CHANGES IN CHEMICAL COMPOSITION AND BACTERIAL COUNT OF CANNED TUNA FISH IN DIFFERENT PACKING SOLUTIONS AND OILS DURING STORAGE

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Abstract

The effect of canning in different oils such as olive oil, cotton seed oil and mixture of the two oils (1 : 1 v/v) with different packing solutions such as nisin, lemon juice and salt solution, and sterilization at 110 °C for 55 min and 121 °C for 40 min then stored at room temp for 6 months was studied. Different treatments were subjected to chemical and microbiological examination during subsequent storage. The obtained results revealed that the moisture, protein and fat contents were decreased, while, the results indicated a remarkable increase in ash content in all canned samples during storage period for 6 months at room temperature. An increase in total bacterial count of canned tuna fish samples without growth of *Clostridium botulinum* during storage period for 6 months at room temperature was recorded. Based on the foregoing results of this investigation, it could be concluded that lemon juice solution at pH 4 as a natural material can be used as a packed solution in canned fish in order to reduce time of heat processing without consequent spoilage during the storage.

INTRODUCTION

Canning and freezing are the preferred methods for long term preservation of fish. It is axiom that the quality of the canned product depends primarily upon the raw material. Beamonte and Castrillon (1989) found that, white tuna muscle, in the canned product, had low fat content. This may be due to removal of the red meat because canned tuna are often considered by consumers to be of a lesser quality when contained muscle. They decleared that, after being steam-cooked, the tuna lost 8 % of its water. This decrease in water content resulted in an increase in protein and fat in the cooked fish. Perez *et al.* (1997) examined the nutritional value of four kinds of canned sardines in olive oil, soybean oil, tomato sauce and a marinade. In the results, it was shown that the content of protein and ash was similar in the four preparations, but not in the level of fat, which was higher in the preparations with oil. The

composition of fatty acids had more to do with the kind of oil used in the preservation of the food than with the commercial preparation of it. Medina *et al.* (1998) declared that, among packing oils used in the fish canning industry, extra virgin olive oil (EVOO) contains natural polyphenols that inhibit fish lipid oxidation during the canning of tuna. The natural polyphenols from EVOO may act as free radical acceptors as well as metal chelators. Although fish lipid oxidation was accelerated in brine and refined olive oil packing media and decreased the quality of canned fish, these effects were inhibited when EVOO was used as the packing medium. However, the strong fruity flavour of EVOO and its higher cost may limit its use in fish processing because oils such as olive oil and seed oils are subjected to lose of natural antioxidants during refining.

From the microbiological point of view, Palomares *et al.* (1986) declared that the thermal processes established allow a spoilage rate of 1 Can/100000 cans. This would ensure the destruction of *Clostridium botulinum*. Storage studies were conducted over 1 year for the 2 canned products. Microbial examinations showed negative growth for pedophilic anaerobes and hemophilic flat sour organisms for 8 weeks at accelerated conditions of 37 °C and 1 year at room temperature (28 – 30 °C). Invariable cut out values, acceptable sensory, acceptable scores and negative rancidity responses resulted throughout the storage period. Bibek (1992) reported that, nisin possesses antimicrobial activity against the gram – positive organisms including many of those bacteria that produce spores. Nisin inhibits the out growth or spores and causes lysis of vegetative cells. Important spore formers that are inhibited include *Clostridium botulinum*, the causative organism of botulism. Besides, the extremely heat resistant spoilage organisms such as *Bacillus stearothermophilus*, *Clostridium sporogenes* and *Clostridium thermossacharolyticum*. This activity against heat resistant spores is very important property of nisin. Nisin also is active against certain non-spore forming bacteria as staphylococcus, micrococcus and lactic acid bacteria. Furthermore, nisin resists the growth of the pathogenic organism, *Listeria monocytogenes*. Nisin does not inhibit gram negative organisms, yeast or fungi.

This work was carried out to study the effect of different temperature and time of sterilization, using different oils (olive, cotton seed oil and mixture of each 1 : 1 v/v), different packing solutions (nisin, lemon juice and salt solution) and the storage at room temperature for six months on the chemical composition and bacteriological status of canned tuna fish.

MATERIALS AND METHODS

This study was carried out in the Central Laboratory for Aquaculture Research (CLAR), Agricultural Research Center, Ministry of Agriculture Abbasa, Abou-Hammad,

Sharkia governorate in cooperation with United Food Products Company Ismaelia industrial zone.

Sampling

Tuna fish was obtained from the local market (El-obor), samples weighted 50 Kg. The fish was cleaned and washed using tap water, then the head and all fins were removed using a sharp knife. The internal viscera were removed by hand, after which the eviscerated fish was washed in tap water. The tuna samples were packed in ice boxes and transported to the factory in the second industrial zone of Ismailia (United Food Products Company).

