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EXTENDING SHELF LIFE OF CHILLED COLD SMOKED SALMON USING SOME ORGANIC ACID SALTS

By

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ABSTRACT

Cold smoked salmon is a highly perishable product that belongs to the group of traditional lightly preserved fish products. The purpose of this study was to quantify the effects of organic acid sodium salts on quality parameters of cold smoked vacuum packaged salmon. Slices of smoked salmon were sprayed with sodium lactate (SL), sodium erythobate (SE) and the commercial buffer glucose syrup (BGS) immediately before being vacuum packaged then stored at 5°C and examined every 5 days for 45 days. Examination of the samples included sensory examination, chemical examinations (TBARS, TVBN and TMA) and microbiological examinations (TBC and TPsC). BGS was the best in keeping the sensory attributes of the product until the end of storage meanwhile; the control was unacceptable at the 35th day, followed by SL at 40th day then SE at 45th day. SE showed the best antioxidant effect (recording TBARS 1.91 versus 2.74 mg MDA/Kg for the control); also BGS, SL treated samples were significantly lower than the control (2.27 and 2.05 mg MDA/Kg). BGS, SL, SE and control reached the maximum acceptable limit of TVBN in the 40th, 35th, 30th and 20th day of storage, respectively. BGS, SL and SE treated samples had TMA values significantly ($P<0.05$) lower than the control; noticing that BGS was significantly lower than SL and SE while there was no significance between SL and SE. All treatments reduced the total bacterial count significantly than control. SL, BGS, SE and control exceeded log 5 cfu/g in the 35th, 30th, 30th and 15thday of storage, respectively. Results indicated that organic acid salts significantly improved the shelf life of cold-smoked salmon. Key words: smoked salmon, organic acid salts, chemical analysis, bacteriological analysis

INTRODUCTION

The development of aquaculture of the Atlantic salmon (Salmo salary) (over half of the salmon sold globally is now farm-raised) allowed producers of smoked salmon to have ready access to fresh raw material of uniform quality available year-round **(Hempel, 1999 and**

FAO, 2000). Salmon is an oily fish rich in the two omega-3 fatty acids; EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Salmon contents of these long chain polyunsaturated fatty acids had supported it to be one of the recommended healthy foods **(EFSA, 2014 and American Heart Association, 2016**). Omega 3 fatty acids intake has the advantage of decreasing the risk of cardiovascular diseases, improving the mood and cognition, joint protection, lowering the risk of eye related problems (muscular degeneration and dry eye) and decreasing cancer risk (Colorectal cancer, prostate cancer and breast cancer) **(Mateljan, 2007**). Cold smoking is a traditional light preservation process where fish is subjected to smoke at temperatures that do not exceed 30°C resulting in incomplete heat coagulation of its protein **(FDA, 2001).** These low temperatures of processing couldn't inactivate the native enzymes in the fish tissues **(Hansen *et al.,* 1995)**. Vacuum-packed, sliced, cold-smoked salmon is a highly perishable product, because of light preservative treatments (salt on product ranging between 2.5 to 3.5 % w/w and phenol generally less than 0.5 mg 100 g^{-1}) and no other additives such as nitrate or nitrite are allowed **(Espe and Rørå, 2004)**. Moreover, cold smoked salmon is typically consumed as ready-to-eat with no heat treatment and usually stored at a chilled temperature,rendering the product very sensitive to deterioration **(Joffraud *et al.*, 2006)**. Generally, the life -time indicated by the producers is limited to 1-8 weeks at 5°C, due to early sensory deterioration **(Leroi *et al.,* 1996; and Rizo *et al.,* 2015)**. The shelf life of seafood products could be short and variable. This may be due to high pH of the fish flesh, high free amino acid contents, presence of trimethylaminoxide TMAO)and the psychrotolerant nature of the spoilage bacteria that have the ability to grow rapidly in the chilled products. Seafood spoilage could be related to microbial activity, chemical spoilage (oxidation and rancidity) and insect problems **(Dalgaard, 2000**). Moreover, shelf life usually depends on factors related to the handling, smoking and hygienic conditions in the smokehouses, raw materials, smoking technologies and the storage conditions. Because of the complexity of the spoilage process, several techniques had developed to evaluate the shelf life of seafood products. Traditional analysis as total viable counts (TVC), total volatile bases (TVB), trimethylamine (TMA), sensory analysis, thiobarbituric acid test, color measurements, K value (a measure of the breakdown of nucleotides) and other techniques, have been reported for monitoring changes occurring during storage of fishery products **(Gill, 1990; Dondero *et al.*, 2004; Haugen *et al.*, 2006 and Rizo *et al.*, 2015**). To extend the shelf life of seafood

