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Changes in the Quality Properties of Grass Carp (*Ctenopharyngodon Idella)* Fillets Smoked During Chilled Storage

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ABSTRACT

The effect of salting and drying before smoking on the keeping quality of grass carp (*Ctenopharyngodon idella*) fillets were studied over a period of 30 days at1±2°C. Quality assessment was based on sensory, microbiological and biochemical determinations. Biochemical indices of smoked samples remained practically constant during the 30 day of chilled storage period. Biochemical indices of salted driedfillets before smoking and salted without drying before smoking increased during the storage period but remained at low levels after 30 days of storage in contrast to biochemical indices of unsalted smoked with dried samples. Relatively constant bacterial counts (total bacterial, psychrophilic bacterial and halophilic bacterial count Log10 CFU/g) and sensory characteristics were observed for unsalted smoked drying samples during the 30 day storage period at 1±2°C while slight differences were observed between salted dried before smoked and salted without dried smoked. A significant reduction in the Biochemical indices sensory scores was recorded for unsalted dried before smoked samples during storage for 30 day at 1±2°C.

Keywords: Grass Carp (*Ctenopharyngodon Idella),* Smoked Fillets, Chilled Storage.

INTRODUCTION

Smokeing curing is a traditional fish preservation method of considerable economic importance worldwide. Smoke, is produced by the process of incomplete combustion of wood. It consists of numerous individual components namely: aldehydes, ketones, alcoholes, acids,

hydrocarbons, esters, phenols, ethers. (Guillen and Errecalde, 2002). Smoking is probably the oldest known method used for preserving fish. In Europe about 15% of the total quantity of fish for human consumption is offered on the market in the form of either cold- or hot-smoked products at present, the effects of brining and smoking on colour and sensory perception are at least as important as the preservative effect due to the use of modern refrigerating systems. There are three different stages of the total smoking process; brining, heating and smoking (Aminullah *et al.* 1986).

These components are transferred to the smoked goods by deposition on their surface and subsequent penetration into their flesh (Doe, 1998). Smoking imparts a characteristic flavour and colour to the fish. In addition, smoking increases the shelf-life of fish as a result of the combined effects of dehydration, antimicrobial and antioxidant activity of several of the smoke constituents mainly: formaldehyde, carboxylic acids, phenols (Leroi and Joffraud, 2000a and Rorvik, 2000). An additional preservative effect is owed to salting which comprises the first step of the fish smoking process. The preservative effect of salting is mainly due to the decrease in water activity (a_w) and thus prevention of growth of many spoilage microorganisms along with the formation of a more membranous surface which further inhibits the growth of microorganisms (Leroi and Joffraud, 2000a and Rorvik, 2000). Moreover, chloride ions are toxic for some microorganisms (Leroi; *et al.* 2000b). There are three methods used to smoke fish: the traditional method by combustion, at either low temperature (cold smoking at 30°C) or high temperature (hot smoking at 65°C); use of a high voltage electrostatic field which accelerates smoke deposition; and use of liquid smoke which lowers the content of poly nuclear aromatic hydrocarbons (potently carcinogenic compounds) in liquid smoked fish (Espe *et al.*, 2002). Hot-smoking is a pasteurizing process, the preservative effect of which depends on the composition and preparation of raw material, temperature, relative humidity, density and composition of the smoke as well as the smoking time. (Kolodziejska; *et al.* 2002). The application of hot smoking for the extension of the shelf-life is a process of interest, given that Grass carp (*Ctenopharyngodon idella*) is generally a fatty fish which spoils easily.

The objectives of the present work were to study the effects of

salting and drying before smoking on the keeping quality of grass carp (*Ctenopharyngodon idella*) fillets as assessed by, determination of biochemical indices, bacteriological count and sensory evaluation.

MATERIALS AND METHODS

Fish samples

Grass carp (*Ctenopharyngodon idella*) was immediately obtained after catching from Abbasa farm in Sharkia governorate, Egypt. Each sample weighted 10 Kg, while the mean of individual weight of grass carp fish was about 2.5 Kg. The fish samples were washed using tap water. The fish samples were cut to fillets. The Grass carp fillets were separated into three groups; 1- salted and dried before smoking. 2- salted before smoking. 3- dried before smoking. The fillets groups were used to study the effect of this treatment on the shelf-life and quality of grass carp fillets under refrigeration. The salting operation was performed by immersing the fillets in a brine solution150 g/L NaCl at 4 ±1°C for 48 hours. Two group of Grass carp fillets were brined after immersion in the same as above reported brine for 150 g/L NaCl at 4 ±1°C for 48 hours. Another group of fillets was stored for 48 hours without salting treatment.