The samples were soaked in saturated salt solution with a little of acetic acid (6 %), followed by washing the samples using tap water to remove the over salt. The fish samples were cutted and packed in the cans. The tuna sample can weight was 105 g (75.0 g tuna, 10.0 ml oil and 20.0 ml packing solution.) The olive oil, cotton seed oil and mixture of each (olive oil and cotton seed oil 1 : 1 v/v) were added for every can.

On the other hand, packing solution consists of: salt solution [prepared from commercial salt containing sodium chloride 2.0 % (w/w), 3.5 % vinegar (6 % conc.), and 1.5 % spices mixture (which consists of 22.5 % coriander, 7.5 % cubeb, 15.0% cummin, 32.0% black pepper, 9.0 % red pepper, 10.0% cardamon and 40.0 % cloves)]. Lemon juice solution prepared from lemon juice and the already prepared salt solution. The pH of a stock lemon solution was adjusted at pH 4, and nisin solution prepared from a commercial preparation containing (14 p.p.m) nisin. The commercial preparation was dissolved in salt solution prepared using HCl 0.02 N to pH 2- 4 in which the nisin will be dissolved (Kelley *et al.*, 1999). The pH of a nisin stock solution was adjusted to pH 4 using pH-meter (Orion Research Digital Ion analyzer, Model 420A.). These solutions were added to each can.

Pre-heating: Samples of tuna fish were pre-heated by steaming at (100 °C for 30 min) and then sealed.

Sterilization of the cans: Sterilization was performed at 110°C and 121°C for 55 and 40 min at pressure, respectively. After sterilization, the cans were cooled for 10 min using cold water. The cans were carefully dried and incubated for 21 days at 37 °C, after which, they were stored at room temperature for 6 months. Samples were periodically withdrawn every month for analysis.

Analytical procedures

Moisture content was determined by oven drying at 105°C to constant weight as mentioned in the A.O.A.C. (1990). Crude protein was determined by Kjeldahl

procedure using a 6.25 conversion factor according to the method described in the A.O.A.C. (1990). Total lipids were measured by extraction from a 2-g portion of dried samples for each treatment A.O.A.C. (1990). Ash was determined by ashing at 550 ºC using a muffle furnace according to the method described in the A.O.A.C. (1990). Total bacterial count,was carried out using the plate count method described by Frazier and Foster (1959) which was adopted using nutrient agar medium which contained 3.0 g. beef extract, 5.0 g peptone and 15.0 g agar in liter of distilled water pH (7.0). One ml from each dilution was plated in the above medium in replicates and incubated at 37ºC for 48hours. The bacterial count was then calculated per 1.0 g sample. Anaerobic thermophilic colony count of *Clostridium botulinum* was carried out according to the method reported by Anderson (1951). The composition medium used was as follows: yeast extract 3.0 g, beef extract 10.0 g, peptone 10.0g, dextrose 5.0 g, soluble starch 1.0 g, sodium chloride 5.0 g, cystein hydrochloride 0.5 agar 15.0 and distilled water 1000 ml, the pH of the final medium was 6.8.

Statistical analysis

Three replicates of each trial were performed for analysis. Moisture, protein, total lipids and ash data were statistically analyzed using ANOVA, and means were separated by Duncan' test at a probability level of $P < 0.05$ (SAS, 2000).

RESULTS AND DISCUSSION

I. Effect of storage period at room temperature on the changes of some physicochemical and chemical properties of canned tuna fish.

Moisture content

The moisture content of canned tuna in different packing solutions (salt, lemon juice and nisin solution) and different oils (olive, cotton seed oil and mixture of each 1 : 1 v/v) sterilized at 110 °C for 55 min and 121 °C for 40 min are shown in Table 1.

Results showed that, moisture content at the end of storage period, was 58.52, 58.36 and 58.54 % at 110 °C for canned tuna samples treated with lemon juice solution in presence of olive, cotton seed oils and mixture of each 1 : 1 v/v respectively, and 58.40, 58.21 and 58.39% at 121 °C for the same samples. There were significant differences between packing solutions, while, no significant differences were noticed between packing oils ($P < 0.05$) in all canned samples. These results are in agreement with those obtained by El-Samkary *et al.* (1997) and Baltasar *et al.* (1998) who found that different samples of canned silver carp fish were subjected to chemical analysis as well as organoleptic evaluation. The moisture content and protein of fresh silver carp were 77.09 % and 82.9 %, respectively. Fat, ash and the moisture content were decreased as the time of storage increased.

Crude protein

Data in Table 2 illustrated the changes in crude protein of canned tuna fish packing in different solution salts, lemon juice and nisin solution in presence of olive, cotton seed oil and mixture of each 1 : 1 v/v and sterilized at 110 °C for 55 min and 121°C for 40 min.