products by controlling water activity, enzymatic, oxidative and microbial spoilage; many preservation methods had been implemented such as drying, freezing, chilling, super chilling, canning, application of high pressure techniques and chemical preservatives such as antioxidants and antimicrobials which include organic acids, nitrites, sulfides, EDTA, BHT and BHA **(Lakshmanan *et al.,* 2003; and Ghaly *et al.,* 2010)**. Organic acids have a long history of being utilized as food additives and preservatives in preventing food deterioration and extending the shelf life of perishable food ingredients. Various organic acids are approved or listed in FDA regulations for various technical purposes, in addition to preservation, such as acidulants, antioxidants, flavoring agents, pH adjusters, and even nutrients and being generally recognized as safe (GRAS). Organic acids exist in two basic forms; pure acid such as lactic, acetic and citric acids and buffered acids that are the calcium and sodium salts of organic acids. Buffered acids are safer to handle and less caustic to machinery compared to the pure form **(Ricke, 2003; Parish *et al.,* 2003; and Theron and Lues, 2007)**. Sodium salts, specifically, of low molecular weight organic acids (such as acetic, lactic, or citric) are commonly used to control microbial growth, improve sensory attributes, and extend shelf life of various meat, poultry, and fish products **(Sallam and Samejima, 2004)**. Several authors reported that sodium lactate, sodium citrate and their different combinations had extended the shelf life of sliced salmon and rainbow trout fillets, sturgeon fillets by 4-7 days more than control **(Juneja and Thippareddi, 2004; Sallam, 2007b; Kilinic *et al.*, 2009; Kashiri, 2010 and Song *et al.,* 2011)**. Furthermore, treatment of fish and fish fillet with citric acid, ascorbic acid, erythorbic acid or sodium erythorbate (which is a cost effective substitute for ascorbic acid) effectively reduce fat rancidity **(Bilinski *et al.*, 1979; Santos and Regenstein, 1990; Mancini *et al.*, 2007 and Rostamzad *et al.*, 2011)**. Citric and ascorbic acids are often used on salad vegetables. Ascorbic acid (l-ascorbic acid) had been popular GRAS antioxidants for many years and used on fruits and vegetables to prevent browning and other oxidative reactions **(Rico *et al.*, 2007)**. Therefore, the present study was designed to investigate the effect of organic acid salts such as sodium lactate, sodium erythorbate and a commercially available combination of organic acid salts BGS (Buffer Glucose Syrup®) on improving the quality of vacuum-packed sliced cold smoked salmon and extending its shelf life.

MATERIAL AND METHODS

Frozen raw salmon of Atlantic *Salmo salar* species was thawed, headed, eviscerated and cut into halves then salted, rinsed and dried. Salted fish was smoked at 15°C for about 2 days. The smoked fish was deboned, skinned and mechanically sliced, sprayed with the treatments and finally vacuum packed. Eighty vacuum packs of cold smoked salmon each weighing 200 grams were divided into 4 groups: 1- non-treated control (C), 2- 0.1% (W/V) Buffer Glucose Syrup {PH Liquid, Belgium, (N.V.)} (BGS), 3- 2.5% (V/V) Sodium lactate (LOBA Chemie, India) (SL), 4 - 1.5% (W/V) Sodium erythorbate (Sigma Aldrich Chemie, Germany) (SE). All the samples were chill stored at 5°C for 45 days and examined every five days.

