56, indicating the faster rate of spoilage at the higher temperature (Fig. 4). The combined data from the three temperatures revealed that, a pH value of 6.3 was determined at the end of useful shelf life in the (CS) which is lower than the value reached in the (RS) when shelf life has expired. The course of basic volatiles production for the three different temperatures seemed to coincide with pH change. The pH value, also, correlated reasonably well with the taste panel results (Table 1 and Fig. 1). Thus, the decrease in quality coincided with the increase in volatile amines and pH.

The rate of increase TVB, TMA, pH, TBA and PV per day was different at different temperature. Generally, the rate of increase in samples (CS) remained relatively low.

The levels of peroxide value, TBA and FFA and its patterns of increase during storage at different temperature are shown in Fig (5,6 and 7).The levels of these parameter varied significantly ($p>0.05$).The CS samples showed the lowest values at any autoxidation of fish lipids and formation of malonal dehyde.

TBA values show the secondary stages of oxidative rancidity and would be expected to increase over the later stages of the storage trial. Peroxides are intermediate fat breakdown poduct and hance accumulate in the early stages of oxidative rancidity and are then broken down. This makes interpretation of a single peroxide value difficult because a very rancid product could have a low peroxide value. As may be seen from (Table 1), and Fig 1, the taste panel scores supported the changes in chemical indices.

The increase in TBA and FFA levels with storage (Fig 6 and 7) suggest that both tests could be a useful quality index.

Organelepicaly, the fish was acceptable up to 7 and 5 weeks at 2 and 10◦C, respectively (Table1). The sample did not show any sign of development of rancidity or off flavour up to these periods of storage. During the later periods, slight rancid flavour and slight yellow discolorations of meat low been observed. On some days later the fish had developed spoilage characteristics texture, flavour and general appearance changes which were disliked by the panel and became inedible

Microbial action has been shown to play large part in the spoilage o fish (shewan, J. M. 1977). Therefore, by monitoring the bacterial load the quality of particular fish species can be indicated. Total counts, molds, happophilic and psychotropic baterial a room temperature (RT), refrigerated storage (RS) and chilled storage (CS) are presented in Table (2). Generally, their growth were higher at higher temperature, meaning that, their growth increased slightly in CS compared with the other treatment. The decrease in quality was not consisted with the increase of the micro under concern. However, the microbiological changes not relatively related to the chemical deterioration indexed the organolrptic evaluation showed that the panelists still accept the samples up to longer period of storage, meanwhile the totl bacterial count reached more to less high number. These may be inducted that the chemical changes take place in slower rate at refrigerated or lower temperature compared to micro flora of fish which seems to be adapted to cooled condition. The result are in agreement with those reported by Curran *et al* (1980) and Plahar *et at* (1991).

Alpha amino nitrogen (Fig 8) showed a steady decrease throughout the storage and the sweet and bitter taste at the end of releasing of amino acids and other amino decomposite proteins which contributed to the sweet and bitter taste (Joseph and Perigreen (1988)

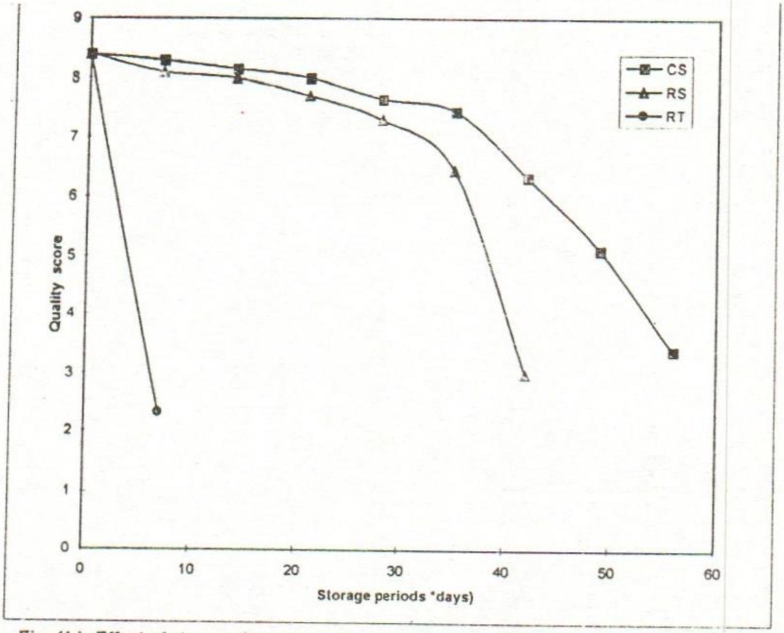

Fig. (1): Effect of storage time on quality score of smoked fillets from kapreeta (Scombromorous sp) fish stored at various temperature.
RT= Room temperature.
CS= Chilled storage.
RS= Rerigerated storage.