The crude protein of canned tuna fish (Table 2) packed in salt, lemon juice and nisin solution in presence of olive oil and sterilized at 110 °C was 71.38, 71.93 and 71.70 %, while, at 121 °C it was 71.48, 72.00 and 71.74 %, respectively. In cotton seed oil treatment, crude protein was 71.33, 71.87 and 71.62 % at 110°C and 71.45, 71.95 and 71.69 % at 121 °C. On the other hand, in the presence of mixture of each (1 : 1 v/v) treatment it was 71.34, 71.90 and 71.64 % at 110 °C and at 121 °C it was 71.46, 71.96 and 71.73% for the same samples, respectively. There were no significant differences between packing solutions and between packing oils ($P < 0.05$) in all canned samples. At the end of storage period at room temperature for 6 months, the above results revealed a decrease in the crude protein of canned tuna fish in all samples. This decrement occurred in canned samples packed in salt solution in presence of different oils compared with lemon juice and nisin solution. The crude protein content of canned tuna packed in salt in presence of different oils was 68.57, 68.40 and 68.49 % at 110°C and at 121°C it was 68.72, 68.59 and 68.65 %, respectively.

From these results, it could be noticed that, reduction in crude protein content may be mainly attributed to autolysis leading to formation of some soluble protein fraction, leached out gradually to packing medium. These results are in a good agreement with those reported by El-Samkary *et al.* (1997) and Baltasar *et al.* (1998) who found that, crude protein in mackerel deceased during storage of canned samples at room temperature.

Fat content

The effect of storage period at room temperature for 6 months on the changes in fat content of canned tuna fish packing in salt, lemon juice and nisin solution in presence of olive, cotton seed oil and mixture of each 1 : 1 v/v and sterilized at 110 °C for 55 min and 121°C for 40 min was given in Table 3.

Data given in Table 3 recorded an increase in the fat content in all canned tuna as compared with the fresh samples, and there were significant differences between packing solutions, while no significant differences were noticed between packing oils in all canned samples. The increment in fat content of samples packed in oils could be due to the absorption of some oil by fish flesh from surrounding medium. It could be

also observed that, the fat content of canned tuna fish packed in different oils (olive, cotton seed oil and mixture of each 1 : 1 v/v), sterilized at 110 °C for 55 min and sterilized at 121°C for 40 min was decreased during storage period at room temperature for 6 months. Data given in Table 3 indicated that, at zero time of storage period, the fat content of canned tuna fish samples packed in salt solution in presence of olive, cotton seed oils and mixture of each 1 : 1 v/v was 16.50, 16.49 and 16.49 % at 110 °C, while, at 121 °C it was 16.48, 16.46 and 16.47 %, while, at the end of storage period it reached to 15.60, 15.49 and 15.54 % at 110 °C and 15.51, 15.45 and 15.48 at 121 °C for the same samples, respectively. Also, fat content of canned tuna samples packed in lemon juice solution and different oils stored with 15.80, 15.75 and 15.76 % at 110°C and at 121 °C was 15.77, 15.73 and 15.75 % at zero time, while, at the end of storage period, the fat content reached to 14.87, 14.76 and 14.82% at 110°C, and at 121 °C, it was 14.79, 14.65 and 14.70% for the same samples, respectively. According to tuna fish packed in nisin solution in presence of different oils, fat content 16.13, 16.10 and 16.11 % at 110 °C, and at 121 °C it was 16.09, 16.05 and 16.06% at zero time of storage period. After 6 months of storage, the fat content reached 15.23, 15.12 and 15.18 % at 110°C and at 121 °C it reacged 15.16, 15.04 and 15.08 % for the same samples, respectively.

The above mentioned results might be explained due to oxidation and hydrolysis of fat during storage period which led to the formation of some volatile compounds as aldehydes and ketons. These data supported by those of Seet *et al.* (1983) and El-Samkary *et al.* (1997).

Ash content

The effect of storage period at room temperature for 6 months on the changes occurring in ash content of canned tuna samples packed in salt, lemon juice and nisin solution in presence of olive, cotton seed oils and mixture of each (1 : 1 v/v) treatments, sterilized at 110 °C for 55 min and at 121 °C for 40 min is presented in Table 4.

Canned samples showed significant difference in ash content between packing solutions and no significant differences between packing oils ($P < 0.05$), in all canned samples. The increase in ash content was also noticed in lemon juice treatment in presence of different oils. Results indicated that, at 121 °C of sterilization for 40 min the ash content reached to 11.54, 11.61 and 11.59 % for canned tuna samples at

zero time of storage period, respectively. At the end of storage period, the ash content in the same samples was 15.06, 15.35 and 15.20 %, respectively for canned tuna packed in lemon juice solution and different oils then sterilized at 121 °C for 40 min. These results are in agreement with those obtained by El-Samkary *et al.* (1997) and Baltasar *et al.* (1998). They found that, the increment in ash content could be mainly due to addition of salt before canning.