Sensory Analysis:

Sensory analysis was performed according to **Archer (2010**). A descriptive test using Tory Sensory Assessment scheme was carried out to evaluate the sensory characteristics of smoked salmon. Samples were scored by five well trained panelists belonging to Animal Health Research Institute and trained on sensory descriptors for smoked salmon. The evaluation included color, odor and texture of the smoked salmon.The scale ranges from 10 to zero where; score 10 is the best, while 4 is borderline for acceptability.

Chemical Analysis:

TVB-N (mg/100g) was determined according to **EU (1995**). Trimethylamine (mg/100g) was performed according to **Malle and Tao (1987)**. Thiobarbituric acid reactive substances (mg malonaldehyde/Kg) were determined according to **Robles-Martinez *et al.* (1982)**. Fat content was determined according to **FAO (1998**). Salt percent and moisture content were determined according to **AOAC (2003)**.

Bacteriological Analysis:

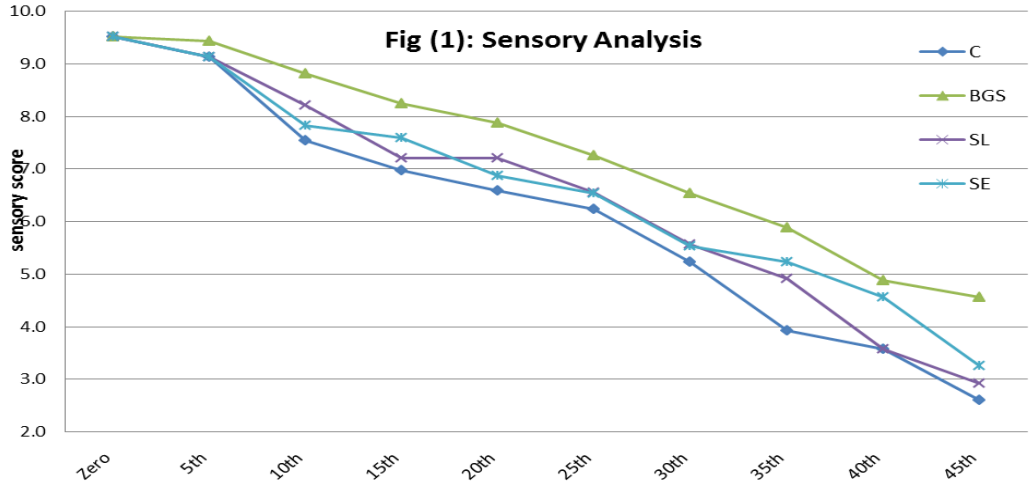
According to **APHA (2001**) a ten-fold serial dilutions (1:10) of food homogenate was prepared using 0.1% peptone water. Total bacterial count (TBC) was carried out using pour plate technique onto plate count agar and incubated at 35°C for 48 hour. Using the same medium, total psychrotrophic count (TPsC) was estimated by incubating the plates at 10°C for 7 days.

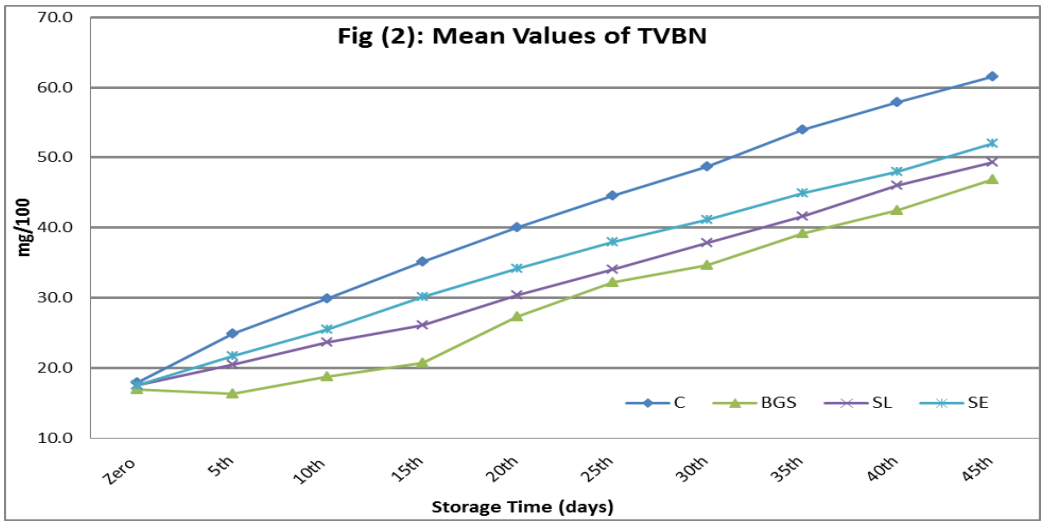
Statistical analysis:

A completely randomized design was selected. The experiment was conducted in three repetitions. Data were analyzed by using the mixed procedure from SPSS software (release 20, IBM CO) after logarithmic transformation. Means were separated by Fisher's least

significant difference test, and significance was tested at $\alpha = 0.05$.

RESULTS





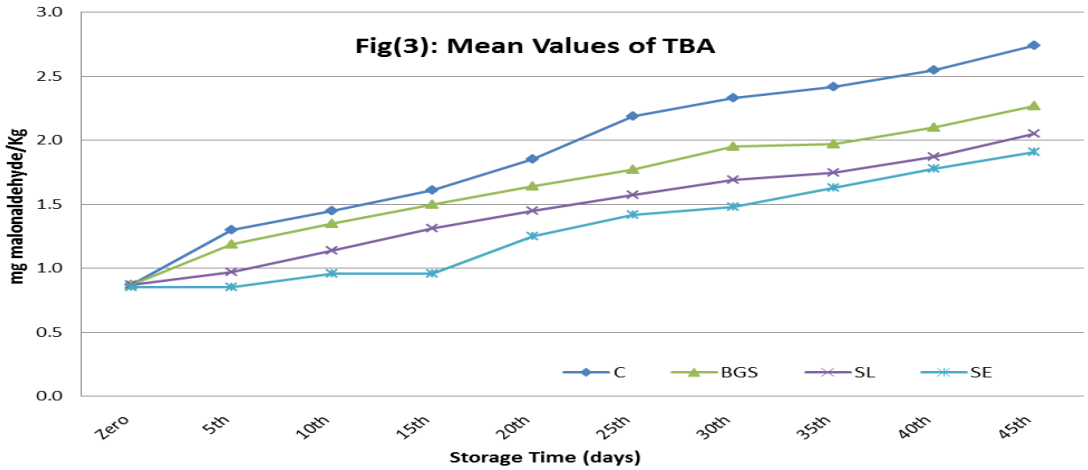


Table (1): Mean values ± SD of TMA (mg/100g) in stored smoked salmon

Group / Time	C	BGS	SL	SE
Zero day	5.18±0.33^{A}	4.86±0.37^{A}	5.18±0.57^{A}	5.26±0.40^{A}
5th day	9.54±0.62 ^{A}	8.34±0.56 ^{A}	8.28±0.43 ^{A}	8.88±0.84 ^{A}
10th day	7.36±0.87^{A}	6.60±0.77^{A}	6.73±0.41^{a}	7.07±1.02^{A}
15th day	13.54±0.62 ^{A}	10.86±2.07^{a}	11.55±0.48 ^{A}	11.57±0.74^{A}
20th day	14.92±1.01 ^{A}	12.47±0.50 ^{a}	12.91±0.67 ^{a}	13.18±0.32^{a}
25th day	16.09±0.81^{A}	13.05±0.61^{a}	14.08±0.68^{a}	13.72±0.46^{a}
30th day	19.41±1.04^{A}	16.63±0.61^{a}	17.50±0.34^{a}	17.11±0.91^{a}
35th day	23.37±0.72^{A}	19.37±1.04^{a}	21.09±1.33^{a}	22.27±1.10^{a}
40th day	24.79±0.61^{A}	20.77±0.58^{aB}	23.72±0.42^{ab}	23.74±0.54^{ab}
45th day	27.62±0.57A	22.82±0.77aB	25.07±0.24ab	25.60±0.66ab

There are significance differences between means that have the same capital and small letter in the same row.