Preparation of samples for salting and smoking

The Grass carp fillets were immersed in a brine containing 150 g/L NaCl at 4 ±1°C for 48 hours with a fish: brine ratio of 1:1 (w/v). Then the fillets were washed for 30 min. The fish were then subjected to oven drying at 40ºC for 2 hours using a Grieve Fish Oven [(f) Cu. F.T. made in USA, Ser-No. 311418] with an air speed of 2.5 m./sec. the fillets were then smoked for 60 min at 50°C in a conventional smoking facility equipped with an automatic control for temperature, humidity and density of wood smoke. After resting to a temperature of 20 °C for 2 hour, all treatments were packed in polyethylene bags and stored at 2±1°C for 30 days. Sampling was carried out at predetermined time intervals namely: 0, 6, 12, 18, 24 and 30 days. At each sampling day 3 fish were randomly chosen for analysis.

Analytical methods

Moisture content was determined by oven drying using a 5g of fish fillet at 105°C until a constant weight was obtained (AOAC, 2000). Total protein, lipids, ash and Salt content were determined according to methods described in AOAC (2000). The pH was estimated according to the method mentioned by Özogul *et al.*

(2005) where 5.0 gram of sample was blended with 100.0 ml. distilled water for 5 min. and the pH was determined by using a pH-meter (Orion Research Digital Ionanalyzer, Model 420a). Total volatile bases nitrogen (TVBN), and Trimethylamine nitrogen (TMAN) were determined according to the method recommended by the AMC (1979). Total bacterial count (TBC) and Psychrophilic bacterial count (PsBC) were analyzed according to the method described by Swanson *et al.* (1992). Halophilic bacterial count (HBC) was determined according to the method mentioned by Baross and Lenovich (1992). Organoleptic properties were evaluated for odour, taste, flesh colour and texture during processing steps where A group of 10 panelists were asked for scoring. The scores ranged from zero to 10 follows as described by Teeny and Miyauchi (1972). Furthermore, the sensory attributes of smoked Grass carp (*Ctenopharyngodon idella*) fillets were evaluated at each sampling time (day 0, 6, 12, 18, 24, 30) by a seven member trained panels as described by Teeny and Miyauchi (1972). Prior to sensory assessment samples were removed from the refrigerator and held for 30 min at room temperature. Samples were then cut in 30 g pieces and presented to each panelist in plastic cups covered with a lid in random order. Panelists were asked to score odour, taste, flesh colour and texture of fillets using a 0–10 scale. For each sensory attribute a score of 6 (recorded by at least of 50% of the judges) was considered to be the lower limit of acceptability, implying that shelf life was terminated when this score was obtained.

Table 1. ***Description of scores***.

Score	Description	Score	Description
10	Ideal	4	Fair
9	Excellent	3	Poorly fair
8	Very good	2	Poor
7	Good	1	Very poor
6	Fairly good	0	Repulsive
5	Acceptable		

Statistical Analysis

Three replicates of each trial were performed for each parameters using ANOVA and the means were separated by Duncan' test (1955) at a probability level of $P<0.05$ (SAS, 2000).

RESULTS AND DISCUSSION

Moisture Content

Moisture content of salted dried (A) grass carp, salted (B) and dried (C) fillets before smoke are given in Table 2. Mean moisture content at zero day of storage were 62.45, 64.23 and

Table 2. ***Changes in moisture, pH and salt content of different treated fillets of smoked grass carp (Ctenopharyngodon idella) during storage at 2±1ºC for 30 days***.

