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Effect of Smoking Methods and Refrigerated Storage on Physicochemical, Microbiological and Sensory Properties of the Sagan Fish

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ABSTRACT

Smoked fish is a worldwide very popular and delicious product. This study aimed to investigate the effects of smoking methods and cold storage 4±1°C on the proximate composition, physicochemical, microbiological and sensory properties of sagan fish. Results revealed that the smoking process significantly decreased the values of moisture, pH, total viable bacteria, yeast and mould counts, while it significantly increased the values of protein, lipid, ash, sodium chloride, carbohydrate, total volatile basic nitrogen, trimethylamine nitrogen, thiobarbituric acid. On the other hand, total coliform decreased during cold smoking though it was not detected in hot smoked samples. Regarding the storage conditions, the moisture content was significantly decreased during storage at 4±1°C, while the values of protein, lipid, ash, sodium chloride, pH, total volatile basic nitrogen, trimethylamine nitrogen, thiobarbituric acid, total viable bacteria, yeast and mold counts and total coliform were significantly increased. Overall acceptability illustrated that hot smoked segan products were highly accepted compared to cold smoked and all those processed by cold storage. Therefore, the results indicated that hot smoked sagan fish possessed higher quality, safety and acceptance than the cold-smoked fish. By cold storage, shelf life was 40 days for hot-smoked compared to 30 days for cold smoked.

INTRODUCTION

Sagan (*Saganus fuscecens*) fish belongs to the genus saganus of the family Saganidae. Sagan are a marine and herbaceous brackish water fish found throughout the western Indo-Pacific, and the most common species are found in the traditional subsistence and commercial fisheries around this region **(Woodland, 1983; Woodland, 1990)**. Sagan fish is one of the most important potential fish and is considered an excellent food in many parts of the world, especially in the eastern Mediterranean and the Indo-Pacific regions of the eastern coast of Africa to Polynesia and from southern Japan to northern Australia. This species is economically important and relatively easy to rear which made it suitable for aquaculture **(Lam, 1974; Hara *et al*., 1986)**. Additionally, the signus have a high market value in the eastern Mediterranean countries, as it invaded the eastern Mediterranean through the Suez Canal **(Stephanou & Georgiou, 2000; Abdel-**

Aziz *et al*., 2016). Smoking is one of the oldest methods that is used in fish preservation; it inhibited fat oxidation, bacterial growth and may extend the shelf life of the final product. Smoking is the process of exposing fish to smoke resulting from incomplete burning of sawdust or plant wood. The smoking process is characterized by an integrated sequence of salting, partial drying and smoking processes and the treatment with smoke in smoking oven. Salting is used to provide a salty flavor and impart storage stability. Preservation properties of smoking treatment are mainly due to the partial drying trend and the precipitation of aliphatic and aromatic vapors on fish surface **(Abd El- Mageed, 1994; Shalaby, 2000)**. Fish smoking is particularly relevant in the artisanal fisheries sector; it prolongs the shelf-life of the fish, enhances flavor and increases fish utilization by reducing the waste and increasing protein availability **(Jallow, 1995)**. The traditional smoking process of fish includes two methods; hot smoking and cold smoking **(Hafez *et al*., 2019)**. Cold storage is a simple and efficient preservation method, keeping the fish in a cool condition with a temperature ranging between 0 and 4°C, which minimizes biochemical and microbiological reactions though it does not prevent enzyme activities or microbial spoilage **(Ghaly *et al*., 2010; Sabine, 2015)**. Therefore, the present investigation aimed to study the quality of raw sagan fish and the effect of traditional smoking methods (cold and hot) as well as refrigerated storage (4±2ºC) on the quality criteria and sensory evaluation of smoked sagan fish.

MATERIALS AND METHODS

About 15 kg of frozen sagan fish (*Saganus rivulatus*) were obtained from El-Yarmouk research ship (Yarmouk ship belongs to the National Institute of Oceanography and Fisheries that collected the fish for scientific research from the Mediterranean Sea for about 7 days) during January, 2021. The fish average weight was 90-120g and their length was 18-20 cm. The frozen fish was transferred in an ice box to Fish Processing Technology Laboratory, Fish Research Station in Shakshuk belonging to the National Institute of Oceanography and Fisheries (NIOF), El-Fayoum, Egypt.

