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EFFECT OF SMOKING MATERIALS AND STORAGE PERIOD ON CHEMICAL AND MICROBIOLOGICAL CHANGES IN COLD SMOKED HERRING FISH

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ABSTRACT

Fish was recognized as a food necessary for good health, especially for brain, so it is called brain food. Unfortunately, fresh fish an extremely perishable food and deteriorates very rapidly after being caught at normal temperatures. Changes occure in its composition and structure due to chemical, physical, enzymatic and bacterial influence. Therefore, this work was planned to evaluate the effect of smoking materials and storage period on the shelf-life of cold-smoked herring fish *(Clupea harengus)* stored at 4°C(refrigeration) for 8 weeks and at -20°C (freezing) for 5 months. Throughout cold or frozen storage periods, moisture and protein contents of cold smoked herring fish were gradually decreased, while fat was increased either under Sweden or corn cobs sawdust smoking. Ash content was nearly stable under both storage and smoking matrials conditions. Salt, trimethylamine nitrogen (TMAN) and thiobarbituric acid (TBA) contents in cold smoked fish were gradually increased throughout storage period. The increase in salt content was higher under frozen storage and Sweden sawdust smoking. The increase in TMAN and TBA contents followed opposite trends. The Sweden sawdust material was better than corn cobs sawdust for smoking herring fish. Cold smoked herring fish can be safely stored under refrigeration and freezing conditions for over 30 days and 5 months, respectively.

Keywords: Cold-somking , herring fish , salting , biochemical analysis , smoking materials , microbiological changes .

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INTRODUCTION

Smoke 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', alcohols, acids, hydrocarbons, esters, phenols, ethers, etc. (Doe, 1998 and Guillen and Errecalde, 2002). These components are transferred to the smoked foods by deposition on their surface and subsequent penetration into their flesh (Doe, 1998). Smoking imparts a characteristic flavor and color to the fish and 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 and phenols (Horner, 1997;Doe, 1998; Leroi and Joffraud, 2000 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 decreasing water activity (a_w) and thus prevention growth of many spoilage microorganisms along with the formation of a more membranous surface which further inhibits the growth of microorganisms (Horner, 1997; Leroi and Joffraud, 2000 and Rorvik, 2000). Moreover, chloride ions are toxic for some microorganisms (Leroi *et al.*, 2000). There are three methods used to smoke fish: the traditional method by combustion, at either low temperature (cold smoking $\leq$ 30 °C) or high temperature (hot smoking $\geq$ 60°C); use of a high voltage electrostatic field which accelerates smoke deposition, and use of liquid smoke which lowers the content of polynuclear aromatic hydrocarbons (potently carcinogenic compounds) in liquid smoked fish (Doe, 1998; Duffes, 1999; Espe. *et al.* , 2002; Hattula *et al.*, 2001and Sigurgisladottir, *et al.*, 2000). Many factors influence the quality of smoked fish products including the properties of the fish flesh, maturity, age, seasonal variations and factors involved in the smoking procedure such as type of wood, composition of the smoke, temperature, humidity, velocity and density of the smoke.The composition of compounds produced during the

smoking process depends on the amount of oxygen supplied for combustion, the temperature in the fire zone, the type of wood burned, and the moisture content of the wood. Specific volatile compounds in particular phenolic compounds have been related to the different smoking techniques which directly influence the sensory characteristics of smoked salmon (Cardinal *et al.,* 1997) and in herring (Cardinal *et al.,* 2006).

The objective of the present work was to study the effects of smoking materials (Sweden and corn cobs sawdust) and storage period on herring fish quality as assessed by determination of some biochemical and microbiological indices.

MATERIALS AND METHODS

Materials

About (60 kg) of frozen Herring fish (*Clupea harengus*) were obtained from Misr – Aswan Company (Swana) for Fishing and Fish Processing in Tenth of Ramadan City, Egypt during (March, 2010). The company imported this kind of frozen fish from Norway and stored it at - 20° C. The average weight of one fish was about 200 gm.

Methods

Salting fish samples

Fish samples were processed at Misr – Aswan Company for Fishing and Fish Processing in Tenth of Ramadan City, Egypt.

All samples were mixed with dry sodium chloride for salting (10% salt of fish weight) as dry salting for 3 hours at room temperature. Thereafter, the salted fish were rinsed by tap water to remove the excess salt, then kept on net shelves and allowed to drain over night inside a chill room.