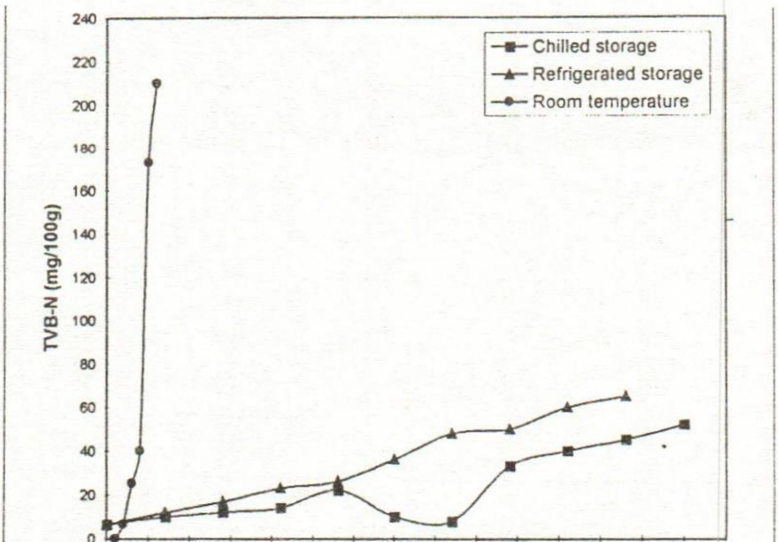

Fig (2): Change in TVB-N during storage of smoked fillets from kapreeta (Scombromorous sp.) fish at different temperatures.

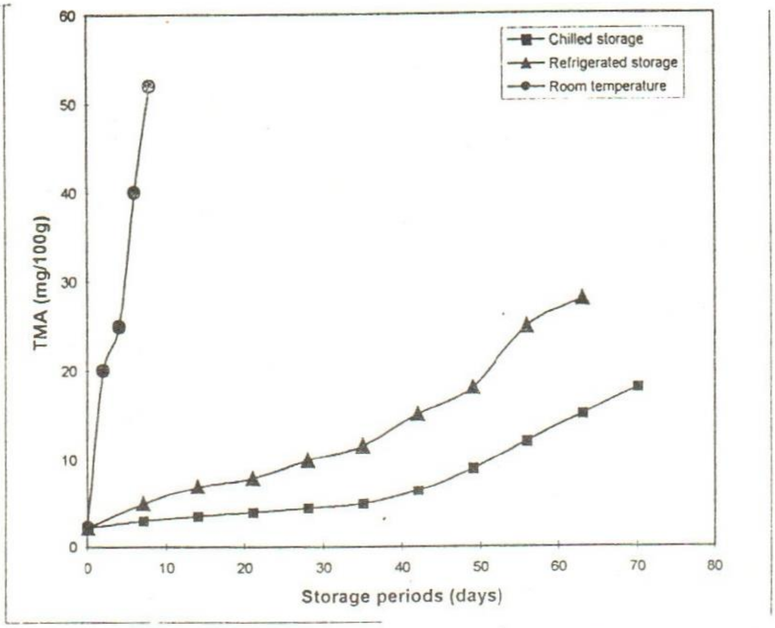

Fig (3): Change in TMA during storage of smoked fillets from kapreeta (Scombromous sp.) at different temperatures