parameter	treatments	Storage time (days)					
		0	**6**	**12**	**18**	**24**	**30**
Moisture content (%)	**A**	62.45± 0.61^{b}	62.23± 0.59^{b}	61.85± 0.60^{b}	61.40± 0.55^{b}	61.00± 0.57^{b}	60.50± 0.56^{b}
	B	64.23± 0.72^{ab}	63.95± 0.63^{ab}	63.55± 0.67^{ab}	63.10± 0.65^{ab}	62.71± 0.63^{ab}	62.22± 0.66^{ab}
	C	66.81± 0.68^{a}	66.39± 0.71^{a}	66.00± 0.65^{a}	65.62± 0.71^{a}	65.12± 0.69^{a}	64.71± 0.67^{a}
pH	**A**	6.6± 0.03^{a}	6.5± 0.03^{a}	6.3± 0.02^{a}	6.1± 0.05^{a}	5.9± 0.04^{a}	5.8± 0.03^{a}
	B	6.2± 0.04^{ab}	6.1± 0.03^{ab}	6.0± 0.05^{ab}	5.8± 0.02^{ab}	5.6± 0.03^{ab}	5.4± 0.04^{ab}
	C	6.0± 0.05^{b}	5.8± 0.04^{b}	5.6± 0.05^{b}	5.5± 0.04^{b}	5.3± 0.03^{b}	5.1± 0.05^{b}
Salt content (%)	**A**	8.12± 0.2^{a}	8.32± 0.2^{a}	8.41± 0.1^{a}	8.65± 0.3^{a}	8.86± 0.2^{a}	9.01± 0.1^{a}
	B	7.05± 0.3^{b}	7.21± 0.3^{b}	7.44± 0.4^{b}	7.69 ±0.4^{b}	7.80± 0.5^{b}	7.98± 0.5^{b}
	C	0.59± 0.05^{c}	0.78± 0.03^{c}	0.85± 0.05^{c}	0.90± 0.04^{c}	1.10± 0.04^{c}	1.29± 0.05^{c}

(A) salted dried before smoked, (B) salted without dried before smoked and (C) unsalted dried before smoked.

$^{a-c}$ Means within a column with the same superscript significantly different (P<0.05).

V alues are expressed as Mean ± SE.

66.81% rerecorded for samples smoked A, B and C respectively. While the moisture content at the end of storage period were 60.50, 62.22 and 64.71%, for samples smoked A, B and C respectively. The decrease in moisture be attributed to the exclusion of available water from the fish by the effect of different treatments salting, drying and smoking. Industrial specifications for ‘‘smoked finished products’’ generally recommend a water content in the fish flesh of less than 65% (Cardinal *et al.*, 2001). These values were in agreement with moisture values of 60.50, 62.22 and 64.71% recorded at the end of the storage period. These content are in complete agreement with those of Kolodziejska *et al.* (2002), who

reported that the mean moisture content of smoked mackerel was 62.7%.

pH content

The changes in the pH of smoked grass carp fillets are given in Table 2. Mean values of pH obtained were 6.60, 6.20 and 6.00 for dry salted (A), salted (B) and dried samples (C) before smoking respectively, at zero time of storage period. While the pH content at the end of storage period were 5.80, 5.40 and 5.10 for dry salted (A), salted (B) and dried samples (C) before smoking respectively, This decline in pH value of all samples may be attributed to protein denaturation and fat autolysis which lead to the liberated of amino acids, free fatty acid and lactic acid which may be produced in different amounts during the storage period. These results coincide with those given by Bibek (1992), Khallaf *et. al.,* (1997) and Nykanen *et. al.,* (2000).

The decrease in pH may be attributed to the production of volatile basic components, such as ammonia, trimethylamine etc. by fish spoiling bacteria (Hyytia *et al.* 1999; Reddy *et al.,* 1997;Ruiz-Capillas and Moral, 2001a). The pH decrease in fish flesh by the addition of salt is explained by the increase of the ionic strength of the solution inside of the cells Leroi and Joffraud (2000a). This is confirmed by our data for unsalted and salted samples, where pH decreased from 6.60 to 6.20 and 6.00 when salt was added to fish fillets (day one of storage).

Salt content

Salt content of smoked grass carp fillets are given in Table 2. A lower salt content was found in the unsalted dried before smoking versus the smoked samples. Mean values of salt content obtained in the fish muscle were 8.12%, 7.05% and 0.59% for salted dried (A) salted (B) and dried (C) samples at zero time of storage period. While the salt content of smoked grass carp (*Ctenopharyngodon idella)* fillets at the end of storage period were 9.01%, 7.98 % and 1.29 % for (A), (B) and (C) respectively. According to the literature (Horner, 1997) Similar results for the preservative effect of salt have been reported by Kolodziejska *et al.* (2002). The increase in the salt content of smoked samples is due to partial dehydration during the smoking process and subsequent changes in the wet weight of the fillets. Specific brining conditions used in our study for the salting of fillets is recommended for fish such as grass carp fillets it has

been reported that salt content in fish muscle enhances oxidation of the highly unsaturated lipids (Aubourg and Ugliano, 2002).