Smoking the salted fish samples

The salted fish samples were cold smoked using Sweden and corn cubs sawdust at 30°C for 12 hours, after that the process was continued without somke for 1 hour at 50°C according to (Hassab Alla, 1997). After the smoking process, the fish samples were removed from the smoking cabinets and put in chilling chambers with force air circulation. The temperature of fish samples was decreased to 3°C through 24 hours. The packaged

smoked fish were put in cartone board boxed and transported to Food Science laboratories, Agriculture Collage, Zagazig University.

Storage

Smoked fish samples were divided into two lots: The first was stored in a refrigerator at 4 ± 1° C throughout the whole period of storage (2 moths). The second lot was stored in deep freezer at – 20°C throughout the whole period of storage (5 mothes).

Fish samples were analyzed at zero time, and at 15 and 30 days intervals during cold storage (for 60 day) and frozen storage (for 5 months), respectively for chemical, microbiological evaluation.

Analytical Methods

Chemical determinations

The fish samples were minced by lab. Braun mincer and well mixed for analysis. Moisture, crude protein, crude fat , ash , and sodium chloride were determined as described in the A.O.A.C. (2005). Also, the total soluble nitrogen was extracted according to the method mentioned by El-Gharabawi and Dugan (1968). The obtained extract was used for the determination of total soluble nitrogen using Micro-Kjeldahl methods as recommended in A.O.A.C. (2005).The soluble non-protein nitrogen was determined by Micro-Kjeldahl method according to Kline and Stewart (1949). The soluble protein nitrogen was calculated by substraction from the total soluble nitrogen of each sample.

Also, total volatile bases nitrogen was determined according to Goulas, and Kontominas (2005). The quantity of TVBN in mg/100 g of fish flesh was calculated from the volume (V) of hydrochloric acid added and its concentration (C) . Meantime , tri-methylamine nitrogen was determined according to Goulas and Kontominas (2005) . The amount of TMAN in mg/100 g of fish flesh was calculated from the volume (V) of hydrochloric acid added. Thiobarbituric acid value was determined according to the method described by Kirk and Sawyer (1991). Again, the TBA value was calculated by multiplying the absorbance (A) by the factor (7.8) , the results represented as mg of malonaldehyde / kg sample.

To estimate pH value, 10 g sample of the fish flesh was homogenised in 100 ml of distilled

water and the mixture was filtered .The pH value of filtrate was measured using digital pH meter (JENCO-Model 5005) according to Goulas and Kontominas (2005). The phenolic compounds in smoked fish samples as mg phenol/ 100 gm sample were determined according to the method of Chan *et al.* (1975).

Microbiological examinations

A homogenate dispersion of fish sample into a sterilized physiological solution (8.5 gm NaCl/liter distilled water) was prepared for bacteriological determinations. It was prepared by mixing 25 gm of grounded representative fish sample in a sterilized blender jar with 90 ml of the above solution, and then blended until a homogenate suspension was obtained. This provides a dilution of 10^{-1}. One ml from this 1 x 10^{-1} was pipetted into sterilized separate tubes containing 9 ml of dilution of 10^{-2}. The last step was repeated until the required numbers of dilutions were made. Each successive dilution will decrease the concentration ten folds.

Total bacterial count per one gram fish samples were enumerated on plate count agar medium, the plates incubated at 30°C for 3 days as the method described by APHA (1992).

Mold and yeast counts were estimated using potato dextrose agar medium, the plates were incubated at 25° C for 5 days according to the method described by APHA (1992) .

The coliform group bacteria was counted according to the method described in APHA (1992) using MaConky agar medium after that the plates were incubated at 37°C for 24 hours.

Psychrophilic bacteria were counted on nutrient media according to APHA (1992), the plates were incubated at 5±1°C for 7 days.

RESULTS AND DISCUSSION

Changes in Chemical Composition of Smoked Fish (%) During Cold and Frozen Storage Condition as Affected by Smoking Materials

Tables 1 and 2 show the changes in moisture, protein, lipid and ash contents(%) of smoked herring fish as affected by smoking materials and storage temperatures. Data

clears that, the moisture content of smoked herring fish was decreased during storage period either under cold storage at (4 ± 1°C) or frozen storage (-20°C).