Smoking processes

Frozen sagan fish was thawed at room temperature, washed using tap water, wet salted using 10% brine solution for two hours and rinsed thoroughly by tap water for1.0 min. to remove the excess salt. Salted samples were kept on net shelves and were partially dried (20-23ºC) for about two hours before the smoking process. Salted samples were subjected to cold and/or hot smoking in a laboratory smokehouse in Fish Research Station in Shakshuk. The inside dimensions of the smokehouse were 1.20 × 1.0 × 3.5 m. A 75 cm- metal boarded plate was used above the smoke source to filtrate the smoke. Fish samples were hooked above the smoke source by about 150 cm and 250 cm in hot and cold smoking, respectively. The cold smoking process lasted for 10-11 hours at 35-45°C. While hot smoking exteded for 5-6 hours at 40-90°C (2 hours at 40°C-50°C, 2 hours at 60°C-80°C and the remained period at 90°C). After smoking, smoked samples were cooled at ambient temperature, packed in polyethylene bags then stored in the

refrigerator at 4±2°C until the beginning of the spoilage. The chemical, physical, microbiological analyses were carried out on raw flesh and immediately after smoking in addition to sensory evolution (at zero time of storage) and periodically every 10 days during storage.

Analytical methods

Chemical composition was determined through the assessment of moisture, crude protein, crude lipids, ash, sodium chloride (NaCl) contents. These variables were carried out according to the methods recommended by the **AOAC (2002)**. Meanwhile, the physicochemical analysis recorded the pH value according to the methods described by the **AOAC (2002)**. Total volatile basic nitrogen (TVB-N, mg/100g) contents were estimated following the method of **Pearson (1976)**. Trimethylamine nitrogen (TMA-N) was determined using the standard method of the **AOAC (2002).** Thiobarbituric acid (TBA, mg MA/kg) value was measured according to the method described by **Pearson (1976)**. Microbiological analysis recorded the total bacterial count (TBC), yeast and molds counts according to **APHA (1992)**.Furthermore, the total coliforms were performed as described by **AOAC (2002)**. The results of all microbiological analysis were expressed as $\log_{10}$cfu/g of sample. Sensory evaluation of cold and hot smoked samples was carried out immediately after smoking and during storage according to **El-Sherif (2001)**. Statistical analyses determined the data of chemical composition and quality criteria, and both were analyzed statistically using the least significant difference test (L.S.D) at $(P \leq 0.05)$ and Standard Deviation (Mean ± SD) which were calculated using SPSS 10.0 for windows **(SPSS, 1998)**.

RESULTS AND DISCUSSION

Proximate chemical composition of raw and smoked sagan fish

The obtained results of proximate chemical composition for raw sagan fish flesh are shown in Table (1). Data illustrated that the moisture, crude protein, crude lipid, ash, salt (NaCl) and carbohydrate contents of fresh sagan fish were 74.47%, 21.26%, 2.39%, 1.70%, 0.20% and 0.28% on wet weight basis (w.w.), respectively.

The chemical composition of the fish indicates that it is a healthy fish, and it belongs to the high protein fish species because the protein content was higher (21%, on w.w.) than the value established by **Stansby (1982)** that defines high protein fish with a protein content between 15 to 20%. After smoking; moisture content was significantly decreased ($P \leq 0.05$) from74.47% of fresh fish to 56.44% and 64.66% in hot and cold smoked fish samples, respectively, but the contents of crude protein, crude lipid, ash, sodium chloride and carbohydrates were significantly ($P < 0.05$) increased; protein content was increased from 21.26% to 28.55% and 26.24%, lipid content was increased from 2.39% to 6.39% and 3.30%, ash content was increased from 1.70% to 8.14% and 5.21%, salt (NaCl) was increased from 0.20% to 3.95% and 3.32% and carbohydrate

content was increased from 0.28% to 0.48% and 0.59% in hot and cold smoked sagan fish samples, respectively. There is also a significant difference ($p \leq 0.05$) between the hot and cold smoking methods in all constituents of the chemical composition. The decrease of moisture content after fish smoking might be due to temperature and reaction between the amino groups and the phenols as well as the reaction between smoke components and sulfhydryl groups of fish proteins and that consequently decreased the chemical groups which are able to bind water **(Asiedu *et al*., 1991; Shehata *et al*., 2018; Mahbooba *et al*., 2019)**.

Table 1. Proximate chemical composition of raw flesh and smoked sagan fish products (w.w.)