Table (2): Mean ± SD of TBC (log cfu/g) in stored smoked salmon

Group / Time	C	BGS	SL	SE
Zero day	4.25±0.05^{A}	4.25±0.05^{A}	4.26±0.05^{A}	4.21±0.05^{A}
5th day	4.58±0.01^{A}	4.49±0.04^{ab}	4.58±0.03^{B}	4.39±0.02^{ab}
10th day	4.79±0.02^{A}	4.67±0.03^{aB}	4.77±0.01^{bC}	4.60±0.02^{abc}
15th day	5.13±0.02^{A}	4.87±0.05^{aB}	5.01±0.02^{abC}	4.79±0.04^{ac}
20th day	5.22±0.01^{A}	4.94±0.05^{aB}	5.07±0.03^{abC}	4.84±0.05^{abc}
25th day	5.30±0.03^{A}	5.00±0.05^{aB}	4.99±0.03^{aC}	5.08±0.03^{abc}
30th day	5.40±0.03^{A}	5.20±0.03^{aB}	5.05±0.03^{abC}	5.24±0.03^{ac}
35th day	5.63±0.04^{A}	5.22±0.02^{aB}	5.22±0.04^{aC}	5.32±0.02^{abc}
40th day	5.79±0.02^{A}	5.45±0.02^{aB}	5.38±0.03^{abC}	5.57±0.03^{abc}
45th day	6.08±0.05^{A}	5.60±0.04^{aB}	5.57±0.04^{aC}	5.84±0.03^{abc}

There are significance differences between means that have the same capital and small letter in the same row.

Table (3): Mean ± SD of TPsC (log cfu/g) in stored smoked salmon

Group / Time	C	BGS	SL	SE
Zero day	4.58±0.05^{A}	4.29±0.07^{a}	4.19±0.02^{a}	4.48±0.07^{a}
5th day	5.10±0.01^{A}	4.42±0.01^{aB}	4.35±0.01^{abC}	4.79±0.00^{abc}
10th day	5.25±0.02^{A}	4.56±0.03^{aB}	4.66±0.05^{abC}	5.10±0.05^{abc}
15th day	5.39±0.04^{A}	4.73±0.05^{aB}	4.86±0.05^{abC}	5.28±0.03^{abc}
20th day	5.50±0.02^{A}	4.83±0.02^{aB}	4.94±0.02^{abC}	5.34±0.02^{abc}
25th day	5.57±0.04^{A}	4.94±0.03^{aB}	5.00±0.02^{abC}	5.43±0.02^{abc}
30th day	5.61±0.02^{A}	4.98±0.02^{aB}	5.05±0.02^{abC}	5.45±0.04^{abc}
35th day	5.63±0.02^{A}	5.00±0.02^{aB}	5.14±0.02^{abC}	5.51±0.03^{abc}
40th day	5.74±0.01^{A}	5.05±0.01^{aB}	5.22±0.02^{abC}	5.53±0.08^{abc}
45th day	5.82±0.01^{A}	5.15±0.01^{aB}	5.32±0.01^{abC}	5.59±0.07^{abc}

There are significance differences between means that have the same capital and small letter in the same row.

DISCUSSION

Sensory analysis:

As shown in Fig (1) it could be noticed that at zero day, sensory scores of all treatments were 9.51. From the 10th until 20th days; all treatments were significantly higher than control ($P<0.05$). In addition, a significant difference was found between the three treatments in the order of BGS > SL > SE ($P<0.05$). By the 25th, 30th and 35th days of storage, all treated samples were significantly higher than the control ($P<0.05$). BGS treated samples were significantly higher than SL and SE treated samples ($P<0.05$). Control samples became unacceptable recording a score 3.92 at the 35th day. Regarding treated groups, SL became unacceptable at the 40th day, SE at the 45th day; meanwhile, BGS continued to be accepted until the end of storage time with score of 4.56. Our results agreed with those recorded by **Haghparast, *et al.* (2010) and Kashiri *et al.* (2010)** who found that sodium citrate and lactate improved the sensory attributes of rainbow trout fillets and sturgeon fillets and that citrate is better than lactate in terms of color, odor and taste. Sallam (2007a) who found sodium citrate obtained slightly different results and lactate significantly improved sensory score of salmon slices than control but there was no significance difference between them. **Kilinic *et al.* (2009)** also found that sodium citrate and lactate improved the sensory quality

