CHANGES IN MICROBIOLOGICAL QUALITY AND SAFETY OF VACUUM-PACKED COLD-SMOKE DURING STORAGE

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ABSTRACT: The first aim of this study was to assess the microbiological quality and safety of ten different brand samples of vacuum-packed cold-smoked salmon, CSS (n=50) from supermarkets of two cities in Egypt. The second aim of the current study was to study the changes in the microbiological quality and safety of CSS (Salmo salar) that obtained from one factory located in 10th Ramadan City after their directly production. Samples from the factory were stored at 5 and 0°C and then examined after 0, 7, 14, 21, 28 and 35 days of storage. For all samples, microbiological parameters [total bacterial counts (TBC), total lactic acid bacteria (LAB), lactobacilli count, Pseudomonas group and Enterobacteriaceae count] were performed at the same time. Pathogenic microorganisms (Staphylococcus aureus and Listeria spp.) were examined in all samples. These pathogenic bacteria were not detected in all factory samples tested and during the time of storage. The TBC, LAB, lactobacilli count, Pseudomonas group and Enterobacteriaceae family showed a significant increase with storage time and temperature regimes. Shelf lives of smoked salmon stored at 0 and 5°C were 26 and 8 days, respectively. Lactobacillus spp. and Pseudomonas spp. were dominant in terms of deterioration in quality.

Key words: Smoke salmon, safety, quality parameters, microbiological evaluation, pathogenic microorganisms.

INTRODUCTION

Smoking is besides drying one of the oldest methods of preserving fish. There are fundamentally three stages of cold smoke processing which contribute to the preservative effect: salting, dehydration, and smoking. Salting and dehydration (the latter is a direct effect of smoking) lower the water activity (aw), thereby inhibiting the growth of bacteria and mold, which generally cannot grow at aw lower than 0.86 in the presence of soluble salt (Sperber, 1983; Løvdal, 2015). In addition, the chlorine ions are toxic to some microorganisms. Anonymous (2001). The bacteriostatic effect of smoke is mainly due to phenols. Drying times, after salting, range from 1 to 6 hr., at 20-28°C, smoking parameters at a maximum of 30°C ranges from 3 to 6 hr., and the recommended smoke chamber temperature combinations must not exceed 32°C for more than 20 hr., and 10°C for more than 24 hr., (Anonymous, 2001; Muñoz et al., 2020). In addition, cold smoked salmon (CSS) is characterized by specific chemical properties, i.e., lipid <18% (W/W), water content <74%, a NaCl concentration between 2.5 and 3.5% (W/W), and smoke treatment corresponding to 0.6 mg of phenol per 100 g of product (Leroy et al., 2000, 2001). CSS is therefore classified under lightly preserved fish products which include fish products preserved with low levels of salt (<6% NaCl (W/W) in the water phase) and the addition of preservatives such as sorbate, benzoate, NO2, or smoke for some products. These products have a high pH (>5.0), they are often packed under vacuum and must be stored and distributed at cool temperatures (5°C). pH in CSS varies

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between 6 and 6.3 (Gram, 2001). CSS is considered a delicacy commonly consumed as a 'ready-to-eat' (RTE) product without heat treatment (Gram and Huss, 1996; Chan et al., 2020). The production and consumption of cold smoked salmon have been increasing in the last decade; for example, Spain represents the sixth highest European country in terms of consumption of smoked salmon (IRI, 2015). CSS, like other cold smoked fish products, is often consumed as RTE with no heat treatment, although it is also suitable as a cooking ingredient in, for example, various casserole dishes.