Constituent (%)	Raw fish	Smoked fish		L. S. D. at 5 %
		Hot	Cold	
Moisture content	74.47±0.850	56.44±1.194	64.66± 1.009	1.525
Crude protein	21.26±0.188	28.55± 0.059	26.24± 0.307	0.720
Crude lipid	2.39± 0.420	6.39± 0.090	3.30± 0.127	0.099
Ash content	1.70± 0.110	8.14± 0.150	5.21± 0.088	1.110
Sodium chloride (NaCl)	0.20± 0.005	3.95± 0.010	3.32± 0.033	0.085
Carbohydrate	0.28± 0.003	0.48± 0.030	0.59± 0.100	0.022

Data are calculated as mean ± (SD) Standard deviation; (n=3). w.w.: On wet weight basis. L.S.D 5%: Least significant difference at $P \leq 0.05$.

While, the increasing of protein, lipid, ash, NaCl and carbohydrates of smoked fillets could be attributed to the loss of water during smoking procedures; consequently dry matters were increased, also, the high increase in ash and NaCl contents were mainly due to brining treatment of fish before smoking **(Abd El- Mageed, 1994; Yanar, 2007; Koral *et al*., 2009; Abraha *et al*., 2018; Popelka *et al*., 2021)**.

Quality criteria of raw and smoked Sagan fish

From the obtained data in Table (2), the pH value of raw sagan fish was 6.22 of raw sagan fish and was decreased to 6.08 and 6.02 of hot and cold smoked sample respectively. The lower pH values of smoked samples might be attributed to the the fact that flesh absorbed some organic acids from the smoke during the smoking process **(Yanar, 2007)**. Total volatile basic nitrogen (TVB-N) content was 22.48 mg/100g in the sample (w.w.) of raw sagan fish and increased to 26.39 and 28.45 (mg/100g), trimethylamine nitrogen (TMA-N) content was 0.37(mg⁄100g) and increased to 0.67 and 0.86 mg ⁄100g of hot and cold smoked products, respectively. Significant ($P<0.05$) increasing of TVB-N and TMA-N contents in smoked samples is mostly caused by autolytic process which produces compounds from volatile amine and could be attributed to the action of protein hydrolysis caused by enzymes during the long time and the lowering heat temperature in cold smoking **(Abd El-Mageed, 1994)**.

Thiobarbituric acid value (TBA) content was 0.18 mg MA/kg in fresh sagan fish and was increased to 0.48 and 0.40 mg MA/kg in hot and cold smoked products, respectively. The high TBA value observed in the hot smoked fish sample may be due to the partial dehydration of fish and oxidation of unsaturated fatty acids due to the use of high temperatures during hot smoking process (up to70°C) **(Goktepe &Moody, 1998; Popelka *et al*., 2021)**.

Table 2. Quality properties of raw and smoked sagan fish

Parameter	Raw Fish	Smoked Fish		L. S. D. at 5 %
		Hot	Cold	
pH value	6.22± 0.010	6.08± 0.104	6.02± 0.009	0.005
TVB-N (mg/100g)	22.48± 0.703	26.39± 0.500	28.45± 1.002	1.008
TMA-N (mg/100g)	0.37± 0.014	0.67± 0.008	0.86± 0.022	0.011
TBA (mg MA/kg)	0.18± 0.008	0.48± 0.130	0.40± 0.011	0.001
TVC (cfu/g)	1.6×10^4	2.0×10^3	3.1×10^3	0.020
TCBC (cfu/g)	3×10^2	ND	0.7×10^2	0.010
M&Y (cfu/g)	0.25×10^3	1.20×10^2	1.35×10^2	0.005

Data are calculated as mean ± (SD) standard deviation; n=3. w.w.: On wet weight basis. L.S.D 5%: Least significant difference at $P \leq 0.05$. TVB-N: Total volatile basic nitrogen. TMA-N: Trimethylamine nitrogen. TBA: Thiobarbituric acid. TVC: Total viable counts. TCBC: Total coliform counts. M&Y: Yeast and mould. cfu: colony forming units. ND: Not detected.