Protein content of grass carp (*Ctenopharyngodon idella*) fillets salted dried before smoked (A), salted without dried before smoked (B) and unsalted dried before smoked (C) fillets are given in Table 3. Mean protein values of 69.30, 69.70 and 70.01% rerecorded for (A), (B) and (C) samples, respectively at zero time of storage period. While the protein content at the end of storage period were 67.78, 67.88 and 67.90% for (A), (B) and (C) samples respectively. From these results, it could be noticed that, the reduction in crude protein content may be attributed mainly to the autolysis process leading to the formation of some soluble protein fractions, which leached out gradually to packing medium, these results are in a good agreement with those reported by Hussein *et. al.* (1980); El-Samkary *et. al.* (1997) and Baltasar *et. al.* (1998).

Fat content

Fat content of grass carp fillets are given in Table 3. A lower fat content was found in the salted dried before smoked versus the smoked samples. Mean values of fat content obtained in the fish muscle were 19.46%, 19.95% and 20.31% for (A), (B) and (C) samples, respectively at zero time of storage period. While the fat content of grass carp fillets at the end of storage period were 18.68%, 19.06 % and 19.23 % for (A), (B) and (C) samples, respectively.

Ash content

The changes in the ash content of grass carp fillets samples are given in Table 3. Mean values of ash content obtained in the fish muscle were 11.20, 10.0 and 9.00% for (A), (B) and (C) samples, respectively at zero time of storage period. While the ash content at the end of storage period were 13.40%, 13.00 and 11.60% for (A), (B) and (C) samples, respectively.

The decrease in crude protein during storage resulted from the decomposition and degradation of nitrogen substances which may be due to the activity of microorganisms and proteolytic enzymes while the decreasing of fat contents may be attributed to the activity of microorganisms and lipolytic enzymes which lead to breakdown of fatty acids. But the increment in ash content could be mainly due to addition of salt. These results coincide with those given by Cardinal *et. al.* (2006).

Table 3. ***Changes in Protein, fat and ash content of different treated fillets of smoked grass carp (Ctenopharyngodon idella) during storage at 2±1ºC for 30 days.***

parameter	treatments	Storage time (days)					
		0	6	12	18	24	30
Protein content (%)	A	69.30± 0.07^{ab}	69.06± 0.05^{ab}	68.63± 0.06^{ab}	68.24± 0.05^{ab}	68.00± 0.07^{ab}	67.78± 0.06^{ab}
	B	69.70± 0.06^{a}	69.41± 0.06^{a}	69.00± 0.07^{a}	68.67± 0.07^{a}	68.24± 0.07^{a}	67.88± 0.05^{a}
	C	70.01± 0.06^{a}	69.62± 0.07^{a}	69.14± 0.05^{a}	68.70± 0.05^{a}	68.35± 0.06^{a}	67.90± 0.06^{a}
Fat content (%)	A	19.46± 0.05^{ab}	19.31± 0.05^{ab}	19.17± 0.06^{ab}	19.00± 0.05^{ab}	18.85± 0.06^{ab}	18.68± 0.06^{ab}
	B	19.95± 0.06^{a}	19.80± 0.06^{a}	19.66± 0.05^{a}	19.49± 0.05^{a}	19.28± 0.06^{a}	19.06± 0.05^{a}
	C	20.31± 0.06^{a}	20.15± 0.05^{a}	20.00± 0.06^{a}	19.78± 0.07^{a}	19.52± 0.05^{a}	19.23± 0.06^{a}
Ash content (%)	A	11.20± 0.04^{a}	11.60± 0.04^{a}	12.11± 0.05^{a}	12.66± 0.04^{a}	13.05± 0.05^{a}	13.40± 0.05^{a}
	B	10.00± 0.05^{b}	10.48± 0.05^{b}	11.12± 0.06^{b}	11.73± 0.05^{b}	12.21± 0.04^{b}	13.00± 0.04^{b}
	C	9.95± 0.04^{bc}	10.31± 0.06^{bc}	11.00± 0.06^{bc}	11.55± 0.04^{bc}	12.19± 0.05^{bc}	12.80± 0.05^{bc}

(A) salted dried before smoked, (B) salted without dried before smoked and (C) unsalted dried before smoked.

$^{a-bc}$ Means within a column with the same superscript significantly different (P<0.05). Values are expressed as Mean ± SE.

Total volatile basic nitrogen (TVBN)

TVBN values for smoked grass carp fillets are presented in Table 4. The initial TVBN values of untreated fillet samples on day 0 (10.93mg N/100 g) is indicative of freshness of raw fish material and is in agreement with the relatively low initial TMAN content. This value is in good agreement with that of Metin *et al.* (2001), who reported that the initial TVBN content in raw chub mackerel was 9.96 mg N/100g. Similar TVBN value was reported for fresh hake:10.44 mg N/100 g (Ruiz-Capillas *et al.* 2001b).