Anyway, the absence of thermal treatment makes the parameters salting and smoking utmost important in order to minimize the risk of foodborne hazards and spoilage. Salting and drying (also as an effect of smoking) are crucial steps to achieve the ideal water phase salt (WPS) level. Salt can be applied in dry form (dry salting), as brine, or by injecting brine. When liquid smoke (LS) is utilized as an alternative to traditional generated wood smoke, this is normally injected, sometimes combined with the brine, to achieve smooth and even colouring of the product. At the same time, processors of smoked salmon have made efforts to adapt their production parameters to this raw material in order to respect the market demand and to satisfy their requirements for profit. The choice of the processes used (salting techniques, drying and smoking procedures, type of equipment) is large and for each step of the process, the choice of control parameters such as time of salting, the concentration of brine, or smoking temperature allows specific finished product characteristics to be reached (Indrasena et al., 2000; Rizo et al., 2017). The knowledge of raw material characteristics is an important factor to control in order to obtain the required product quality and many studies have shown their effects on final characteristics and yield (Beltran and Moral, 1991; Rora, et al., 1998; Cardinal et al., 2001). Also, the wide range of raw salmon characteristics as well as the many salting and smoking techniques used by different processors gives rise to a wide range of smoked salmon characteristics available in the market. All year rounds there are wide selection of products available to consumers. However, consumers have great difficulties in identifying criteria in order to be able to choose a product according to their preference. Often, the only information available which can help consumers to make their selection are the appearance (e.g., the colour) of the product, the brand name, processing references e.g., dry salting, the shelf life of the product, and of course the price. Recent French market surveys on smoked salmon products, published by consumer review point out a general decrease in quality of smoked 3 salmon on the market (Maleysson and Bonneff, 2001; Anonymous, 2002; Pedro and Nunes, 2019).

However, the main criticisms on the quality of the product refer to the appearance, the texture related to fat content, the level of salt and the taste. A study performed on the Italian market reveals that the hygienic quality of the smoked salmon is poor at the expiry date (Vergara et al., 2001). Quality is one of the most frequently used words relating to food. However, it is exceptionally difficult and complicated to define quality in terms that are widely understood (Meiselman, 2001). Smoked salmon is a ready-to-eat food, normally vacuum packed, with a refrigerated shelf-life of 3-8 weeks (Rørvik, 2000). Cold smoked fish is usually consumed without any further cooking (Eklund et al., 1995; Gudmundsdóttir et al., 2005), and salmon has a high lipid content which may protect microorganisms from a possible thermal treatment or from freezing. The production of smoked salmon includes several technological steps, such as filleting, salting (dry-salting or brine microinjection), drying, smoking, trimming and packaging, that require a lot of handling by workers (Rørvik, 2000). The spoilage bacteria depends on the type of processing. The microflora in spoiled CSS also varies widely between different processing plants and smokehouses (Hansen and Huss, 1998; Hansen et al., 1998). The aim of the present study was to describe the smoked salmon characteristics sold on the Egyptian markets by microbiological analyses and physical measurements (colour, expressible liquid), chemical analyses (pH values) in order to get an objective overview of the quality of the smoked salmon.
MATERIALS AND METHODS

Materials

Sampling from supermarkets

Samples of commercial smoked salmon products were collected from supermarkets of two cities, Egypt. Supermarkets were chosen as a favorite market for most consumers. Samples of sliced vacuum-packed cold-smoked salmon (Salmo salar) were purchased during January, February, and March 2019, sent to Agricultural Microbiology Laboratory in refrigerated truck. In total, 50 samples were received: 25 samples (A-E=25) from Tenth of Ramadan City (these products were produced in this city) and 25 samples (F-J=25) from El-Obour City. Altogether the sampling corresponded to different producers in Tenth of Ramadan City.

Sampling from industry

Samples of smoked salmon were then ordered directly from one factory named A in Tenth of Ramadan City. This was done in order to control our experimental design according to the shelf life of the product. All the samples were vacuum packed and evaluated after 0, 7, 14, 21, 28 and 35 days of storage at 0°C and 5°C in order to include the effect of the shelf life in the study.

Methods

Microbiological analysis

Total bacterial counts (TBC), Total lactic acid bacteria count (LAB), lactobacilli count (LC), Enterobacteriaceae count (ENT), staphylococci count (SC), Staphylococcus aureus, psychrotrophic count (TPC), Listeria spp. and Pseudomonas spp., were determined as described by US Food and Drugs Administration (FDA, 1992). In briefly, after 30 min at room temperature for resuscitation, when sensory evaluation was carried out, three packages per sample were opened and a 10 g portion of each bag, representing all the slices, was stomached in 90 ml buffered diluents (0.85% NaCl and 0.1% peptone) for two min in a stomacher 400 (Lab. Blender, London, UK). Ten-fold serial dilutions were spread or poured on selective agar media for count of different microorganisms.

For the first experiment (Microbiological analyses of market samples of smoked salmon), total bacterial count (TBC) was counted on plate count agar (PCA; Merck, 1.05463) incubated at 25°C for 72 hr. Spread plates of modified Long and Hammer’s medium (Van Spreekens 1974) incubated at 15°C for 5 days were used to determine the total psychrotrophic count (TPC).