High TVB-N, TMA-N and TBA values of raw sagana fish may be due to irregularity in freezing during fishing and handling **(Bekhit *et al*., 2021),** but is still lower than the international maximum permissible limits. Regarding microbial safety; total viable counts (TVC) of fresh fish flesh were recorded 1.6×10^4 cfu/g significantly ($P>0.05$) and decreased to 2.00×10^3 and 3.10×10^3 cfu/g in hot and cold smoked products, respectively. Total coliform bacteria counts (TCBC) was 3×10^2 for the fresh sample and was not detected in hot smoked sample, while in the cold smoked sample,a decrease to 0.73×10^2 was detected. Yeast and mould (M&Y) count was 0.25×10^3 of fresh sample and was decreased to 1.20×10^2 and 1.35×10^2 of hot and cold smoked samples. A significant difference ($p \leq 0.05$) between the hot and cold smoking methods was determined in all microbiological parameters. The reduction of microbial values of smoked samples could be attributed to the actions of many factors; antimicrobial effect of smoke compounds, the temperature used while smoking, partially drying, the effect of sodium chloride for lowering the water activity of fish flesh and the harmful effect of chloride ion in sodium chloride on microorganisms **(Lueck, 1980; Odeyemi *et al*., 2020).** A significant difference ($p \leq 0.05$) was found between the hot and cold smoking methods in values of all parameters of the quality properties and microbiological load.

Sensory properties of hot and cold smoked sagan fish

The sensory properties are the main quality criteria that affect the consumer acceptability of fish products. The results of Fig. (1) revealed that the values scores of

appearance, flavor (taste and odour), texture and overall acceptability of hot smoked sagan samples were higher than that of cold smoked samples, especially the texture, as the skin grips the meat firmly in cold smoked samples.

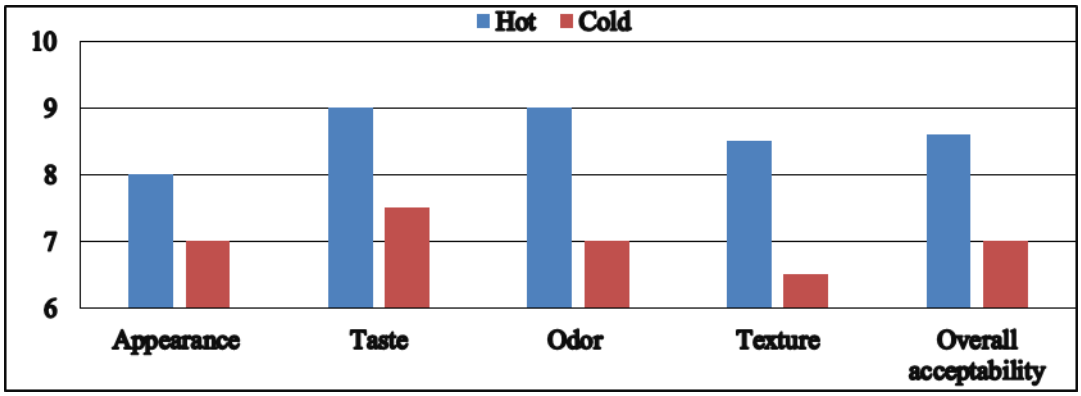

Fig. 1. Sensory evaluation of hot and cold smoked sagan fish samples

The changes of smoked sagan fish samples during refrigerated storage at 4±2 ºC.

Changes in chemical composition

The results presented in Fig. (2) explain the effect of refrigerated storage on chemical composition of smoked sagan samples. During storage, the moisture contents of hot and cold smoked samples were gradually and significantly (P>0.05) decreased until the storage time. The recorded decrease in hot smoked samples ranged from 56.44% at zero time of storage to 55.80% at the end of the storage time (40) days. While, in the cold smoked samples, the moisture content was 64.66% at zero time of storage and decreased to 62.25% at the end of the storage time (30) days. This reduction of moisture content during cold storage may be due to the evaporation **(Abd El-Mageed, 1994)**, or the interaction between the amino groups and phenols as well as the interactions between the smoke contents and the sulfhydryl groups in the fish proteins resulting in the decrease of the chemical groups capable of binding water **(Koral *et al*., 2010; Shehata *et al*., 2018; Mahbooba *et al*., 2019; Popelka *et al*., 2021)**.

Additionally, the protein content was gradually decreased during cold storage; a decreasing value of 28.55% was detected at zero time of storage of hot smoked samples to 24.85% (w.w.) at the end storage (40 days). It decreased from 26.24% at zero time to 23.80% at the end storage (30 days) of the cold smoked product. The decrease of protein during cold storage may be due to the degradation of protein by both enzymes and microorganism of the fish tissue **(Abd El-Mageed, 1994; El-Lahamy *et al.*, 2018a; Popelka *et al*., 2021)**.