II. Bacteriological effect of storage period at room temperature on the changes of canned tuna fish

Total bacterial counts

Changes in the total bacterial count of canned tuna fish samples packed in salt, lemon juice and nisin solutions; and olive, cotton seed oil and mixture of each (1 : 1 v/v) sterilized at 110 °C for 55 min and 121°C for 40 min and stored at room temperature for 6 months are shown in Table 5 with significant difference between packing solutions and no significant difference between packing oils ($P < 0.05$) in all canned samples.

The results presented in Table 5 showed that, the total bacterial counts of canned tuna in contained salt, lemon juice and nisin solutions and olive oil sterilized at 110°C was 0.77, 0.69 and 0.73 CFU/gx10^2, while, for the same samples at 121°C they were 0.75, 0.68 and 0.72 CFU/g.x10^2, respectively, at zero time of storage. It could be noticed that there was a slight increase in the total bacterial count as the storage period was prolonged, especially in canned samples packed in salt solution. At the end of storage period at room temperature for 6 months, the total bacterial counts were 1.13, 0.93 and 1.07 CFU/g.x10^2 110 °C, while, the total bacterial counts for the same samples at 121 °C were, 1.05, 0.89 and 1.00 CFU/gx10), respectively. The total bacterial counts of canned tuna packed in salt, lemon juice and nisin solution with cotton seed oil sterilized at 110°C were 0.79, 0.71 and 0.75 CFU/gx10^2, the total bacterial counts for the same samples at 121 °C was, 0.78, 0.70 and 0.75 CFU/g,x10^2, at zero time of storage. During storage period, a slight continuous increase in the total bacterial count as the storage period was prolonged especially canned samples packed in salt solution with different oils. At the end of storage period at room temperature for 6 months the total bacterial counts of canned tuna fish packed in salt, lemon juice and nisin solutions with cotton seed oil sterilized at 110°C were 1.17, 1.00 and 1.10 CFU/gx10^2, while, the total bacterial counts for the same samples at 121°C were,

1.07, 0.98 and 1.08 CFU/gx10^2, respectively. On the other side, the total bacterial counts of canned tuna fish packed in salt, lemon juice and nisin solutions with mixture of each (1 : 1 v/v) sterilized at 110 °C were 0.77, 0.70 and 0.74 CFU/gx10^2, while the total bacterial counts for the same samples at 121 °C were, 0.76, 0.68 and 0.73 CFU/gx10^2, at zero time of storage. During storage period, it could be noticed that there was a slight continuous increase in the total bacterial counts as the storage period was prolonged especially for the canned samples in salt solution with different oils. At the end of the 6 months storage period at room temperature, the total bacterial counts of canned tuna in different solutions salt, lemon juice and nisin solution with mixture of each (1 : 1 v/v) sterilized at 110°C were 1.14, 0.96 and 1.08 CFU/g.x10^2, while, the total bacterial counts for the same samples at 121 °C were, 1.05, 0.92 and 1.04 CFU/gx10^2, respectively. These results are in accordance with the maximum permitted level given by Egyptian Standard (1990) in which the total count/gram should not exceed 300 CFU/g.

Clostridium botulinum

Changes in *Clostridium botulinum* count of canned tuna fish samples packed in salt, lemon juice and nisin solutions and olive, cotton seed oil and mixture of each (1 : 1 v/v) sterilized at 110°C for 55 min and 121 °C for 40 min and stored at room temperature for 6 months are studied.

From the results it could be seen that all investigated samples of canned tuna samples were found to be negative to *Clostridium botulinum* at any time during storage period, even after 6 months of storage period at room temperature. These results are in agreement with the Egyptian standard (1990). The most important thermoresistant spores seem to be mesophlic anaerobes *Clostridium sporogenous* and *Clostridium putrefaciens* producing changes in colour, flavour texture and sometimes swelling. Besides, the obligate thermophilic (flat sour) organisms were found to be rare in canned fish products. Frazier and Westhoff (1978) declared that, the processing for local canned fish was sufficient to destroy aerobic and anaerobic bacteria which cause spoilage of the canned fish. Therefore, neither *Bacillus cereus* nor *Clostridium perfringes* were observed in the canned sardines and mackerel stored for 24 months at room temperature.

CONCLUSION

From the results obtained in the present study, it could be concluded that lemon juice solution at pH 4 as a natural material can be used as a packed solution in canned fish in order to reduce time of heat processing without consequent spoilage during the storage.