The loss of moisture content in cold storage at (4 ± 1° C) for 60 days was 1.95 and 1.81 under Sweden and corn cobs sawdust smoking, respectively .The corresponding values for frozen storage at -20° C for 5 months were 3.68 and 2.72, respectively .These results are similar to that found by Arafa-Fatma (2005), since she stated that during storage the moisture content of smoked herring were decreased and the percentage of loss were 1.20 and 1.94 of smoked herring.

Generally, it could be concluded that the moisture losses during storage were slightly decreased by lowering the storage temperature. Such decrease may be due to separation of some fluids from fish tissues (Gunnar *et al.*, 1980), or the continuous hydrolysis of protein and evaporation, as well as the decrease occurred in water holding capacity (El – Akel, 1988) .

As for the changes in protein content, the same results in Tables 1 and 2 declare some differences between total protein content of cold and frozen storages. The loss of crude protein in cold storage samples by the end of storage period was 2.25 and 3.33%, but in frozen storage conditions it was 2.17 and 2.27 % under Sweden and corn cobs sawdust smoking, respectively. This slight decrease in total protein during storage period might be attributed to the continuous hydrolysis of protein due to the enzymatic proteolysis which leads to the formation of simple nitrogenous compounds (El-Nemer *et al.*, 1995 and Zotos *et al.*, 1995).

As shown in Tables 1 and 2 fat content was slightly increased from 11.26 to 14.34 % and from 12.00 to 14.68 % in cold smoked samples (Table1), using Sweden and corn cobs sawdust smoking by the end of cold storage.While, at the end of frozen storage fat content was increase from 11.26 to 15.91 % and from 12.00 to 16.32 % in cold smoked samples by Sweden and corn cobs sawdust, respectively. This increase could be due to the slight decrease of the other components .This result was in agreement with Hassab Alla (1997).

The ash content of cold smoked samples were nearly stable during cold storage periods , since it was 4.04 , 4.50 % at zero time after smoking process, and became 4.65 and 4.77 % after 60 days for Sweden and corn cobs sawdust smoking, respectively. Under frozen storage conditions, the ash

Table 1. Changes in chemical composition of smoked fish (%) during cold storage as affected by smoking materials

Smoking material	Sweden sawdust				Corn cobs sawdust			
Storage period (week)	Moisture	Protein	Fat	Ash	Moisture	Protein	Fat	Ash
0	64.42	17.80	11.26	4.04	63.21	18.00	12.00	4.50
2	64.29	17.77	12.00	4.39	63.17	17.76	12.50	4.57
4	63.64	17.41	12.86	4.50	62.55	16.66	13.60	4.61
6	62.70	16.24	13.68	4.57	61.65	15.23	14.53	4.69
8	62.47	15.55	14.34	4.65	61.40	14.67	14.68	4.77

Table 2. Changes in chemical composition of smoked fish (%) during frozen storage as affected by smoking material

Smoking material	Sweden sawdust				Corn cobs sawdust			
Storage period (Month)	Moisture	Protein	Fat	Ash	Moisture	Protein	Fat	Ash
0	64.42	17.80	11.26	4.04	63.21	18.00	12.00	4.50
1	63.01	17.00	13.20	4.57	61.92	16.46	14.20	4.50
2	62.05	16.02	14.33	4.87	61.15	16.08	15.05	4.73
3	61.42	15.97	14.69	4.84	60.74	16.04	15.54	4.52
4	61.16	15.89	15.12	4.86	60.74	15.96	15.91	4.43
5	60.74	15.96	15.91	4.43	60.49	15.73	16.32	4.52

content was 4.04 and 4.50 at zero time and reached 4.43 and 4.52 % after 5 months for Sweden and corn cobs sawdust smoking, respectively .This means that there were a slight increase in ash content in both storage condition. These results are in agreement with those of El –Akel (1988), Abd El-Mageed (1994) , Hegazy (1998) and Ibrahim (1999). They found that ash content of Atlantic mackerel tissues was markedly increased during storage, and this increase might be due to increase of sodium chloride content and decrease in both moisture and protein contents.

As a whole, throughout cold or frozen storage periods, moisture and protein contents of cold smoked fish were gradually decreased , while fat was increased either under Sweden or corn cobs sawdust smoking. Ash content was nearly stable under both storage and smoking materials conditions.