Total lactic acid bacteria (LAB) was enumerated on spread plates of Nitrite Actidione Polymyxin agar (NAP, Davidson and Cronin, 1973) at pH 6.8 and lactobacilli on MRS (ROG, Biokar, Beauvais, France) at pH 5.5 as suggested by Leroi et al. (2000). NAP and ROG plates were incubated at 20°C in anaerobic conditions (Anaerocult A, Merck, Darmstadt, Germany). At least 10 colonies grown in NAP and Rogosa agar with different morphologies were phenotypically characterized according to the Bergey Manual of Systematic Bacteriology, 8th edition. The colonies were classified according to their shape, colour, edge and size, and at least 10–15 colonies per plate were picked up and purified by plate-streaking technique, to detect the dominant bacteria in CSS. Presumptive LAB (Gram+ and catalase -) colonies were transferred into MRS broth (Merck) containing 40% (V/V) sterile glycerol (Merck) solution and stored at −25°C until identification and used in the other research. Enterobacteriaceae counts were determined in pour plates of CASO agar (Merck) overlaid by Violet Red Bile Glucose agar (Oxoid), incubated at 30°C for 2 days.

Assuming that non-typical colonies could also belong to the Enterobacteriaceae family, all the colonies growing in the plate were enumerated after 48 hr. of incubation at 30°C. Staphylococci were counted on Baird Parker agar (Biolife, Milano, Italy) supplemented with egg yolk incubated at 37°C for 48 hr. Staph. aureus was detected by examining the plates for typical black colonies, convex colonies, with a light halo, and these were tested for positive coagulase reaction (Bactident Coagulase Biolife, Milano, Italy). Enumeration of Pseudomonas spp. was performed by spread plate method on Pseudomonas agar base media (Biolife, Italy) and incubated at 25°C for 48 hr. Listeria spp. were determined by surface plating on polymyxin-acriflavine-lithium chloride-ceftazidime-aesculin-mannitol agar (PALCAM, Biolife,
Italy) and the plates were incubated at 30°C for 48 hr.

For the second experiment (Microbiological changes in smoked salmon during storage), total bacterial count (TBC), Enterobacteriaceae counts, total lactic acid bacteria (LAB) and Pseudomonas spp. were determined according the procedures above.

**Sensory and pH evaluation**

A descriptive test with conventional profiling (Stone and Sidel, 1985) was carried out in industry samples to evaluate the sensory characteristics of smoked salmon. All samples were scored by twenty panelists belonging to the Agric. Microbiol. and Food Sci. Depts. Fac. Agric., Zagazig Univ. staffs and trained on sensory descriptors for smoked salmon. The descriptors related to the appearance, odour, flavour and texture of smoked salmon slices. An experimental design was constructed in order to balance various parameters, the characteristics of products presented within a session (it was decided to present samples that had previously identified as samples belonging to different groups at the same session), the company of production of the product and the remaining shelf life.

According to the package weight (100g or 200g), seven to fourteen packages from each sample were necessary to give one slice to each panelist. All samples were stored at 0.0 or 5.0 °C until sensory analysis was performed. The day of sensory analysis, the packages of smoked salmon were opened and kept open for 15 minutes at ambient temperature, after that every 6 slices was individually repacked in aluminum foil. Panelists rated the sensory attributes on a continuous unstructured line scale from low intensity (0) to high intensity (10). Products were assigned 3-digit numbers, randomised and served simultaneously. Botelled water and balady bread were presented between samples. A sensory description test was performed on each product by a panel consisting of 5 people with a large experience in tasting smoked salmon. The following criteria were used: odour, appearance, flavour, and texture. Each panelist described the main characteristics of the products as well as the intensity of perception. All samples were evaluated and assessed. After an individual evaluation of each product, a discussion allowed panelist's descriptions to be compared, and samples were gathered in class according to their common characteristics. Finally, this screening allowed products to be sorted out, and 100 products were selected. The remaining flesh in the 3 packages opened for microbiological analysis was homogenized in a Warring Blender. The flesh was diluted five times with distilled water and measured using a pH meter, Mettler 320 (Mettler-Toledo, England).