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Table 1. Effect of storage period at room temperature for six months on moisture content (%) of canned tuna fish *(Tuna sp.)* packed in salt, lemon juice and nisin solution in presence of olive oil, cotton seed oil and mixture of each (1 : 1 v/v) and sterilized at 110 °C and 121 °C (on dry weight basis)*.

Oils		Olive oil						Cotton seed oil						Mixture of oils (1 : 1 v/v)					
Solution		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin	
Sterilization		110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C
Storage period (Month)	0	63.69 ± 0.80 a	63.65 ± 0.74 a	62.37 ± 0.40 b	62.34 ± 0.63 b	63.23 ± 0.75 a	63.17 ± 0.70 a	63.60 ± 0.80 a	63.52 ± 0.75 a	62.31 ± 0.36 b	62.25 ± 0.40 b	63.15 ± 0.70 a	63.14 ± 0.70 a	63.65 ± 0.77 a	63.58 ± 0.75 a	62.33 ± 0.40 b	62.29 ± 0.35 b	63.19 ± 0.70 a	63.15 ± 0.70 a
	1	63.29 ±0.80 a	63.20 ±0.72 a	61.80 ±0.40 b	61.75 ±0.35 b	62.70 ±0.80 a	62.60 ±0.70 a	63.20 ±0.76 a	63.12 ±0.71 a	61.75 ±0.40 b	61.67 ±0.36 b	62.58 ±0.50 ab	62.47 ±0.50 a	63.23 ±0.78 a	63.15 ±0.72 a	61.78 ±0.40 b	61.71 ±0.39 b	62.64 ±0.70 a	62.56 ±0.49 ab
	2	62.80 ±0.80 a	62.73 ±0.80 a	61.29 ±0.40 b	61.22 ±0.40 b	62.12 ±0.61 ab	62.00 ±0.60 ab	62.69 ±0.80 a	62.67 ±0.80 a	61.20 ±0.45 b	61.16 ±0.39 b	62.00 ±0.65 ab	61.93 ±0.65 ab	62.75 ±0.70 a	62.70 ±0.70 a	61.23 ±0.44 b	61.21 ±0.45 b	62.05 ±0.60 ab	61.97 ±0.60 ab
	3	62.27 ±0.77 a	62.21 ±0.74 a	60.65 ±0.49 b	60.57 ±0.39 b	61.71 ±0.80 a	61.64 ±0.80 a	62.15 ±0.72 a	62.07 ±0.70 a	60.54 ±0.50 b	60.43 ±0.50 b	61.56 ±0.80 a	61.52 ±0.77 a	62.26 ±080 a	62.17 ±0.78 a	60.61 ±0.48 b	60.53 ±0.44 b	61.67 ±0.80 a	61.60 ±0.75 a
	4	61.65 ±0.80 a	61.60 ±0.80 a	60.00 ±0.49 b	59.93 ±0.40 b	61.20 ±0.77 a	61.09 ±0.73 a	61.60 ±0.80 a	61.52 ±0.77 a	59.94 ±0.52 b	59.80 ±0.49 b	61.00 ±0.73 a	61.00 ±0.73 a	61.62 ±0.80 a	61.57 ±0.80 a	59.96 ±0.46 b	59.85 ±0.40 b	61.12 ±0.80 a	61.03 ±0.80 a
	5	61.06 ±0.75 a	61.00 ±0.71 a	59.26 ±0.50 b	59.17 ±0.26 bc	60.50 ±0.66 a	60.39 ±0.64 a	60.98 ±0.75 a	60.87 ±0.72 a	59.16 ±0.35 bc	59.09 ±0.29 bc	60.42 ±0.73 a	60.29 ±0.70 a	61.00 ±0.75 a	60.93 ±0.74 a	59.21 ±0.44 b	59.13 ±0.40 bc	60.46 ±0.79 a	60.34 ±0.72 a
	6	60.44 ±0.80 a	60.37 ±0.80 a	58.52 ±0.50 b	58.40 ±0.20 bc	59.78 ±0.75 a	59.71 ±0.71 a	60.29 ±0.80 a	60.21 ±0.80 a	58.36 ±0.20 bc	58.21 ±0.30 bc	59.57 ±0.65 ab	59.50 ±0.65 ab	60.46 ±.80 a	60.38 ±0.76 a	58.54 ±0.50 b	58.39 ±0.30 bc	59.76 ±0.80 a	59.69 ±0.80 a

* Means within a raw with the same superscript are not significantly different ($P < 0.05$).

Table 2. Effect of storage period at room temperature for six months on crude protein content (%) of canned Tuna fish *(Tuna sp.)* packed in salt, lemon juice and nisin solution in presence of olive oil, cotton seed oil and mixture of each (1 : 1 v/v) and sterilized at 110 °C and 121 °C (on dry weight basis)*.