of rainbow trout fillets but lactate is better than citrate. **Song *et al.* (2011)** found that ascorbate extended the shelf life of sea bream to 21 days with sensory score 15.97 versus the control having 12 days shelf life with score 16. In addition, **Fu *et al.* (2012)** found that ascorbic acid improved the flavor of carp. While **Banon *et al.* (2007)** limited the effects of ascorbate that it did not have anomalous impact on the sensory traits of beef patties. **Rostamzad *et al.* (2011)** found that ascorbic acid improved the flesh odor and appearance of Persian sturgeon fillets much better than citric acid. Losing the textural quality of cold smoked salmon is mainly due to autolytic enzymes and the characteristic off odors and off flavors was typical of microbiological activity as suggested by **Dondero *et al.* (2004) and Hansen *et al.* (1996)**. Moreover, **Yerlikaya and Gökoğlu1ge (2010)** added that lipid oxidation and protein degradation cause unpleasant physical and sensory alterations even during freezing process. It should be mentioned that organic acid salts known to have antibacterial and antioxidant effects, which may be reflected upon sensory attributes. The effectiveness of BGS could be attributed to its nature being a combination of sodium citrate, lactate and ascorbate.

Total volatile Basic Nitrogen (TVBN):

As shown in Fig. (2) BGS, SL and SE could significantly lower the TVBN values than the control. Throughout the storage period it was obvious that BGS treated samples recorded the lowest TVBN values among other treatments and SL was lower than SE. However, TVBN values of BGS samples were low significantly for both SL and SE from the 5th day until the 15th day and extended until the 35th day for SE. In the interval between the 15th day and the 25th day, SL samples were significantly lower than that of SE. The ability of organic acid salts to reduce TVBN values were confirmed by several authors. **Song *et al.* (2011)** found that ascorbate treated bream scored (15.79 mg/100g) versus the control (18.54 mg/100g). **Sallam (2007a)** recorded (15.8, 17.8 and 22.8 mg/100 g) for sodium lactate and citrate and the control respectively; also **Kilinic *et al.* (2009) and Masniyom and Benjama (2007)** stated the same results and ranking. **Dalgaard (2000)** in his technical manual produced by the FLAIR-FLOW EUROPE dissemination project and **Rizo *et al.* (2015)** estimated the values of TVBN ranges between 30 - 40 mg/100g at the point of sensory rejection of sliced cold smoked vacuum-packed salmon.Therefore, from Fig. (2) And according to the maximum level of TVBN (40 mg/100g) as mentioned before by **Dalgaard (2000)**; the examined control

samples became rejected at the 20th day, while SE between 25th and 30th, followed by SL between 30th and 35th, and finally BGS between 35th and 40th. Although, there was a strong negative correlation (-0.99) between the TVBN values and the sensory analysis of the product; the Egyptian Standards Specifications did not set limits for the TVBN in smoked fish. Also it shall be noticed that TVBN values reached the maximum acceptable limit five days before the sensory appearance of the product became rejected.