**RESULTS AND DISCUSSION**

**Microbiological Results of Market Samples of Smoked Salmon**

This study was performed to examine the microbiological quality and safety of cold smoked salmon sold in Egypt from different markets on either plate counts or selective agar. The results of total bacterial counts (TBC), total psychrotrophic count (TPC), total lactic acid bacteria (LAB), lactobacilli count (LC), Enterobacteriaceae count (ENT), total staphylococci count (SC), Staphylococcus aureus and Listeria spp. are shown in Tables 1 and 2. A total of 50 samples of cold smoked salmon (n=50) were purchased from various markets to examine the safety and quality of different brands sold from different factories. The TBC and TPC were very different from one sample to another, which ranged from 2.67 to 6.70 Log CFU/g and 2.17 to 7.30 Log CFU/g, respectively except the F and H samples. The TBC and TPC in F and H samples were ranged between 6.70 to 6.24 and 7.30 to 7.10 Log CFU/g, respectively. Among samples that had not exceeded 6 Log CFU/g which means these samples do not pass the existing regulation (for the Egyptian and French market where the limit is 6 Log CFU/g). However, it is important to point out that the TBC and TPC were enumerated by spread plates onto PCA and LH media, respectively instead of the pour plate media onto PCA that recommended in the European standard, and it has been clearly shown that counts on LH are generally one logarithm higher than PCA counts (Joffraud and Leroi, 2000). Final report of European contract FAIR-PL- 95-1207- Spoilage and safety of cold-smoked fish).
Table 1. Total bacterial count (TBC), Total psychrotrophic count (TPC), lactic acid bacteria (LAB), lactobacilli and *Pseudomonas* spp., in cold smoked salmon from different supermarkets (log CFU/g)

| Smoked salmon brand sample (n=50) * | TBC    | TPC    | LAB    | Lactobacilli | *Pseudomonas* spp. |
|-----------------------------------|--------|--------|--------|--------------|--------------------|
| A                                 | 2.67±0.22 | 2.17±0.12 | 2.25±0.25 | 2.15±0.22 | 1.22±0.12 |
| B                                 | 3.70±0.23 | 3.10±0.13 | 2.72±0.34 | 1.92±0.28 | 1.74±0.34 |
| C                                 | 3.85±0.32 | 3.35±0.30 | 2.83±0.12 | 1.87±0.29 | 1.82±0.19 |
| D                                 | 2.88±0.11 | 2.28±0.21 | 2.11±0.54 | 2.09±0.19 | 1.14±0.17 |
| E                                 | 3.78±0.24 | 3.18±0.29 | 2.73±0.24 | 2.89±0.24 | 1.71±0.11 |
| F                                 | 6.70±0.32 | 7.30±0.12 | 2.76±0.11 | 2.55±0.23 | 5.72±0.29 |
| G                                 | 3.90±0.13 | 3.40±0.11 | 2.92±0.58 | 2.62±0.09 | 1.61±0.18 |
| H                                 | 6.24±0.19 | 7.10±0.15 | 3.10±0.45 | 3.18±0.11 | 2.40±0.19 |
| I                                 | 3.78±0.18 | 3.18±0.12 | 2.38±0.23 | 2.18±0.19 | 1.48±0.17 |
| J                                 | 4.38±0.13 | 4.18±0.17 | 3.48±0.24 | 2.38±0.21 | 2.06±0.11 |

All values reflect the mean values of 3 replicates and standard errors. *The name of the brands: A-J. each brand 5 samples were analyzed.

Table 2. Total *Enterobacteriaceae* group (ENT), staphylococci count (SC) *Staph. aureus* and *Listeria* spp. in cold smoked salmon from different supermarkets (log CFU/g)

| Smoked salmon brand sample (n=50) * | ENT     | SC      | *Staph. aureus* | *Listeria* spp. |
|------------------------------------|---------|---------|-----------------|-----------------|
| A                                  | 1.22±0.22 | 2.15±0.25 | 2.15±0.13 | 1.12±0.11 |
| B                                  | 2.75±0.23 | 3.12±0.15 | 2.91±0.16 | 1.71±0.13 |
| C                                  | 1.95±0.32 | 3.13±0.08 | 2.81±0.15 | 1.32±0.14 |
| D                                  | 1.58±0.11 | 1.71±0.23 | 1.18±0.11 | 1.14±0.15 |
| E                                  | 2.38±0.24 | 3.03±0.21 | 2.81±0.09 | 1.41±0.23 |
| F                                  | 1.73±0.32 | 2.56±0.13 | 2.15±0.07 | 1.62±0.34 |
| G                                  | 2.50±0.13 | 2.42±0.26 | 2.12±0.16 | 1.51±0.16 |
| H                                  | 2.06±0.19 | 3.00±0.19 | 2.28±0.15 | 2.49±0.10 |
| I                                  | 1.88±0.18 | 2.68±0.11 | 2.38±0.14 | 1.38±0.16 |
| J                                  | 1.08±   | 2.14±0.13 | 2.36±0.15 | 2.30±0.23 |