As results show, the TVBN level increased gradually with time of storage till the end of storage period. TVBN increase is expected because it

Table 4. ***Changes in Total volatile basic nitrogen (TVBN), Trimethylamine nitrogen (TMAN)*** **and** ***Thiobarbituric acid (TBA) values of different treated fillets of smoked grass carp (Ctenopharyngodon idella) during storage at 2±1ºC for 30 days.***

parameter	treatments	Storage time (days)					
		0	6	12	18	24	30
TVBN mg/100g.	A	9.20± 0.03^{ab}	10.6± 0.0^{4c}	13.9± 0.3^{c}	17.3± 0.3^{c}	20.4± 0.5^{c}	22.9± 0.5^{c}
	B	9.70± 0.03^{a}	12.8± 0.05^{b}	17.4± 0.5^{b}	22.0± 0.6^{b}	26.5± 0.5^{b}	32.5± 0.6^{b}
	C	10.20± 0.04^{a}	15.3± 0.03^{a}	27.1± 0.5^{a}	32.4± 0.5^{a}	38.6± 0.5^{a}	44.3± 0.7^{a}
TMAN mg/100g.	A	1.13± 0.01^{a}	3.01± 0.02^{c}	4.43± 0.2^{c}	6.44± 0.3^{c}	8.53± 0.3^{c}	10.57± 0.3^{c}
	B	1.23± 0.02^{a}	4.20± 0.03^{b}	7.63± 0.3^{b}	10.04± 0.3^{b}	14.52± 0.4^{b}	16.46± 0.5^{b}
	C	1.43± 0.03^{a}	6.37± 0.02^{a}	15.79± 0.3^{a}	17.79± 0.4^{a}	20.30± 0.4^{a}	22.80± 0.5^{a}
TBA mg malondialdehyde /kg.	A	0.13± 0.01^{a}	0.46± 0.01^{ab}	0.85± 0.1^{ab}	1.00± 0.2^{b}	1.29± 0.2^{b}	1.72± 0.1^{b}
	B	0.13± 0.01^{a}	0.73± 0.02^{a}	1.05± 0.2^{a}	1.50± 0.1^{ab}	2.19± 0.2^{ab}	2.87± 0.2^{ab}
	C	0.13± 0.01^{a}	0.85± 0.01^{a}	1.36± 0.2^{a}	2.00± 0.2^{a}	2.76± 0.2^{a}	3.77± 0.3^{a}

(A) salted dried before smoked, (B) salted without dried before smoked and (C) unsalted dried before smoked.

$^{a-c}$ Means within a column with the same superscript significantly different (P<0.05).

Values are expressed as Mean ± SE.

is related to bacterial spoilage (Connell, 1990). This increase was higher in the salted without dried before smoked samples than in the salted dried before smoked and unsalted dried before smoke samples and can be attributed to the preservative effect of salt, dring and smoke. (Kolodziejska *et al.*, 2002).

The changes in the TVBN of grass carp fillets are given in Table 4. Mean values of TVBN obtained in the fish muscle were 9.30, 9.70 and 10.20 mg/100g. for (A), (B) and (C) samples, respectively, at zero time of storage period. While the TVBN content at the end of storage period were 22.9, 32.5 and 44.3 mg/100g. for(A), (B) and (C) samples, respectively. The above

results are in agreement with those reported by (Plahar *et al.* 1999). Various authors have reported different acceptability levels for TVBN value: 35–40 mg N/100 g (Connell, 1990) 25–30 mg N/100 g (Lopez-Caballero *et al.* 2000); 20–25 mg N/100 g (Kim; *et al.* 2002). Such differences reflect different products, specific treatments and processing conditions.

Trimethylamine (TMA)

Trimethylamine (TMA) values of smoked grass carp fillets are presented in Table 4. The levels of TMA depend on species, age, time of year, muscle type and diet of fish Reddy *et al.*, 1997 TMA is produced from trimethylamine oxide(TMAO) possibly partly by the action of intrinsic enzymes but certainly through bacterial action (Connell,1990).

Maga (1978) reported that, perfectly fresh fish had 3.37 mg./100 g. of TMA, good grade fish showed 3.79-5.90 mg./100 g., fair fish had 12.65-16.02 mg./100 g. while spoiled fish contained as high as 59.01 mg./100 g.