Changes in Some Chemical Quality Attributes of Cold Smoked Fish under Cold and Frozen Storage Conditions as Affected by Smoking Materials

Changes in total volatile basic nitrogen (TVBN)

Total volatile basic nitrogen (TVBN) values for herring smoked fish are presented in Tables (3 and 4). The initial TVBN values at zero time were 17.16 and 17.22 mg N/100 g and reached 32.20 and 36.40 mg N/100 g after 60 days at cold storage under Sweden and corn cobs sawdust smoking, respectively. While the corresponding values under frozen storage conditions were 41.30 and 43.40 mg N/100 g for the same samples, respectively. It is worthly to notice that TVBN values at the end of the storage period reached more than 2 folds its initial values at zero time under cold or frozen storage with the superiority to frozen storage. Total volatile basic nitrogen (TVBN) increase was expected mainly because it is related to bacterial spoilage (Connell, 1990). Various authors reported different acceptability levels for TVBN value ranging from 35–40 mg N/100 g (Connell, 1990) ; 25–30 mg N/100 g (Lopez-Caballero *et al.*, 2000) and 20–25 mg N/100 g (Kim *et al.*, 2002). Such difference reflects different products, specific treatments and processing conditions.

Changes in trimethylamine nitrogen (TMAN)

Data in Tabels 3 and 4 declares that TMAN values were gradually increased throughout storage period from 2.44 and 2.74 mgN / 100 g at zero time to 5.49 and 5.88 mg N / 100g and 3.78 and 4.17

4.17 mgN/100g by the end of cold and frozen storage periods under Sweden and corn cobs sawdust smoking, respectively. This increase was higher under cold storage and corn cobs sawdust smoking than frozen storage and Sweden sawdust smoking. By the end of cold storage, TMAN content in cold smoked fish was 100.36 and 140.98 % higher than its content at zero time under Sweden and corn cobs smoking, respectively. The corresponding increasing percentages under frozen storage were 37.96 and 70.90%, respectively.

According to Connell (1990), a value of 1.5 mg TMAN /100 g of product has been recommended as an upper limit for very good quality of cod. Levels of TMAN depends on fish species, age, time of year, muscle type and diet of fish (Reddy *et al.*, 1997; Rodriguez, *et al.*, 1999). Trimethylamine nitrogen is produced from trimethylamine oxide (TMAO) possibly partly by the action of intrinsic enzymes, but certainly through bacterial action (Connell, 1990 and Rodriguez *et al.*, 1999).These results are nearly in agreement with those found by Goulas and Kontominas (2005).

Changes in protein fractions

The obtained results of protein fractions are shown in Tables (3 and 4) .Generally, there was a direct relationship between storage time and changes occurred in protein fractions at cold and frozen storages. At zero time, total soluble nitrogen (TSN) in all cold smoked samples were 2.69 and 2.61 %, while at the end of storage period it reached 4.29 and 4.17%during cold storage and 4.78 and 4.87% during frozen storage, in case of Sweden and corn cobs sawdust, respectively. This increase in TSN might be due to dehydration of smoked fish samples during storage as explained by (Sulieman , 1993 and Hassab Alla , 1997) . The same trend was detected with soluble protein nitrogen (SPN) and soluble non protein nitrogen (SNPN) as shown in Tables (3 and 4). The SPN and SNPN were increased gradually in smoked fish during storage. The SPN in cold storage after 60 days were 3.00 and 3.08 under Sweden and corn cobs sawdust smoking, respectively, while in frozen storage after 5months it were 3.36% and 3.52%, respectively. The corresponding values of SNPN were 1.17% and

1.21% under cold storage and 1.42% and 1.35% under frozen storage, respectively.

Generally, the increase of the mentioned SPN in all smoked fish samples may be due to the degradation of protein fractions during storage. These results are in agreement with those reported by Hassab Alla (1997), who stated that there was a direct relationship between storage time and changes occurred in protein fractions at cold storage.