All values reflect the mean values of 3 replicates and standard errors. *The name of the companies: A-J. each brand 5 samples were analyzed.
Based on the different microbiological counts, the 50 samples could be divided into 2 groups. Group 1 consisted of samples with generally high contamination level (TBC > 6 Log CFU/g). Group 2 consisted of samples with generally low contamination level (TBC < 6 Log CFU/g). However, most samples were composed of a mixture of LAB (mostly Lactobacillus), Enterobacteriaceae, staphylococci, Pseudomonas and in a lesser extend Staph. aureus and Listeria spp. As TPC of F and H samples were on average one log higher than the other TBC, and based on results from Leroi et al. (1998, 2001), their results also presume that marine Gram-negative bacteria such as Vibrio spp, Photobacterium sp, Aeromonas, Shewanella spp. are also dominant. LAB and lactobacilli were the dominating flora in the examined samples while staphylococci were dominated and higher than Enterobacteriaceae and Listeria spp. in all the tested samples. Groups A and D consisted of samples with better hygienic profile. Groups A, B, C, D, E, G, I and J consisted of samples with a relatively low TBC, TPC, LAB and ENT but with different qualitative microflora composition. Microflora of group H (5 samples) was dominated by Pseudomonads, probably belonging to Pseudomonas genus, while lactobacilli selective count on Rogosa agar was very low (3.18 Log CFU/g). In Group F (5 samples), all counts enumerated on selective media were very high and TPC was probably constituted of Pseudomonas. Group A (5 samples) was a particular group, consisting of samples for which all the counts were below than all the tested groups. The presence of staphylococci may have been due to the fact that these foods were often prepared hardly in final packaging and this direct contact may lead to an increase of contamination with Staphylococcus (Colombari et al., 2007; Dalgaard and Mejholm, 2019). The results of this study indicated that there were some poor handling practices during the preparation of smoked salmon which require more attention. In spite that, Pathogenic microorganisms (Staphylococcus aureus, and Listeria monocytogenes) were examined in all samples and were not detected in all the fifty samples tested (the data not shown).

Microbiological Changes in Smoked Salmon during Storage

The results of total bacterial counts (TBC) and total lactic acid bacteria (LAB) made on cold smoked salmon are presented in Fig. 1. There was a positive increase in both TBC and LAB with storage temperatures and time. The LAB and TBC at the beginning of storage ranged from 2.62 to 3.95 Log CFU/g, respectively. At the end of shelf life, after 28 and 14 days, at 0 and 5°C, respectively, levels of 6 and 6.28 Log CFU/g were reached. However, Sernapesca (1996), established limits for total viable count of bacteria between 10^5 and 5 × 10^5 CFU/g. Truelstrup et al. (1995) also found that cold-smoked salmon with a high number of microorganisms (10^8 CFU/g) was not always spoiled. The results of Pseudomonas group and Enterobacteriaceae count are shown in Fig. 1. The ENT and Pseudomonas ranged from 1.30 to 2.0 Log CFU/g at the beginning of storage and after 28 and 14 days at 0 and 5°C, levels of 2.77 and 3.40 Log CFU/g and 2.58 and 3.97 Log CFU/g were found, respectively. No correlation was found between ENT storage time and temperature. Staphylococcus aureus and Listeria monocytogenes were not detected in cold-smoked salmon throughout storage time at 0 or 5°C. Truelstrup et al. (1996) have reported that yeasts and molds were not considered to be of any importance for spoilage of cold smoked salmon. However, lactic acid bacteria dominated the microflora throughout the storage period of cold smoked salmon (Fig. 1). This was also reported by Leroi et al. (1996 and 1998). The lactic acid bacteria group (LAB) is known to produce organic acids and ethanol as typical fermentation end products (Gottschalk, 1986).