In general, the TMA content of unsalted dried fillets samples before smoke, was higher than TMA content of salted dried before smoke and salted without drying before smoke samples. This observation is in complete agreement with results reported by Hansen *et al.* (1995) and Leroi and Joffraud (2000a). After 30 days of storage the highest TMA value was recorded in the unsalted smoked samples with drying (22.80 mg N/100 g) while the lowest TMA value was recorded in the salted smoked with dried and salted smoked without dried samples being 10.57 and 16.46 mg N/100 g respectively. These TMA results correlate well with those reported by Hansen *et al.* (1995).

Thiobarbituric acid (TBA) values

TBA values for grass carp are presented in Table 4. The initial TBA value of grass carp was 0.13 mg malondialdehyde /kg. after the smoking process respectively. The increase in TBA value during the smoking procedure may be attributed to the partial dehydration of fish and to the increased oxidation of unsaturated fatty acids as a result of smoking at relatively high temperatures (up to 60 °C). This observation is in agreement with results reported by Goktepe and Moody (1998) who observed a two fold increase in TBA value of raw catfish after smoking (smoke temperature up to 82°C). Final TBA values of grass carp were 1.72, 2.87

and 3.77 mg malondialdehyde /kg for (A), (B) and (C) samples, respectively. For smoked fish did not exceed the value of 1–3 mg malondialdehyde /kg which is usually regarded as the limit beyond which the fish will normally develop an objection able dour/taste (Connell, 1990).

This fact can be attributed to the antioxidant activity of phenolic constituents of smoke deposited onto the fish during the smoking process. As can be seen in Table 6, there is a trend towards an increase in TBA values up to a certain point during the storage period; followed by either, a decrease in the revalues or a lower increase rate. Given that TBA index is a measure of malondialdehyde which is an end-product of lipid oxidation decrease in malondialdehyde content may be caused by interaction between malondialdehyde and proteins, amino acids, glycogen, etc. Fernandez *et al.,* 1997; Gomes *et al.,* (2003). This observation suggests that in chilled fish products rancidity does not depend only on the amount of oxygen in the package but also on the type of microbial flora present. This observation is in agreement with results reported by other authors Curzio and Quaranta, 1982; Fernandez *et al.,* 1997; Gomes *et al.,* (2003).

Total bacterial count (TBC)

(Log_{10} CFU/g) of grass carp (*Ctenopharyngodon idella*) fillets samples, salted dried before smoked(A), salted without dried before smoked (B) and unsalted dried before smoked (C) fillets are given in Table 5. Mean (TBC) values 2.40, 3.37 and 3.41 Log_{10} CFU/g rerecorded for, (A), (B) and (C) smoked samples, respectively at zero time of storage period. While the (TBC) at the end of storage period were 5.02, 6.50 and 7.80 respectively.

On the other hand the lower content of Psychrophilic bacterial count (Log_{10} CFU/g) was found in the salted dried before smoked versus the smoked samples. Mean values of Psychrophilic bacterial count content obtained in the fish muscle were 0.3, 1.31 and 1.57 Log_{10} CFU/g for smoked samples, respectively at zero time of storage period. While at the end of storage period were 2.64, 4.15 and 6.37 Log_{10} CFU/g for (A), (B) and (C) smoked samples, respectively.

The changes in the Halophilic bacterial count H.B.C. (Log_{10} CFU/g) of smoked grass carp fillets are given in Table 5. Mean values of H.B.C.

Table 5. ***Changes in Total bacterial, Psychrophilic bacterial and Halophilic bacterial count (Log10 CFU/g) of different treated fillets of smoked grass carp (Ctenopharyngodon idella) during storage at 2±1ºC for 30 days.***