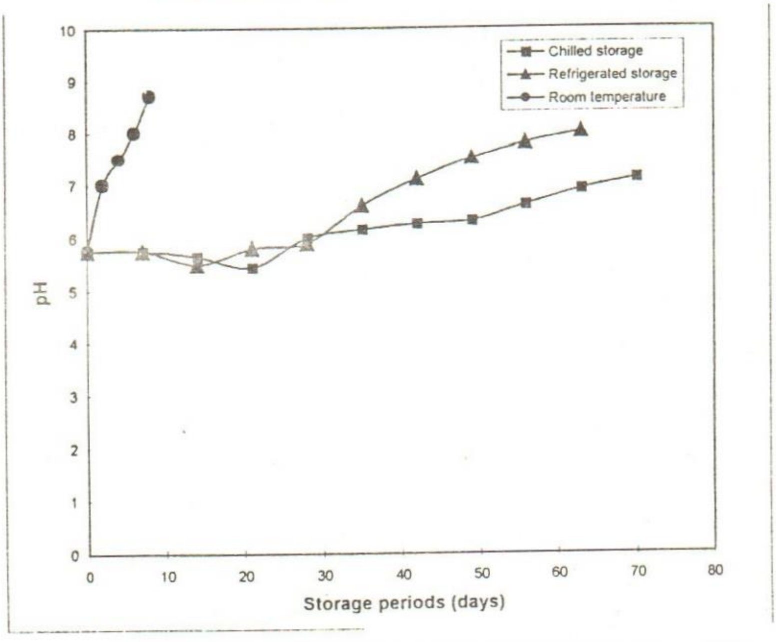

Fig (4): Change in pH during storage of smoked fillets from kapreeta (Scombromous sp.) at different temperatures

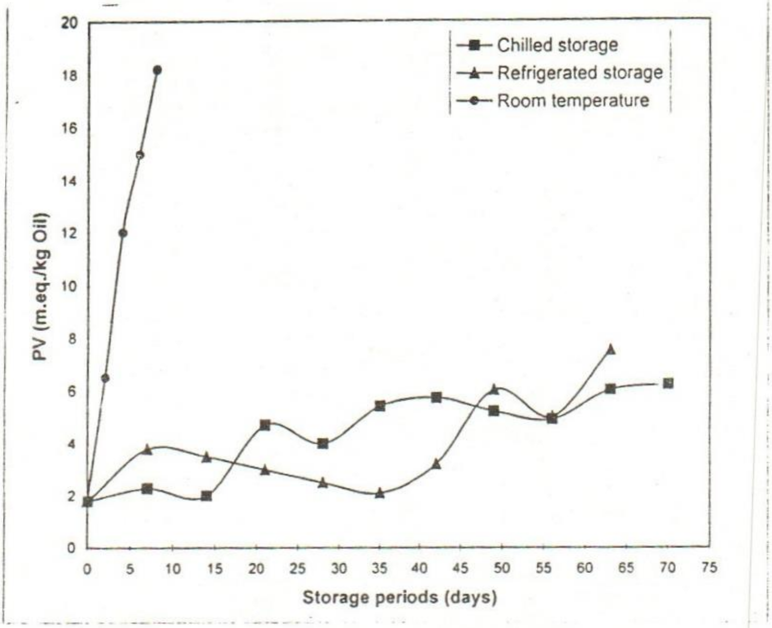

Fig (5): Change in PV during storage of smoked fillets from kapreeta (Scombromorous sp.) fish at different temperatures.

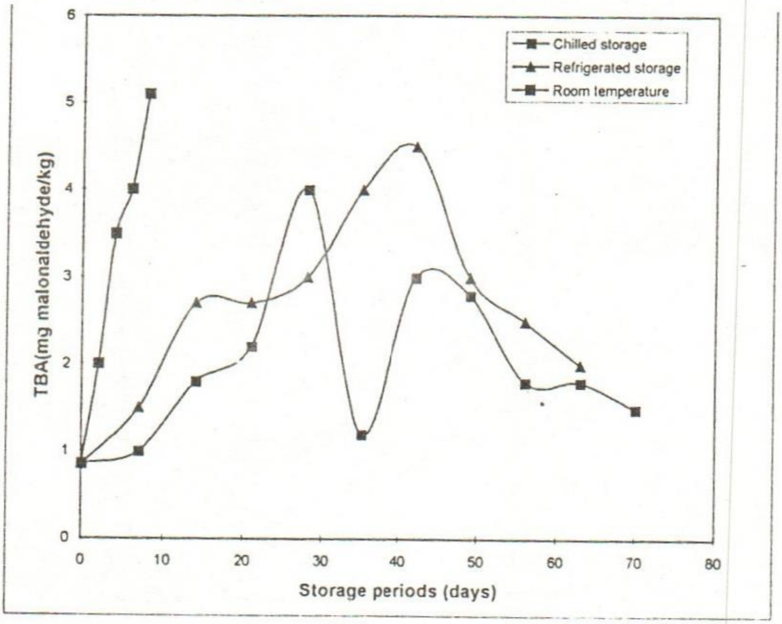

Fig (6): Change in TBA during storage of smoked fillets from kapreeta (Scombromorous sp.) fish at different temperatures