Changes in salt content

The changes in salt content in cold smoked fish was showed in Tables (3 and 4) under cold and frozen storage conditions. The obtained data cleared that sodium chloride content tended to increase in all stored samples. This increase was more pronounced under frozen storage than cold storage. So, salt content in cold smoked fish by the end of cold storage period was 18.67 and 26.75% higher than its content at zero time under corn cobs and Sweden sawdust smoking conditions, respectively. The corresponding increasing percentages by the end of frozen storage were 45.10 and 59.11%, respectively, under smoking with Sweden sawdust than with corn cobs sawdust. These results are in accordance to those given by Arafa- Fatma (2005), since she attributed this change in salt content to the loss of both volatile substances and moisture during storage.

Even though salting effectively prevents the growth of both spoilage and pathogenic bacteria (Doe, 1998 and Leroi *et al.*, 2000). Moreover, Aubourg and Ugliano, 2002 reported that salt content in fish muscle enhances oxidation of the highly unsaturated lipids.

Changes in phenolic compounds

Tables 3 and 4 show the changes in phenolic compounds during storage of smoked fish under cold and frozen storage conditions. The phenol concentration at zero time under cold storage conditions were 89.42 and 70.33 mg/100g for Sweden and corn cobs sawdust smoked fish , while at the end of storage period it decreased to 67.66 and 50.12 mg/100g ,respectively . Also, phenol concentration by the end of frozen storage period were 61.34 and 43.18 mg/100g for Sweden and corn cobs sawdust, respectively. It could be observed that during storage, their was a continuous

decrease in phenolic compounds either under cold or frozen storage conditions. The decreasing rate of phenolic compounds was higher for cold storage samples than those of frozen storage.

Recent studies performed on phenolic compounds (Se´rot *et al.*, 2004) showed that deposition of phenolic compounds depends on the smoking conditions which play a key role in smoke perception. The loss in phenolic compounds could be attributed to the reaction between phenolic compounds and other chemical constituents (Sulieman, 1993 and Hassab Alla, 1997).

Changes in pH value

As shown in Tables (3and4), pH value of fish samples remained constant to somewhat during cold storage until 30 days, followed by an increase during the last two periods of cold storage. Under frozen storage conditions, pH values increased slightly, since it was 6.31 and 6.39 at zero time in Sweden and corn cobs sawdust smoking and reached to 6.65 and 7.17 by the end of storage period, respectively.

The increase of pH values 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 and Ruiz-Capillas and Moral, 2001).

Changes in thiobarbituric acid (TBA)

Thiobarbituric acid value used for the evaluation of lipid quality. The obtained results in Tables (3 and 4) revealed that the TBA values of cold smoked fish were increased during cold (by 55.32 and 98.29%) and frozen storage (by 89.36 and 141.88%) for all samples under Sweden and corn cobs sawdust smoking, respectively. This means that the increase in TBA value was higher under frozen storage and corn cobs sawdust smoking as compared with cold storage and Sweden sawdust. The increase in TBA value during the smoking procedure may be attributed to the partial dehydration of fish and the increased oxidation of unsaturated fatty acids as a result of smoking at relatively high temperatures (up to 70° C). This result is in agreement with those reported by Goktepe and Moody (1998) who observed two fold increase in TBA value of raw catfish after smoking (at 82°C).

Table 3. Changes in some chemical quality attributes of cold smoked fish under cold storage conditions as affected by smoking materials

Smoking material	Item	Storage Period (Week)				
		0	2	4	6	8
Sweden sawdust	TVBN(mg/100g)	17.16	17.50	19.60	25.80	32.20
	TMAN (mg/100g)	2.44	2.80	3.43	5.355	5.495
	TSN (%)	2.61	2.85	2.99	3.84	4.17
	NSPN (%)	0.83	0.85	1.03	1.00	1.17
	SPN (%)	1.78	1.99	1.96	2.84	3.00
	Salt Cont (%)	12.3	13.10	13.68	14.90	15.59
	Phenol Cont.(mg/100g)	89.42	86.54	74.52	70.09	67.66
	PH Value	6.31	6.415	6.31	6.5	6.65
	TBA (mg /kg)	1.41	1.69	1.73	1.84	2.19
Corn cobs sawdust	TVBN (mg/100g)	17.22	17.50	21.70	30.80	36.40
	TMAN (mg/100g)	2.74	2.87	5.25	5.71	5.88
	TSN (%)	2.69	2.94	3.27	3.75	4.29
	NSPN (%)	0.85	0.88	1.06	1.03	1.21
	SPN (%)	1.84	2.06	2.21	2.72	3.08
	Salt Cont (%)	12.75	13.49	14.07	14.48	15.13
	PhenolCont. (mg/100g)	70.33	67.81	55.78	51.50	50.12
	PH Value	6.39	6.52	6.48	6.70	7.17
	TBA (mg /kg)	1.17	1.47	1.57	1.90	2.32