The lipid content of hot smoked sample was gradually and significantly (P>0.05) decreased from 6.39% at the beginning of storage period to 4.15% (w.w.) at end of storage (40 days). The value of the cold smoked sample was 3.30% at zero time of storage and decreased to 2.88% at end of storage (30) days. This decrease in lipid content

of all smoked fish samples during cold storage may be due to the oxidation and hydrolysis of fish lipids causing conversionof some lipid into ketones and aldehydes **(Mackie, 1993; Verma *et al*., 1995; El-Lahamy, 2018; Mahbooba *et al*., 2019)**.

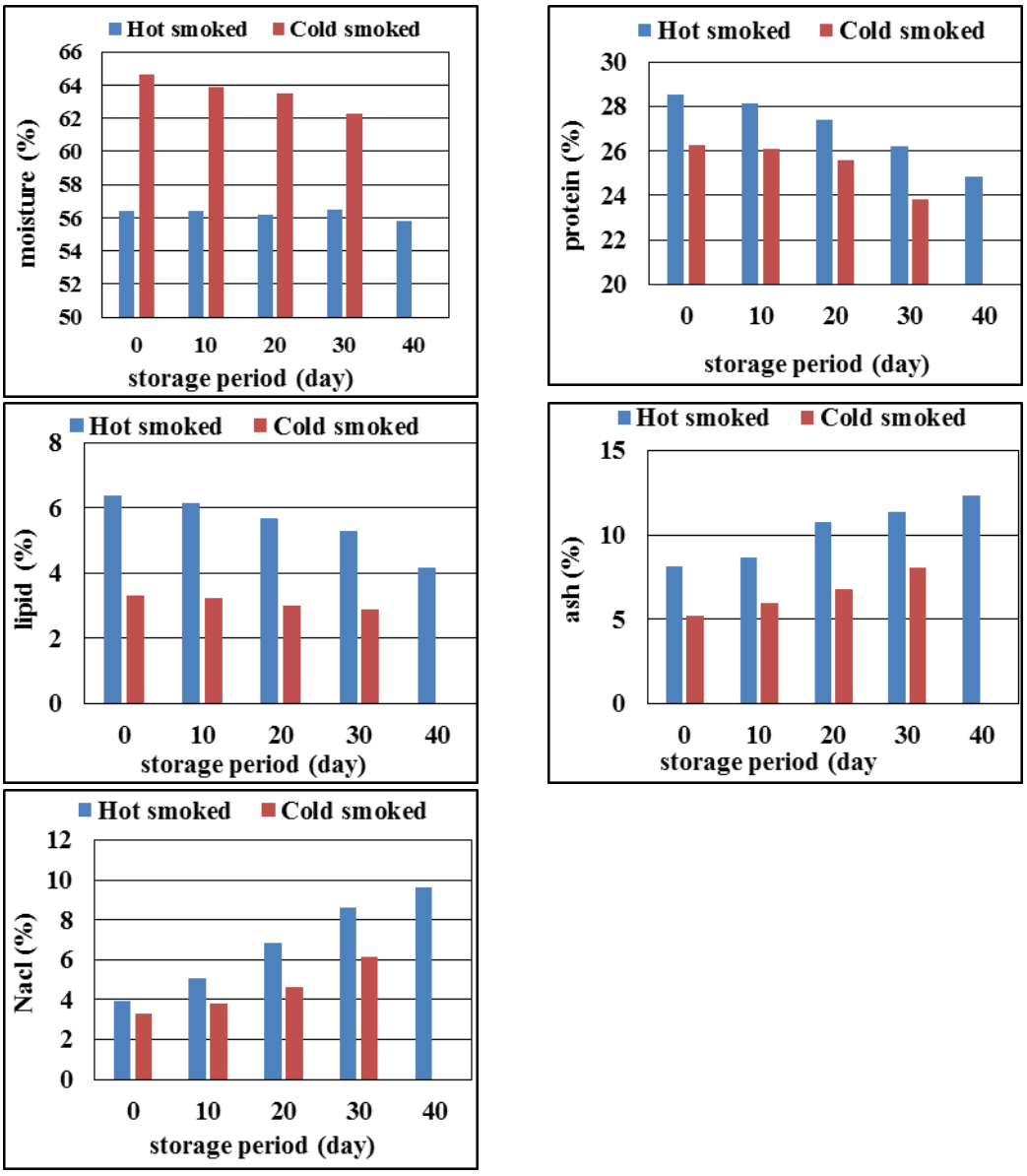

Fig. 2. Changes in chemical composition of hot and cold smoked saganduring refrigerated storage (4±2˚C).