In the case of smoked-salmon, the roles of the microflora are not as clear as many authors have shown, in that there is no correlation between shelf life and LAB count, or any other bacterial number (Dodds et al., 1992; Chan et al., 2020). They may be found in high numbers before the product is spoiled (Truelstrup et al., 1996). Lactobacillus spp., showed significant correlation with storage time and sensory quality at all storage temperatures. Differences among the microflora isolated from three different smokehouses and production batches, indicate
that the existence of one typical microflora including one specific spoilage organism for cold smoked-salmon is unlikely. The microflora at the time of spoilage is highly variable with lactic acid bacteria, Enterobacteriaceae and marine bacteria among the dominating microorganisms (Truelstrup et al., 1998). The bacteria mainly responsible for spoilage in sterile cold-smoked salmon stored in vacuum packs at 5°C were Lactobacillus. sakei, Lactobacillus. farciminis and Brochthrix thermophacta, which produced sulphurous, acidic and rancid off-odours, respectively. Some strains of Streptococcus. liquefaciens produced rubbery, cheesy or acidic off-flavours. Some Photobacterium. phosphoreum isolates were characterized by an acidic effect (Stohr, et al., 2001). In cold-smoked fish, aerobic conditions lead to faster spoilage than under vacuum or modified atmosphere packaging. Under aerobic conditions, Pseudomonas and some lactic acid bacteria developed, whereas anoxic packaging conditions resulted in development of lactic acid bacteria with a minor component of Gram-negative bacteria. Typically, shelf life is reduced by aerobic storage as compared to vacuum-packed storage (Dufresne et al., 2000; Gram, 2001).

Sensory Evaluation and pH

Results of the sensory analyses and pH values of cold-smoked salmon at 0 and 5°C are shown in Fig. 2. The results showed reduction in mean sensory scores and pH levels during storage at 0 and 5°C. With increasing storage temperatures, decreased shelf life was obtained. The spoilage patterns described by the panelists were: softening of texture before off-odours developed and presence of bitter, sour, rancid and ammonia off-flavours. Appearance score decreased as colour discolouration increased. Autolytic enzymes can have a major impact on the loss of textural quality of cold-smoked salmon during the early stages of deterioration, but they did not produce the characteristic off-flavours and off-odours, which are typical of microbiological activity (Truelstrup et al., 1996). Shelf-life values were 28 and 7 days for samples stored at 0 and 5°C, respectively. Truelstrup et al. (1998), found that the estimated shelf life at 5 and 0°C of vacuum-packed slices of cold-smoked salmon

Fig. 1. Changes in total bacterial count (TBC), lactic acid bacteria (LAB), Pseudomonas spp. and Enterobacteriaceae count (Log CFU/g) in vacuum-packed cold-smoked salmon during storage
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Fig. 2. Changes in pH value and sensory scores in vacuum-packed cold-smoked salmon during storage

ranged between 21 and 36 days, respectively. Shelf lives of whole fillets were always longer than shelf lives of the corresponding sliced products. It may, however, be difficult to compare salmon produced by different smokehouses because a number of important factors, such as packaging material, production method, size and composition of initial microflora, numbers of freezing and thawing cycles and quality of raw material, varied and this may explain why salmon with 4.1% and 6.1% salt in the water phase, had comparable longer shelf lives. For French vacuum-packed cold-smoked salmon stored at 5 °C, the shelf life was very variable (1–6 weeks) and was related to the initial Enterobacteriaceae load, depending on hygienic conditions in the smokehouse rather than on the material quality or the processing parameters (Leroi et al., 2001).

Based on our results, for Egyptian vacuum-packed cold-smoked salmon stored at 0 or 5°C, the shelf life was very variable (4 or 2 weeks, respectively). Estimation of cold-smoked salmon quality is possible by measuring three parameters: TBC, LAB and lactobacilli concentration. Positive correlations were found between storage time, sensory quality and TBC, LAB, Lactobacillus spp., and pH values at different storage temperatures. These indicators were found to be superior as an indicator of quality because a clear relation to sensory evaluation could be established.

Conclusions

According to microbiological quality and sensory analysis of vacuum-packed cold smoked salmon presented a shelf life of 28 days at 0°C and 14 days at 5°C. TBC, TPC, LAB and Lactobacillus spp., were the most suitable indicators to determine cold smoked salmon freshness. There was a significant correlation of these variables with storage time and sensory analysis at different storage temperatures. Pseudomonas and ENT were not useful deterioration indicators of cold smoked salmon at temperatures in the range of 0–5°C. Pathogenic microorganisms such as L. monocytogenes and Staph. aureus were not detected in cold-smoked salmon.

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العنوان:
التغيرات في الجودة الميكروبيولوجية وسلامة السلمون الهوائي أثناء التخزين

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