Table 4. Changes in some chemical quality attributes of cold smoked fish under frozen storage conditions as affected by smoking materials

Smoking Material	Item	Storage Period (Months)					
		0	1	2	3	4	5
Sweden sawdust	TVBN (mg/100g)	17.16	18.20	21.00	23.80	32.90	41.30
	TMAN (mg/100g)	2.74	3.18	3.40	3.67	3.74	3.78
	TSN (%)	2.61	3.12	3.42	3.95	4.27	4.78
	NSPN (%)	0.83	1.01	1.08	1.17	1.34	1.42
	SPN (%)	1.78	2.11	2.34	2.78	2.94	3.36
	Salt Cont (%)	12.30	15.02	16.96	17.60	18.19	19.57
	PhenolCont. (mg/100g)	89.42	83.41	80.32	77.23	70.37	61.34
	PH Value	6.31	6.48	6.46	6.66	6.92	6.91
	TBA (mg /kg)	1.41	1.32	1.64	1.92	2.29	2.67
Corn cobs sawdust	TVBN (mg/100g)	17.22	18.20	23.10	27.30	36.40	43.40
	TMAN (mg/100g)	2.44	3.57	4.06	4.10	4.13	4.17
	TSN (%)	2.69	3.22	3.50	3.85	4.17	4.87
	NSPN (%)	0.85	0.95	1.01	1.19	1.27	1.35
	SPN (%)	1.84	2.27	2.49	2.66	2.90	3.52
	Salt Cont (%)	12.75	14.62	15.83	17.26	17.89	18.50
	Pheno Cont.(mg/100g)	70.33	64.46	62.15	59.07	52.21	43.18
	PH Value	6.39	6.53	6.52	6.72	6.91	6.95
	TBA (mg /kg)	1.17	1.47	1.81	2.08	2.43	2.83

The Effect of Smoking Materials and Storage on the Microbial Content of Herring Fish

The total bacterial count, coliform group, yeast and moulds and psychrophilic bacteria were determined during storage period under cold and .frozen storage conditions. The results are shown in Tables (5and 6). The tabulated data showed that there was a grdual increase in total bacteria count during the first 30 days in cold storage samples, followed by sharp increase until 60 days. It was to 3.1×10^4 after 8 weeks and 3.6×10^4 after 5 months, respectively. These findings are in agreement with those stated by Magnusson and Martinsdottir,(1995) and Arafa- Fatma, (2005) .

The total bacterial count in frozen storage samples were less than those in cold storage, due mainly to the lower freezing temperature. These results are in agreement with those reported by the Dillon and Patel (1993).

The coliform group were detected in herring smoked fish stored at refrigation. It was 0.5×10^2, 0.8×10^2 at zero time, and reached to 7.2×10^2, 7.7×10^2 under Sweden and corn cobs sawdust smoking, respectively, and not detected under frozen storage conditions. The same results were found in psychrophilic bacteria, since it did not found under frozen storage condition.

The moulds and yeast counts were appeared on cold storage samples only, since they were 0.4×10^2 at zero time to reach to 3.4×10^2 after 60 days. Ibrahim (1999) noticed that, after cold smoking moulds counts were lowered in cured herring, mainly due to the effect of components of curing solution, besides smoke compounds penetrated into herring tissues.

Smoked fish constitute a significant part of the human diet, mainly because of their desirable sensory properties, high nutritional value and abundance in fatty species, of lipid rich in η - 3 fatty acid residues. The Sweden sawdust material was better than corn cobs sawdust for smoking herring fish. Cold smoked herring fish can be safely stored under refrigeration and freezing conditions for over 30 days and 5 months, respectively.