Trimethylamine (TMA):

From (Table 1), it could be concluded that BGS, SL and SE treated samples were lower than the control samples in the course of the storage period, with a variation in the significance between the treatments. From (Table 3), at the end of the storage period, the 40th and the 45th days of examination showed that BGS, SL and SE were significantly lower than the control. According to the Egyptian Standard Specification **(ESS, 2005)** concerning the smoked fish, the maximum acceptable limit of TMA value is 10 mg/100g. In the same time, **Hansen *et al.* (1995)** suggested the same value of TMA at the point of sensory rejection of cold smoked salmon. However, **Dondero *et al.* (2004)** suggested higher TMA value (15mg/100g) found to be at the point of sensory rejection of the vacuum-packed cold smoked salmon**.** Thus, control and the treatments reached this level between 10th and 15th days of storage taking into consideration that BGS was significantly lower than the control and the other two treatments. TMA was negatively correlated (-0.97) with the sensory changes but it appears that, the smoke flavor could mask the alterations in the sensory attributes of the product; taking into account the strong fishy odor accompanying high levels of TMA.

Thiobarbituric acid reactive substances (TBARS):

The used organic acid salts were able to delay lipid oxidation until the end of the storage period. SE was the best antioxidant among the other treatments. SE and SL were significantly lower than the control from the 5th day until the end of the storage period, while the BGS reduction of TBARS compared to the control was only significant from the 20th day until the end compared to the control. SE was significantly lower than both BGS and SL; and SL was significantly lower than the BGS; as shown in Fig (3). Erythorbate potency in retardation of lipid oxidation and thus lowering the TBARS value may be due to its nature as an oxygen scavenger by removing molecular oxygen in polyphenol oxidase reactions **Yin *et al.* (1993); Rico *et al.* (2007); and Pourashouri *et al.* (2009)**. **Nitipong *et al.* (2014)** found that

snakehead fish combined with sodium ascorbate, propyl gallate and packed under vacuum showed an increase from 0.40 to 11.19 mg MDA/Kg after 49 days of storage. While the untreated ones increased from 0.46 to 14.52 mg MDA/Kg. **Song *et al.* (2011)** found ascorbate treated bream to have TBARS (1.02 mg MDA/Kg) while the control was (2 mg MDA/Kg). Similar results were recorded by **Kashiri *et al.* (2010) and Haghparast *et al.* (2010)** who found citrate treated rainbow trout sticks to have significantly lower TBARS values (1.02 mg MDA/Kg) versus lactate (1.32 mg MDA/Kg) and the control (1.91 mg MDA/Kg). **Kilinic *et al.* (2009)** found sodium citrate treated rainbow trout fillets were significantly lower (0.82 mg MDA/Kg) than both lactate (1.41 mg MDA/Kg) and control (1.73 mg MDA/Kg). **Williams *et al.* (1995)** assured the effectiveness of sodium lactate to reduce TBARS values of catfish. In contrast, **Masniyom and Benjama (2007)** found organic acid salts to have a possible adverse effect on TBARS. In the same way, sodium salts of organic acids (citrate and lactate) delay lipid oxidation through inhibition of various spoilage microorganisms **(Sallam, 2007a)**. **Rostamzad *et al.* (2011)** found ascorbic acid to be more effective than citric acid in delaying the lipid oxidation (TBARS values) of Persian sturgeon fillets. They also, suggested a possible powerful combination of the two acids. Even after the sensory deterioration of the product, all test groups didn't reach the maximum acceptable limit of TBARS (4.5 mg MDA/kg) set by the Egyptian standards Specification **(ESS, 2005)**; suggesting that this limit is not reliable for the judging the rancidity of the vacuum packed cold smoked salmon. **Robles-Martinez *et al.* (1982)** set comprehensive recommendations concerning TBARS in relation to the degree of rancidity and overall quality. The range (mg MDA/kg) from 0 to 2.3 is considered not rancid, from1.98 to 4.41 is slightly rancid and over 4.62 is rancid and unacceptable. A level of 2.5 mg MDA/kg was guided (**Huss, 1995).** In technical paper of FAO and the **Canadian Food Inspection Agency (2013)** in its GuidanceDocumentary Repository.Considering this level, the control became unacceptable at the 40th day, but none of the treatments reached that limit taking into account that BGS was close to this rejection limit. As the product is rich in polyunsaturated fatty acids, which made it prone to oxidation and the rise of stale oil flavor had lowered the sensory score remarkably. That accounts for thestrong negative correlation (0.97) found between the sensory analysis and the TBARS value.