parameter	treatments	Storage time (days)					
		0	6	12	18	24	30
Total bacterial count	A	2.40± 0.02^{ab}	2.80± 0.01^{b}	3.71± 0.01^{c}	3.83± 0.02^{c}	4.22± 0.02^{c}	5.02± 0.03^{c}
	B	3.37± 0.02^{a}	3.91± 0.02^{ab}	4.43± 0.02^{b}	4.90± 0.02^{b}	6.07± 0.01^{b}	6.50± 0.01^{b}
	C	3.41± 0.03^{a}	4.79± 0.01^{a}	5.90± 0.02^{a}	6.40± 0.02^{a}	6.90± 0.03^{a}	7.80± 0.03^{a}
Psychrophilic bacterial count	A	0.30± 0.01^{b}	0.70± 0.01^{c}	1.01± 0.02^{c}	1.62± 0.02^{c}	2.12± 0.01^{c}	2.64± 0.01^{c}
	B	1.31± 0.01^{a}	1.81± 0.01^{b}	2.33± 0.01^{b}	3.37± 0.02^{b}	4.00± 0.02^{b}	4.15± 0.02^{b}
	C	1.57± 0.02^{a}	2.99± 0.02^{a}	4.11± 0.02^{a}	5.09± 0.03^{a}	5.71± 0.03^{a}	6.37± 0.02^{a}
Halophilic bacterial count	A	2.12± 0.02^{a}	2.26± 0.01^{ab}	2.41± 0.01^{a}	2.57± 0.01^{a}	2.75± 0.02^{a}	2.92± 0.02^{a}
	B	2.12± 0.03^{a}	2.27± 0.01^{a}	2.44± 0.01^{a}	2.63± 0.02^{a}	2.86± 0.02^{a}	3.13± 0.02^{a}
	C	1.89± 0.02^{a}	1.79± 0.02^{b}	1.69± 0.02^{b}	1.60± 0.02^{b}	1.47± 0.02^{b}	1.35± 0.02^{b}

(***A) salted dried before smoked, (B) salted without dried before smoked and (C) unsalted dried before smoked.***

$^{a-c}$ ***Means within a column with the same superscript significantly different (P<0.05).***

Values are expressed as Mean ± SE.

obtained in the fish muscle were 2.12, 2.12 and 1.89 Log_{10} CFU/g for (A), (B) and (C) samples, respectively, at zero time of storage period. While the H.B.C. at the end of storage period were 2.92, 3.13 and 1.35 Log_{10} CFU/g for (A), (B) and (C) samples, respectively. From the abovementioned results, it may be concluded that, there are slow significant differences between treatments of smoked grass carp fillets during storage at (2±1 ºC), The highest level of HBC was observed in the fillets salted after 48 hours, these results may be due to the water activity which was more suitable for growth of most halophilic bacteria. Moreover, the growth of extremely halophilic bacteria might have been

initiated by the high salt concentrations in the products. Herrero *et al.,* (1999).

Sensory evaluation

The results of the sensory evaluation of grass carp samples are given in Table 6. As can be seen, the smoked samples were scored as excellent or very good throughout the entire storage period. The mean score for taste of smoked samples were 9.3, 9.3 and 9.1 for (A), (B) and (C) samples, respectively, at the beginning of storage. After 30 days of storage the mean score for taste of smoked samples were 5.9, 5.2 and 4.4 respectively.

The corresponding values for odour of smoked samples were 9.5, 9.5 and 9.2 for (A), (B) and (C) samples, respectively, at the beginning of storage. After 30 days of storage the mean score for odour of smoked samples were 6.0, 5.3 and 4.5 respectively,

As a matte of fact the smoked samples were scored as excellent or very good throughout the entire storage period. The mean score for texture of smoked samples were 9.1, 9.1 and 9.1 for (A), (B) and (C) samples, respectively respectively, at the beginning of storage. After 30 days of storage the mean score for taste of smoked samples were 6.1, 5.2 and 4.9 respectively.

The corresponding values for colour of smoked samples were 9.5, 9.5 and 9.1 for (A), (B) and (C) samples, respectively, at the beginning of storage. After 30 days of storage the mean score for colour of smoked samples were 6.3, 5.0 and 4.7 respectively.

Similar sensory characteristics of smoked samples may be attributed to the adequate cooking provided by the smoking process used. In general as time of storage progressed, the sensory properties of salted smoked with dried received a higher score than samples salted without dried before smoked and unsalted dried before smoked. This may be attributed to the fish/smoke higher contacting time and temperature.

As the results in Table 6 show, there is a good correlation between sensory scores and chemical indices of quality determined. Odour and texture proved to be the most sensitive of the sensory properties evaluated. Based on present data the shelf life of salted dried before smoked, was 30 days and shelf life of salted without drying before smoked fillets was 24 days