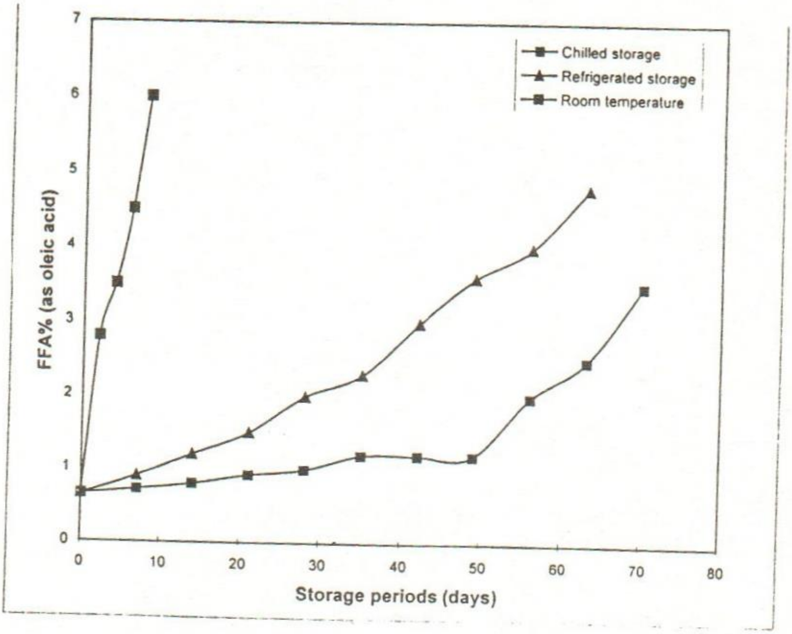

Fig (7): Change in FFA during storage of smoked fillets from kapreeta (Scombromorous sp.) fish at different temperatures

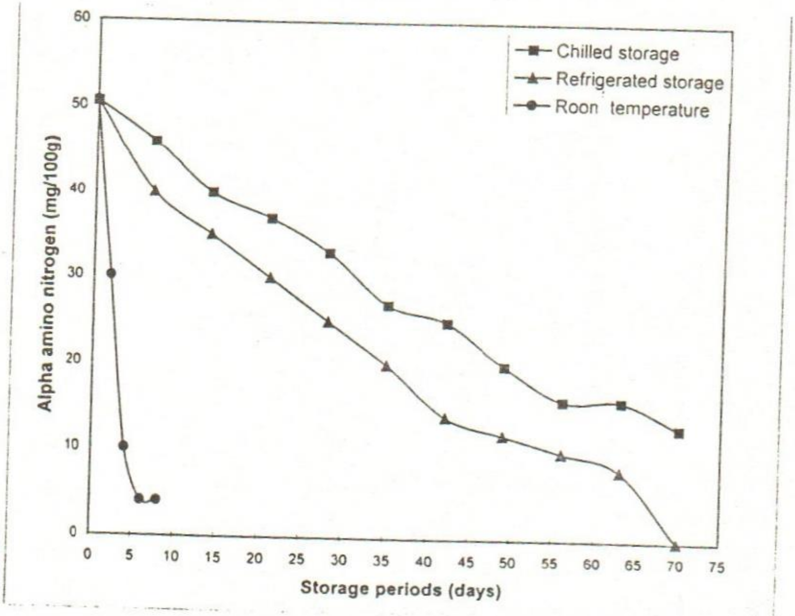

Fig (8): Change in alpha amino nitrogen during storage of smoked fillets kapreeta (Scombromorous sp.) fish at different temperatures.

Table (1):Quality changes in organolephic characteristics of smoked fillets from kapreeta (Scombromorous sp.) during storage at different temperatures

Periods storage, Days	Storage conditions		
	chilled storage (Cs) 0°C	**Refrigerated storage (Rs) 10±2°C**	**Room temperature (RT) 25±2°C**
0	Good taste, lightly salted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Good taste ,lightly salted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour,not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Good taste ,lightly salted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific
7	Good taste ,lightlysalted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Good taste ,lightlysalted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Rancid, sour, puteefied, bitter, dry and tough, off flavcur raised and growth of bacteria, molds and yeasts, Not acceptable.
14	Good taste ,lightlysalted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Good taste ,lightlysalted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	
21	Good taste ,lightlysalted.Smoky flavour free of any other objection nabletastes or odours, golden brownish colour, not homogeneous, Free of burnt areas, good texture firm, juicy, not chewy. Typical quality for hot smoked product ≡ species specific	Good to fair taste, colour and texture. Not much more change	------------------
28	Good to fair taste, colour and texture.	Good to fair taste, colour and texture. Not much more change	------------------
35	Good to fair taste, colour and texture.	Fair taste and flavour, slight changes in texture and colour	------------------
42	Fair taste, slight changes in colour, odour and texture, but acceptable	Original taste lost, putrefied rancid, soft texture, changes,in colour and flavour, Growth of bacteria, molds and yeasts. Not acceptable	------------------
49	Taste satisfactory, slight changes in texture and colour, but acceptable	------------------	------------------
56	Original taste lost, rancid, bitter, soft texture. Growth of bacteria, molds and yeasts	------------------	------------------