Oils		Olive oil						Cotton seed oil						Mixture of oils (1:1 v/v)					
Solution		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin	
Sterilization		110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C
Storage period (Month)	0	71.38 ±0.70 ab	71.48 ±0.75 a	71.93 ±0.82 a	72.00 ±0.90 a	71.70 ±0.80 a	71.74 ±0.80 a	71.33 ±0.59 ab	71.45 ±0.75 a	71.87 ±0.80 a	71.95 ±0.85 a	71.62 ±0.77 a	71.69 ±0.73 a	71.34 ±0.66 ab	71.46 ±0.80 a	71.90 ±0.85 a	71.96 ±0.90 a	71.64 ±0.77 a	71.73 ±0.80 a
	1	70.89 ±0.65 ab	71.00 ±0.90 a	71.51 ±0.75 a	71.62 ±0.84 a	71.19 ±0.86 a	71.30 ±0.90 a	70.79 ±0.63 ab	70.92 ±0.66 ab	71.52 ±0.75 a	71.50 ±0.84 a	71.00 ±0.88 a	71.20 ±0.90 a	70.83 ±0.67 ab	70.98 ±0.69 ab	71.49 ±0.79 a	71.55 ±0.85 a	71.00 ±0.80 a	71.25 ±0.80 a
	2	70.42 ±0.63 ab	70.50 ±0.90 a	71.06 ±0.80 a	71.15 ±0.90 a	70.87 ±0.84 a	71.00 ±0.88 a	70.37 ±0.65 ab	70.43 ±0.65 ab	70.90 ±0.80 a	71.09 ±0.80 a	70.70 ±0.77 a	70.85 ±0.80 a	70.37 ±0.67 ab	70.48 ±0.67 ab	70.98 ±0.80 a	71.11 ±0.85 a	70.79 ±0.80 a	70.93 ±0.80 a
	3	69.88 ±0.50 b	70.01 ±0.50 b	70.70 ±0.80 a	70.86 ±0.80 a	70.40 ±0.75 a	70.46 ±0.77 a	69.77 ±0.30 b	69.93 ±0.40 b	70.61 ±0.73 a	70.70 ±0.74 a	70.31 ±0.71 a	70.36 ±0.71 a	69.83 ±0.66 ab	69.96 ±0.68 ab	70.65 ±0.70 a	70.73 ±0.72 a	70.35 ±0.72 a	70.42 ±0.75 a
	4	69.50 ±0.69 ab	69.57 ±0.69 ab	70.33 ±0.80 a	70.45 ±0.84 a	70.00 ±0.79 a	70.10 ±0.79 a	69.39 ±0.69 ab	69.44 ±0.69 ab	70.20 ±0.90 a	70.30 ±0.90 a	69.82 ±0.80 a	69.91 ±0.85 a	69.46 ±0.68 ab	69.50 ±0.69 ab	70.29 ±0.90 a	70.37 ±0.90 a	69.96 ±0.79 a	70.00 ±0.85 a
	5	68.95 ±0.50 ab	69.09 ±0.69 ab	69.94 ±0.88 a	69.98 ±0.90 a	69.61 ±0.83 a	69.70 ±0.89 a	68.90 ±0.60 ab	69.00 ±0.60 ab	69.85 ±0.80 a	69.91 ±0.90 a	69.49 ±0.75 a	69.57 ±0.80 a	68.90 ±0.63 ab	69.05 ±0.66 ab	69.90 ±0.80 a	69.93 ±0.80 a	69.55 ±0.73 a	69.61 ±0.75 a
	6	68.57 ±0.45 b	68.72 ±0.55 ab	69.55 ±0.75 a	69.61 ±0.75 a	69.29 ±0.73 a	69.39 ±0.71 a	68.40 ±0.40 b	68.59 ±0.30 b	69.43 ±0.90 a	68.92 ±0.90 a	69.18 ±0.86 a	69.24 ±0.83 a	68.49 ±0.44 b	68.65 ±0.49 b	69.49 ±0.80 a	69.57 ±0.85 a	69.23 ±0.77 a	69.31 ±0.79 a

* Means within a raw with the same superscript are not significantly different ($P < 0.05$).

Table 3. Effect of storage period at room temperature for six months on fat content (%)of canned Tuna fish *(Tuna sp.)* packed in salt, lemon juice and nisin solution in presence of olive oil, cotton seed oil and mixture of each (1 : 1 v/v) and sterilized at 110 °C and 121 °C (on dry weight basis)*.