Table 6. ***Changes in taste, ouder, texture and color of different treated fillets of smoked grass carp (Ctenopharyngodon idella) during storage at 2±1ºC for 30 days.***

parameter	treatments	Storage time (days)					
		0	6	12	18	24	30
Taste	A	9.3± 0.05^{a}	8.8± 0.05^{a}	8.0± 0.04^{a}	7.4± 0.04^{a}	7.0± 0.03^{a}	5.9± 0.03^{a}
	B	9.3± 0.04^{a}	8.5± 0.04^{a}	7.8± 0.05^{ab}	7.2± 0.04^{ab}	6.5± 0.04^{ab}	5.2± 0.04^{ab}
	C	9.1± 0.04^{a}	8.1± 0.05^{ab}	7.6± 0.05^{ab}	7.0± 0.05^{ab}	6.0± 0.04^{b}	4.4± 0.04^{b}
Ouder	A	9.5± 0.06^{a}	8.9± 0.06^{a}	8.1± 0.06^{a}	7.5± 0.05^{a}	7.0± 0.05^{a}	6.0± 0.04^{a}
	B	9.5± 0.05^{a}	8.6± 0.04^{a}	7.9± 0.04^{ab}	7.3± 0.05^{ab}	6.6± 0.04^{ab}	5.3± 0.04^{b}
	C	9.2± 0.04^{ab}	8.2± 0.04^{ab}	7.7± 0.03^{ab}	6.9± 0.03^{b}	5.9± 0.03^{b}	4.5± 0.05^{c}
Texture	A	9.1± 0.04^{a}	8.9± 0.04^{a}	8.4± 0.03^{a}	7.8± 0.03^{a}	7.0± 0.03^{a}	6.1± 0.02^{a}
	B	9.1± 0.04^{a}	8.7± 0.03^{a}	8.0± 0.03^{ab}	7.1± 0.04^{ab}	6.1± 0.03^{b}	5.2± 0.03^{b}
	C	9.1± 0.03^{a}	8.3± 0.03^{ab}	7.0± 0.02^{b}	6.1± 0.02^{b}	5.1± 0.02^{c}	4.9± 0.02^{c}
Color	A	9.5± 0.06^{a}	9.2± 0.06^{a}	8.3± 0.05^{a}	7.4± 0.05^{a}	7.0± 0.04^{a}	6.3± 0.03^{a}
	B	9.5± 0.05^{a}	8.6± 0.05^{ab}	7.6± 0.04^{b}	6.6± 0.04^{b}	6.0± 0.03^{b}	5.0± 0.03^{b}
	C	9.1± 0.03^{a}	8.0± 0.03^{b}	7.2± 0.04^{c}	6.4± 0.04^{b}	5.6± 0.03b^{c}	4.7± 0.02b^{c}

(***A) salted dried before smoked, (B) salted without dried before smoked and (C) unsalted dried before smoked.***

$^{a-c}$ ***Means within a column with the same superscript significantly different (P<0.05). Values are expressed as Mean ± SE.***

while the unsalted dried before smoked fillets was18 days.

The present results indicate that, the application of salted smoked with dried, salted smoked without dried and unsalted smoked with dried resulted in a product with more distinct smoked odour, taste and colour which were retained throughout the 30 day storage

period of the study. Both smoking methods produced good quality grass carp products for the entire storage period. In general smoking produced products with better sensory characteristics while no significant differences were observed in the biochemical indices between samples.

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التغيرات فى خواص جودة فيليه مبروك الحشائش المدخن خلال التخزين بالتبريد

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تم دراسة تأثير التمليح والتجفيف قبل التدخين على خواص جودة فيليه اسماك مبروك الحشائش عند تخزينه لمدة 30 يوم وقد لوحظ ان تقييم خواص الجودة يعتمد اساسا على الدلائل الكيميائية والميكروبيولوجية والحسية للعينات المدخنة خلال فترة التخزين والتى تبلغ 30 يوم على درجة حرارة 1±2°م وقد اظهرت النتائج ان الدلائل الكيميائية للفيليه المملح المجفف قبل التدخين و الفيليه المملح الغيرمجفف قبل التدخين تزيد خلال فترة التخزين ومستوياتها منخفضة مقارنة بالخواص والدلائل الكيميائية للفيليه الغيرمملح والمجفف قبل التدخين وقد لوحظ ان خواص الجودة الحسية للفيليه الغير مملح المجفف قبل التدخين تقل خلال فترة التخزين والتى تبلغ 30 يوم على درجة حرارة 1±2°م ولكن لوحظ اختلاف طفيف بين الفيليه المملح المجفف قبل التدخين و الفيليه المملح الغيرمجفف قبل التدخين والانخفاض المعنوى كان واضحا فى الخواص الكيميائية والميكروبيولوجية والحسية للفيليه الغيرمملح والمجفف قبل التدخين خلال فترة التخزين والتى تبلغ 30 يوم على درجة حرارة 1±2°م