Table 5. Changes in some microbial determinations (cfu/ g) of cold smoked fish under cold storage conditions as affected by smoking materials

Smoking material	Microorganisms	Storage Period (week)				
		0	2	4	6	8
Sweden sawdust	Total bacterial count	1.4×10^3	2.1×10^3	3.2×10^3	4.7×10^5	3.1×10^6
	Coliform bacteria	0.5×10^2	0.9×10^2	1.1×10^2	2.5×10^2	7.2×10^2
	Psyshrophilic	0.9×10^2	1.3×10^2	1.6×10^2	2.0×10^2	5.5×10^2
	Mold & yeasts	0.4×10^2	0.8×10^2	1.3×10^2	1.9×10^2	3.4×10^2
Corn cobs sawdust	Total bacterial count	1.6×10^3	3.0×10^3	4.3×10^3	5.3×10^5	3.3×10^6
	Coliform bacteria	0.8×10^2	1.0×10^3	1.6×10^3	2.9×10^3	7.7×10^3
	Psyshrophilic	0.9×10^2	1.5×10^3	1.8×10^3	2.3×10^3	7.8×10^3
	Mold & yeasts	0.9×10^3	0.9×10^3	1.5×10^3	2.1×10^3	4.2×10^3

Table 6. Changes in some microbial determinations (cfu/ g) of cold smoked fish under frozen storage conditions as affected by smoking materials

Smoking material	Microorganisms	Storage Period (month)					
		0	1	2	3	4	5
Sweden sawdust	Total bacterial count	1.4×10^3	3.0×10^3	4.6×10^3	5.9×10^3	1.4×10^4	3.6×10^4
	Coliform bacteria	0.5×10^2	-----	-----	-----	-----	-----
	Psyshrophilic	0.9×10^2	-----	-----	-----	-----	-----
	Mold & yeasts	0.4×10^2	-----	-----	-----	-----	-----
Corn cobs sawdust	Total bacterial count	1.6×10^3	3.2×10^3	4.9×10^3	6.2×10^3	2.9×10^4	3.9×10^4
	Coliform bacteria	0.8×10^3	-----	-----	-----	-----	-----
	Psyshrophilic	0.9×10^3	-----	-----	-----	-----	-----
	Mold & yeasts	0.6×10^3	-----	-----	-----	-----	-----

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تأثير مواد التدخين وفترات التخزين علي التغيرات الكيميائية والميكروبيولوجيه لسمك الرنجة المدخن علي البارد

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السمك غذاء ضروري للصحة الجيدة، خاصة للمخ لذلك فإنه يعرف بغذاء المخ،ولكن لسوء الحظ، فإن السمك الطازج يتعرض للتلف والتدهور بسرعة كبيرة علي درجة حرارة الغرفة بعد عملية الصيد. حيث تحدث تغيرات كيميائية وفيزيائية وإنزيمية وبكتيرية في مكونات وتركيب السمك. لذلك تم إجراء هذا البحث لتقييم تأثير مواد التدخين المختلفة وفترات التخزين علي مدة صلاحية سمك الرنجة المدخن علي البارد والمخزن بالتبريد علي درجة حرارة ٤°م لمدة ٨ أسابيع وبالتجميد علي درجة -٢٠° م لمدة ٥ شهور. وتشير النتائج إلي حدوث انخفاض تدريجي في المحتوي الرطوبي والبروتين الكلي،بينما زادت نسبة الدهن خلال فترات التخزين بالتبريد أو بالتجميد عند التدخين باستخدام نشارة الخشب السويدي أو قوالح الذرة.أما نسبة الرماد فكانت ثابتة تقريبا سواء خلال فترات التخزين أو عند استخدام مادتي التدخين تحت الدراسة. زاد محتوي سمك الرنجة المدخن علي البارد تدريجيا من كل من الملح والتراي ميثيل أمين وحامض الثيوباربيتوريك خلال فترات التخزين، وكان معدل الزيادة في محتوي الملح أكثر في العينات المدخنة بالخشب السويدي والمخزنة بالتجميد.في حين إتخذت الزيادة في التراي ميثيل أمين وحامض الثيوباربيتوريك اتجاها عكسيا. كان تدخين سمك الرنجة باستخدام نشارة الخشب السويدي أفضل منه عند استخدام نشارة قوالح الذرة. وتشير نتائج البحث إلي إمكانية تخزين سمك الرنجة المدخن علي البارد بأمان تحت ظروف التبريد لمدة ٨ أسابيع والتجميد لمدة ٥ شهور.