Table (2): Changes in some chemical parameters, cfu, moulds and yeasts, halophilic and sychrotrophic bacteria during storage of smoked kapreetat fillets at different temperature

Storage conditions Chilledstorage (CS) (2°C)	NaCl (%)	H_2O (%)	Cfulge (cfu /g)	Moulds/g	Hallophilic/g bacteria	Psycrotrophic Bacteria
0	7.23	55.23	1.1X10^2	0.25 X10^2	2.33 X10^2	0.65 X10^3
7	7.25	55.18	0.8 X10^2	0.2 X10^2	2.20 X10^2	0.50 X10^3
14	7.30	55.05	0.5 X10^2	0.2 X10^2	2.10 X10^2	0.23 X10^3
21	7.30	54.50	0.4 X10^2	0.1 X10^2	1.90 X10^2	0.20 X10^3
28	7.40	54.02	0.3 X10^2	0.5 X10^2	2.50 X10^2	0.15 X10^3
35	7.42	53.30	0.6 X10^2	1.5 X10^2	3 X10^2	1 X10^3
42	7.46	52.00	1.2 X10^2	1.8 X10^2	3.5 X10^2	2 X10^4
49	7.50	51.40	3.4 X10^3	2 X10^3	4.2 X10^2	2.5 X10^4
56	7.50	51.10	5.2 X10^3	2.2 X10^3	2 X10^3	3 X10^4
63	7.60	50.00	2 X10^3	2.5 X10^3	3.2 X10^3	3.1 X10^4
70	7.70	-	1.8 X10^4	3 X10^4	4 X10^3	3.5 X10^4
Refrigerated storage (RS) (10°C±2)						
0	7.2	55.23	1.1 X10^2	0.25 X10^2	2.33 X10^2	0.65 X10^3
7	7.25	55.00	0.9 X10^2	0.28 X10^2	2.30 X10^2	0.6 X10^3
14	7.30	54.30	0.6 X10^2	0.3 X10^2	2.20 X10^2	0.4 X10^3
21	7.32	53.30	0.5 X10^2	0.2 X10^2	2.10 X10^2	0.32 X10^3
28	7.35	52.00	0.2 X10^2	0.8 X10^2	2.5 X10^2	0.2 X10^3
35	7.50	50.00	0.6 X10^2	1.8 X10^2	3.2 X10^2	1.5 X10^3
42	7.60	49.10	1.2 X10^3	2.2 X10^2	3 X10^2	02 X10^4
49	7.70	48.00	04 X10^4	3 X10^3	4.5 X10^2	2.5 X10^4
56	7.75	-	5.2 X10^4	3.5 X10^3	3 X10^3	3.5 X10^4
63	7.85	-	06 X10^4	3 X10^4	4 X10^3	04 X10^4
Room temperature(RT) (25°C±2)						
0	7.23	55.23	1.1 X10^2	0.2 X10^2	2.33 X10^2	0.65 X10^3
2	7.50	50.10	1.8 X10^2	1.5 X10^2	2.6 X10^2	0.70 X10^3
4	8.00	43.10	03 X10^2	03 X10^2	3.2 X10^2	01 X10^3
6	9.50	35.00	02 X10^2	04 X10^3	3 X10^3	02 X10^3
8	12.0		04 X10^2	05 X10^4	4.5 X10^3	4.5 X10^4
10				-	-	

CONCLUSIONS

1-Taste panel result suggest a shelf -life of up to 6 days at room temperature (RT), 35 and 49 days at RS and CS; respectively for hot smoked fillets. The rate of spoilage at room temperature, therefore, approximately 5 and 7 times greater than at RS and CS; respectively.

2-The loss of sensory quality in this species was determined by bacterial spoilage and by the change due to flesh degradation

3-The bacterial metabolic and product (TVB and TMA), are less useful as objective measurements of freshness, whereas it could be used as an indicator of the nest of bacterial spoilage.