Total Bacterial Count (TBC) and Total Psychrotrophic count (TPsC):

Using organic acid salts could significantly lower the TBC when compared with the control samples; however, the results had shown some fluctuations between the three treatments during the storage period. During the interval starting from fifth to the 20th days the count was in the order SE<BGS<SL<C; while during the interval starting from 25th day until the end, the count was in the order SL<BGS<SE<C. According to **ESS (2005)**, the maximum acceptable limit of TBC in smoked fish is log 5 CFU/g. Thus the control exceeded the limit by the 15th day, 30th day for BGS , SE and 35th day for SL**.** Spoilage of lightly preserved fish is caused by the growth and activity of specific spoilage organisms (SSOs) which produce metabolites causing off-flavors or off-odors and consequently cause consumer food rejection as explained by **Gram and Dalgaard (2002)**.In addition,**Gram and Huss (1996)** estimated that, the Gram-negative psychrotrophic bacteria are the major group of microorganisms responsible for spoilage of aerobically stored fresh fish at chilled temperatures. Sodium lactate found to be effective in reducing total plate count of cold smoked salmon versus the control as mentioned by **Simmons *et al.* (1996).** Similarly, sodium lactate was reported to reduce mesophillic count by **Williams *et al.* (1995) and Zhuang *et al.* (1996)**.However, **Nykänen *et al.* (1998)** stated that SL did not exhibit anyantibacterialeffect on rainbow trout. **MasniyomandBenjama (2007)** found sodium lactate to have better antibacterial action than cirate in green mussels. The variation in the antimicrobial properties of sodium lactate in fish products is dependent on several factors; such as the concentration of sodium lactate used, the dipping time, the species of fish, the type of fish product, the degree of microbial contamination, as well as the storage condition **(Sallam, 2007b)**.Regarding ascorbate, similar results for TBC were obtained by **Song *et al.* (2011)** who found that ascorbate treated bream didn't reach log 7 cfu/g; throughout the entire storage period (24 days) while the control reached it at day 17. All psychrotrophic results showed that starting from the 10th day until the end of the storage time, the count reduction was significant between all the tested groups. It was in the following order BGS<SL<SE<C. **Cardinal *et al.* (2004)** found that two thirds of the collected examined cold smoked samples recorded TPsC ranging between log 6 and log 7 while the examined samples did not exceed "the use by date". **Sallam (2007b) and Kilinic *et al.* (2009)** recorded that aqueous solution of sodium lactate and citrate able to significantly delay the microbial growth and extend the shelf life of salmon slices and refrigerated rainbow

trout fillets. Organic acids passively diffuse through the bacterial cell wall and internalizing into neutral pH dissociating into anions and protons. Release of the protons causes the internal pH to decrease which exert inhibitory effects on the bacteria **(Ricke, 2003)**. Erythorbate sequesters iron in meat, not making it available for bacterial growth **(Tompkin, 2005)**.While the antimicrobial effects of lactates are due to their ability to lower water activity and the direct inhibitory effect of the lactate ion **(Koos and Jansener, 1995)**. At the point of sensory rejection of the vacuum packed cold smoked salmon**,** TBC ranges between log 6 and log 8 CFU/g **Jørgensen *et al.* (2001); Arashisar *et al.* (2004); Dondero *et al.* (2004) and Ozogul *et al.* (2004)**. TBC and TPSC showed high negative correlation with the sensory analysis (-0.96 and-0.9) but was far less than that found between the sensory and the chemical parameters examined. **Leori *et al.* (1998)** found similar low correlation between sensory analysis and total bacterial count**.**

CONCLUSION

Generally, organic acid salts have improved the sensory characters and extended the shelf life of the cold smoked vacuum-packed salmon. BGS was the best in lowering TVBN, TMA and psychrotrophic bacteria; consequently, it was the superior in improving the sensory attributes of vacuum-packed cold smoked salmon. SE was the most effective in reducing TBARS and thus controlling the rancidity of vacuum-packed cold smoked salmon. However, SL was very effective only in reducing the total bacterial count.

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