Oils		Olive oil						Cotton seed oil						Mixture of oils (1:1 v/v)					
Solution		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin	
Sterilization		110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C
Storage period (Month)	0	16.50 ±0.36 a	16.48 ±0.36 a	15.80 ±0.22 b	15.77 ±0.19 b	16.13 ±0.35 ab	16.09 ±0.34 ab	16.49 ±0.35 a	16.46 ±0.40 a	15.75 ±0.21 b	15.73 ±0.25 b	16.10 ±0.34 ab	16.05 ±0.32 ab	16.49 ±0.41 a	16.47 ±0.39 a	15.76 ±0.20 b	15.75 ±0.19 b	16.11 ±0.34 ab	16.06 ±0.33 ab
	1	16.40 ±0.38 a	16.36 ±0.37 a	15.66 ±0.22 b	15.64 ±0.20 b	16.03 ±0.35 ab	15.97 ±0.35 ab	16.38 ±0.41 a	16.33 ±0.41 a	15.62 ±0.16 b	15.60 ±0.22 b	16.00 ±0.36 ab	15.92 ±0.34 ab	16.39 ±0.35 a	16.34 ±0.40 a	15.63 ±0.22 b	15.61 ±0.22 b	16.01 ±0.34 ab	15.95 ±0.34 ab
	2	16.28 ±0.38 a	16.25 ±0.38 a	15.55 ±0.25 b	15.51 ±0.27 b	15.89 ±0.29 ab	15.82 ±0.30 ab	16.24 ±0.37 a	16.20 ±0.37 a	15.50 ±0.24 b	15.44 ±0.21 b	15.88 ±0.28 ab	15.78 ±0.30 ab	16.25 ±0.40 a	16.21 ±0.36 a	15.52 ±0.19 b	15.58 ±19 b	15.87 ±0.30 ab	15.80 ±0.27 ab
	3	16.15 ±0.44 a	16.09 ±0.40 a	15.44 ±0.27 b	15.38 ±0.19 b	15.78 ±0.33 ab	15.73 ±0.32 ab	16.09 ±0.39 a	16.05 ±0.37 a	15.36 ±0.27 b	15.29 ±0.25 b	15.70 ±0.28 ab	15.63 ±0.29 ab	16.11 ±0.41 a	16.06 ±0.40 a	15.39 ±0.26 b	15.33 ±0.26 b	15.74 ±0.35 ab	15.67 ±0.30 ab
	4	15.90 ±0.39 a	15.87 ±0.40 a	15.29 ±0.22 b	15.20 ±0.22 b	15.60 ±0.40 a	15.57 ±0.35 ab	15.93 ±0.38 a	15.85 ±0.39 a	15.18 ±0.27 b	15.09 ±0.22 b	15.55 ±0.26 ab	15.47 ±0.32 ab	15.92 ±0.42 a	15.84 ±0.40 a	15.23 ±0.19 b	15.14 ±0.21 b	15.57 ±0.33 ab	15.50 ±0.32 ab
	5	15.78 ±0.40 a	15.65 ±0.40 a	15.10 ±0.18 b	14.99 ±0.19 b	15.40 ±0.34 a	15.38 ±0.34 ab	15.71 ±0.40 a	15.70 ±0.39 a	14.97 ±0.15 b	14.87 ±0.16 bc	15.32 ±0.30 ab	15.28 ±0.34 ab	15.75 ±0.42 a	15.69 ±0.40 a	15.00 ±0.21 b	14.94 ±22 b	15.36 ±0.30 ab	15.31 ±0.29 ab
	6	15.60 ±0.44 a	15.51 ±0.39 a	14.87 ±0.19 b	14.79 ±0.19 b	15.23 ±0.32 ab	15.16 ±0.30 ab	15.49 ±0.42 a	15.45 ±0.40 a	14.76 ±0.19 b	14.65 ±0.16 bc	15.12 ±0.33 ab	15.04 ±20 b	15.54 ±0.40 a	15.48 ±0.39 a	14.82 ±0.21 b	14.70 ±0.19 b	15.18 ±0.30 ab	15.08 ±0.22 b

* Means within a raw with the same superscript are not significantly different ($P < 0.05$).

Table 4. Effect of storage period at room temperature for six months on ash content (%)of canned Tuna fish *(Tuna sp.)* packed in salt, lemon juice and nisin solution in presence of olive oil, cotton seed oil and mixture of each (1 : 1 v/v) and sterilized at 110 °C and 121 °C (on dry weight basis)*.