4- The pH was not good indicator of early storage changes, TBA, PV and FFA values could be used to determine loss of acceptability or end of shelf-life. Moreover, it showed a correlation with taste panel results.

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تغيرات الجودة ومدة حفظ شرائح السمك (الكبريتة (سكومبرومورس) خلال التخزين على درجات حرارة مختلفة

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فى هذه الدراسة تم استخدام شرائح سمك الكبريتة (جنس سكومبرومورس) المدخنة على الساخن المعبأة فى عبوات مزدوجة الطبقات (فويل معامل /بولى ايثلين) والمغلقة تحت تفريغ. البيانات الخاصة بالتغيرات فى الجودة ومدة الحفظ ومُعدلات الفساد الحادثة أثناء التخزين على درجة حرارة الغرفة (٢٥ °م)، التبريد (صفر إلى ٢°م) والثلاجة (-١٠± ٢°م) قد تم عرضها. وقد تم شرح طريقة لعرض البيانات تسمح بأخذ القرارات الخاصة بمدة الحفظ للمنتجات المخزنة تحت ظروف التبريد على درجة حرارة منخفضة. والنتائج المتحصل عليها هى كالتالى:

١-بداية كانت شرائح السمك المدخنة ذات لون ذهبى مائل للبنى، وأظهرت علامات بهتان بعد ٦، ٣٥، ٤٩ يوم من التخزين على حرارة ٢٥ °م و صفر °م على الترتيب والتى زادت فى مراحل التخزين التالية وفى النهاية أصبحت الشرائح بنية داكنة مع وجود لون أصفر باهت بالداخل. وقد تغير القوام من عصيرى متماسكة إلى مطاطى وطرى فى نهاية فترة التخزين معدل الفساد على درجة حرارة الغرفة حوالى من ٥-٧ مرات أكبر مقارنة بمثيله عند التخزين على حرارة التبريد والثلاجة على الترتيب.

٢-سجلت شرائح السمك المدخنة المحفوظة بالتبريد والثلاجة أقل قيم بينما المحفوظة على حرارة الغرفة أعلى قيم لكل معايير الجودة موضع الدراسة مثل الأحماض الدهنية الحرة، حمض الثيوباربتيوريك ، رقم البيروكسيد، والقواعد النيتروجينة الكلية الطيارة، الأمين ثلاثى الميثايل والنيتروجين الألفا أمينى. العدد الكلى للبكتريا، الخمائر والفطريات والبكتريا المحبة للملوحة والمحبة للحرارة المنخفضة بينت أيضا إتجاه مماثل فى التغير.

٣-على درجات الحرارة من صفر إلى ٢°م قد زادت كل من الأحماض الدهنية الحرة من ٠,٦٥% (كحامض أوليك) إلى ١,٥% ، والقواعد النيتروجينية الطيارة الكلية من ٦,٥ إلى ٣٣ ملجم/١٠٠ جم. أظهرت ايضا كلا من حامض الثيوباربتيوريك ، رقم البيروكسيد وثلاثى ميثايل الأمين إتجاه مماثل للزيادة بينما إنخفضت قيمة النيتروجين الألفا أمينى من ٥٠,٦ إلى ٢٠ ملجم/١٠٠ جم . المحتوى الرطوبى قد بين إتحاة مماثل

٤-إتضح أن النواتج الأيضية النهائية للبكتريا مثل القواعد النيتروجينية الكلية الطيارة، الأمين ثلاثى الميثايل كانت قليلة الأهمية كمقايس للطزاجة بينما يمكن استخدمها كدليل للفساد البكتيرى

٥-رقم الحموضة والقلوية pH لم يكن جيدا كد ليل للتغيرات المبكرة أثناء التخزين بينما وجد أن رقم الثيوباربتيوريك، رقم البيروكسيد والأحماض الدهنية الحرة يمكن إستخدامه لتقدير الفقد فى التقبل أو نهاية مدة الحفظ. علاوة على ذلك فإن تلك التقديرات قد أظهرت علاقة تلازم مع نتائج ختبارات التذوق

٦-شرائح سمكة الكبرتة امدخنة جنس سكومبرومورس يمكن حفظهما فى جودة عالية لمدة (٧) أسابيع إذا تم الحفاظ على درجة الحرارة لأقل من٢ °م التذبذب فى درجة الحرارة والحرارة العالية فى المخازن تعتبر عوامل محددة لجودة منتجات الأسماك.