Ash content is a measure of the mineral content of food item. It is the residue that remains after the organic matter is burnt off. The recorded value of ash content was 8.14% in the hot smoked fish samples at zero time of storage and it increased to 12.30% (w.w.) at the end of storage period (40 days). On the other hand, the value increased from 5.21% at the beginning of storage period of the cold smoked sample to 8.04% at the end

storage period (30 days). The significantly (P<0.05) increase in the ash contents of the smoked fish samples can be attributed to the loss of moisture content during storage **(Hussein *et al*., 1980)**. These results are in agreement with that reported by **El-Lahamy (2018)** and **Abo-Zeid (2020)**.

Sodium chloride content (NaCl) in the hot smoked samples was gradually increased; with recorded values from 3.95% at zero time of storage to 9.54% at the end of the storage (40) days, while it increased from 3.32% in cold smoked fish samples to 6.15% at the end of the storage (30) days. The significantly (P<0.05) increase in the NaCl content of smoked fish samples may be due to moisture loss during storage and dry matter increase **(Dessouki, 1971; Hussein *et al*., 1980)**. Similar results are found in the study of **Abd El-Mageed (1994)** who reported that, the ash and sodium chloride of hot and cold smoked silver carp fillets increased during refrigerated storage.

Changes of quality properties

pH is the most important factor influenced by the microbial growth and fish spoilage. The pH value was determined in smoked sagan fish products during refrigerated storage and the obtained results are tabulated in Fig. (3).

The pH values were slightly increased in all smoked samples during storage, especially cold smoked samples which recorded a higher increasecompared to the hot smoked samples. The pH value in hot smoked sample increased from 6.08 at zero time of storage to 7.24 at the end of the storage (40) days. However, in the cold smoked sample the recorded increase changed from 6.02 to 7.85 at the end of the storage (30) days. The increase in pH values of smoked samples during storage time is due to the protolytic enzymes that hydrolysed fish protein to simple proteins, polypeptides and amino acids which were nutrient intermediate compounds **(Khallaf, 1990; Abd El-Mageed, 1994)**.

The TVB-N in fish andin fish products is an index for the degree of putrefaction, deteriolysis and breakdown of protein contents **(Shaheen *et al*., 1973; Shehata *et al*., 2018; Mahbooba *et al*., 2019; Popelka *et al*., 2021)**. TVB-N values of hot and cold smoked sagan fish samples were estimated during refrigerated storage and data are illustrated in Fig. (3). It was found that the TVB-N values of the smoked samples increased gradually throughout the storage periods, TVB-N values in the cold smoked samples were significantly (P<0.05) higher than that of hot smoked samples. The values of cold smoked samples increased from 28.45 mg⁄100g sample at zero time of storage to 73.61 mg⁄100g sample (w.w.) at the end storage (30) days, while in case of hot smoked samples, the values increased from 26.39 mg⁄100g sample at zero time of storage to 58.23 mg⁄100g sample at the end of storage (40) days. The increase in TVB-N values through storage period is due to the activity of endogenus and microbail protolytic enzymes that break down proteins to many volatile nitrogen compounds **(Yassin & Abo-Taleb, 2007; Bekhit *et al*., 2021)**.

Malonaldehyde (MA) as a carbonyl compound was formed during oxidation of polyunsaturated fatty acids and was evaluatedin smoked sagan fish products during

refrigerated storage; data obtained are presented in Fig. (3). It can be seen that the TBA values were gradually and significantly (P<0.05) increased during the storage time, the rate of increase of TBA value in cold smoked samples was higher than the rate of increase in hot smoked samples. The TBA values of cold smoked samples increased from 0.40 mg MA/kg sample at zero time of storage to 1.86 mg MA/kg sample(w.w.) the end of storage (30) days, while the values of TBA increased in hot smoked samples from 0.48 mg MA/kg sample at zero time of storage to 1.58 mg MA/kg sample the end of storage time (40 days). The observed increasing in values of TBA for smoked sagan fish products were at their most because of both autoxidation of fish lipid and the formation some of TBA-reaction substances throughout the storage **(El-Akeel, 1988; Domínguez *et al*., 2019)**.

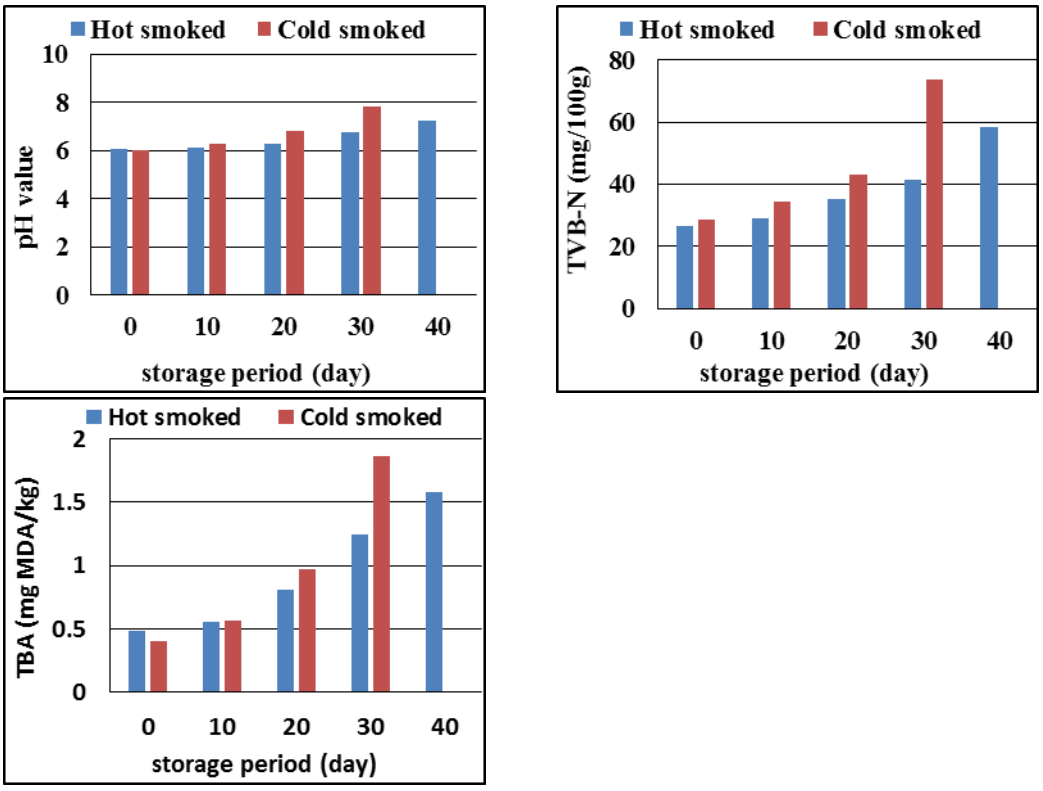

Fig. 3. Changes in physicochemical quality aspects of smoked sagan fish products during cold storage (4±2˚C).

Changes in microbiological aspects

Total viable count (TVC): A good technique for fish preservation was used to prevent microbial spoilage of fish without affecting its quality and nutritional value **(Ghaly *et al*., 2010; Odeyemi *et al*., 2020; Tavares *et al*., 2021)**. Therefore, the results in Table (3) illustrates the effect of cold storage on microbiological aspects of hot and cold smoked sagan samples. The current findings revealed that the TVC counts were significantly (P<0.05) increased in both hot and cold smoked sagan products during cold

storage and this increase was higher in cold smoked products compared to the hot smoked because the temperature of cold smoking had a little effect upon the general flora presented.

The values of TVC counts in hot smoked samples were increased from 2.0×10^3 cfu/g sample at zero time of storage to 20×10^5 cfu/g sample at the end of storage (30) days, while in the cold smoked samples, the values of TVC were increased from 3.1×10^3 cfu/g sample at zero time of storage to 28×10^5 cfu/g sample at the end of storage time (40 days). These results were lower than the maximum permissible levels (MPLs) recommended by the International Commission for microbiological specifications of TBC in all fish and fish products which is below 7 $\log_{10}$ cfu/g sample **(ICMSF, 2002; Alkuraieef *et al.*, 2021)**. The significantly ($P\leq 0.05$) increase of TVC of smoked fish samples throughout refrigerated storage could be attributed to pronounced loss of both carbonylic compounds and phenolic which acted as the antimicrobial agents **(El-Akeel, 1988; El-Lahamy, 2018)**.

Table 3. Changes of microbiological quality aspects of smoked sagan fish products (cfu/g sample)

Smoked Samples	Storage period (days)					L. S. D. at 5 %
	0	10	20	30	40	
TVC counts of smoked sagan samples (cfu/g)						
Hot smoked	2.0×10^3	3.5×10^3	2.00×10^4	12×10^4	20×10^5	0.011
Cold smoked	3.1×10^3	3.8×10^3	3.5×10^4	28×10^5	Rejected	0.029
Y&M counts of smoked Sagan products (cfu/g)						
Hot smoked	1.20×10^2	1.5×10^3	5×10^3	6.6×10^3	9.0×10^3	0.008
Cold smoked	1.35×10^2	3.0×10^3	4×10^3	8×10^3	rejected	0.021

TVC: Total viable counts. M&Y: Yeast and mould. cfu: colony forming units. L.S.D 5%: Least significant difference at $P \leq 0.05$.

Yeast and mold are considered a causative agent for rapidly spoilage especially in smoked fish. The obtained results that are found in Table (3) show that the yeast and mold were gradually and significantly ($P<0.05$) increased in all smoked samples throughout storage time until the end storage. The values of Y&M count in hot smoked sagana samples were increased from 1.20×10^2 cfu/g sample at zero time of storage to 9.0×10^3 cfu/g sample at the end of storage (30) days, while in the cold smoked samples, the values of Y&M were increased from 1.35×10^2 cfu/g sample at zero time of storage to 8×10^3 cfu/g at end storage (40) days. The significantly ($P< 0.05$) increase in TVC and Y&M of hot and cold smoked sagana fish samples during cold storage was observed by

Abd El-Mageed (1994) and **El-Lahamy (2018)** in hot and cold smoked silver carp and catfish, respectively.

Changes in sensory evaluation

Overall acceptability

The results of sensory evaluation are one of the most important criteria responsible for quality, which is used to determine the shelf life of seafood. Sensory parameters; appearance, odour, taste, texture and overall acceptability of hot and cold smoked sagan fish products were recorded. While, in this study, only data for overall acceptability of hot and cold smoked sagan fish during cold storage at (4±2ºC) is presented in Fig. (4).

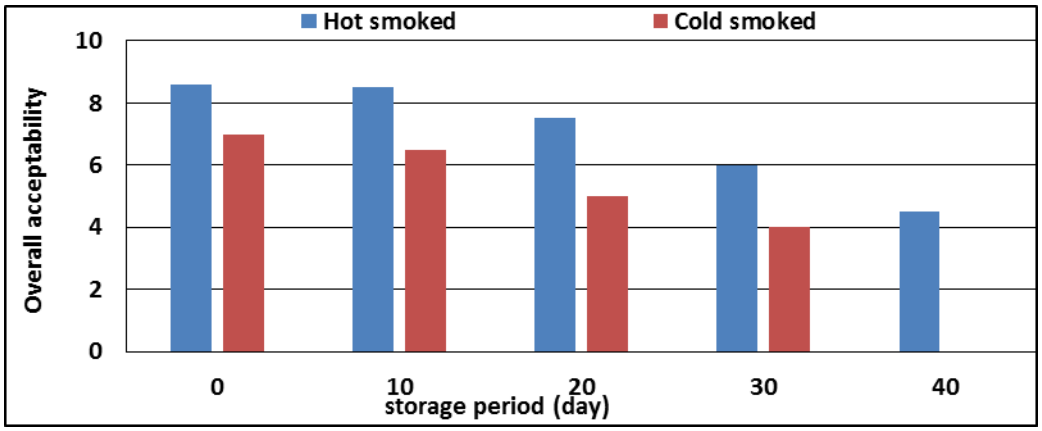

Fig. 4. Changes of values of overall acceptability during cold storage at (4±2ºC)

The values of overall acceptability were gradually decreased throughout the storage time. The overall acceptability values of hot smoked samples were decreased from 8.6 at zero time of storage to 4.5 at end storage time (40 days), while in the cold smoked samples, the values were decreased from 7.0 at zero time of storage to 4.0 at end storage time (30 days). The decline in overall acceptability of smoked samples during storage as a result of changes in taste and odour and the unpleasant flavor formation occurred at the end of storage period. The decrease in the general acceptance of cold and smoked samples during storage occurred as a result of changes in the taste, odour and unpleasant flavour formation at the end of the storage period.

CONCLUSION

Results revealed that raw flesh of sagan fish was of high quality and safety. Hot smoked sagan fish samples possessed higher quality and safety and also acceptance from panelists than the cold smoked samples. Shelf life, acceptable quality and general acceptability of hot-smoked sagan fish samples recorded 40 days in the cold storage compared to 30 days for the cold smoked samples.

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