Oils		Olive oil						Cotton seed oil						Mixture of oils (1:1 v/v)					
Solution		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin	
Sterilization		110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C
Storage period (Months)	0	11.00 ±0.39 ab	11.10 ±0.42 ab	11.42 ±0.50 a	11.54 ±0.50 a	11.33 ±0.57 a	11.41 ±0.52 a	11.10 ±0.37 ab	11.20 ±0.43 ab	11.46 ±0.50 a	11.61 ±0.54 a	11.41 ±0.56 a	11.53 ±0.55 a	11.08 ±0.40 ab	11.15 ±0.45 ab	11.45 ±0.55 a	11.59 ±0.57 a	11.36 ±0.50 a	11.50 ±0.57 a
	1	11.39 ±0.41 ab	11.52 ±0.45 ab	11.91 ±0.55 a	12.00 ±0.57 a	11.78 ±0.51 a	11.87 ±0.53 a	11.54 ±0.40 ab	11.68 ±0.45 a	12.04 ±0.55 a	12.05 ±0.52 a	11.94 ±0.50 a	12.00 ±0.50 a	11.43 ±0.45 ab	11.60 ±0.55 a	11.97 ±0.51 a	11.96 ±0.50 a	11.85 ±0.55 a	11.95 ±0.57 a
	2	11.92 ±0.38 b	12.00 ±0.45 ab	12.49 ±0.55 a	12.55 ±0.57 a	12.29 ±0.51 a	12.40 ±0.53 a	12.05 ±0.43 ab	12.29 ±0.50 a	12.57 ±0.57 a	12.67 ±0.55 a	12.47 ±0.55 a	12.60 ±0.57 a	12.00 ±0.45 ab	12.16 ±0.45 ab	12.52 ±0.54 a	12.62 ±0.56 a	12.38 ±0.50 a	12.49 ±0.51 a
	3	12.41 ±33 b	12.53 ±0.35 b	13.00 ±0.57 a	13.05 ±0.50 a	12.77 ±0.41 b	12.88 ±0.45 ab	12.56 ±0.52 b	12.70 ±0.56 b	13.18 ±0.57 a	13.39 ±0.50 a	12.92 ±0.45 ab	12.84 ±0.42 ab	12.49 ±0.35 b	12.60 ±0.38 b	13.13 ±0.54 a	13.30 ±0.57 a	12.86 ±0.54 ab	13.00 ±0.55 a
	4	13.00 ±0.29 b	13.09 ±0.30 b	13.54 ±0.50 a	13.72 ±0.57 a	13.31 ±0.50 ab	13.45 ±50 a	13.12 ±0.29 b	13.31 ±0.39 ab	13.70 ±0.54 a	13.83 ±0.55 a	13.45 ±0.57 a	13.61 ±0.53 a	13.05 ±0.31 b	13.20 ±0.47 ab	13.68 ±0.50 a	13.77 ±0.57 a	13.39 ±0.52 ab	13.51 ±0.56 a
	5	13.56 ±0.35 b	13.70 ±0.35 b	14.20 ±0.50 a	14.33 ±0.50 a	13.90 ±0.39 ab	14.06 ±0.39 ab	13.76 ±0.33 b	14.00 ±0.45 ab	14.41 ±0.50 a	14.58 ±0.57 a	14.12 ±0.55 a	14.22 ±0.57 a	13.66 ±0.30 b	13.89 ±0.45 ab	14.34 ±0.50 a	14.43 ±0.50 a	14.00 ±0.39 ab	14.10 ±0.50 a
	6	14.22 ±0.20 bc	14.36 ±0.31 b	14.90 ±0.57 a	15.06 ±0.52 a	14.61 ±0.30 b	14.75 ±0.47 ab	14.42 ±0.35 b	14.60 ±0.38 b	15.29 ±0.50 a	15.35 ±0.55 a	14.82 ±0.48 ab	14.98 ±0.53 a	14.30 ±0.31 b	14.48 ±0.36 b	15.05 ±0.50 a	15.20 ±0.55 a	14.71 ±0.47 ab	14.89 ±0.50 a

* Means within a raw with the same superscript are not significantly different (P<0.05).

Table 5. Effect of storage period at room temperature for six months on total bacterial count (CFU / g.x10^2) of canned Tuna fish *(Tuna sp.)* packed in salt, lemon juice and nisin solution in presence of olive oil, cotton seed oil and mixture of each (1 : 1 v/v) and sterilized at 110 °C and 121 °C*.

Oils		Olive oil						Cotton seed oil						Mixture of oils (1:1 v/v)					
Solution		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin		Salt		Lemon Juice		Nisin	
Sterilization		110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C	110 °C	121 °C
Storage period (Months)	0	0.77 ±0.05 a	0.75 ±0.05 a	0.69 ±0.03 b	0.68 ±0.02 b	0.73 ±0.03 ab	0.72 ±0.04 ab	0.79 ±0.05 a	0.78 ±0.05 a	0.71 ±0.04 ab	0.70 ±0.03 ab	0.75 ±0.05 a	0.75 ±0.04 a	0.77 ±0.03 a	0.76 ±0.03 a	0.70 ±0.02 b	0.68 ±0.03 b	0.74 ±0.03 ab	0.73 ±0.04 ab
	1	0.83 ±0.05 a	0.79 ±0.04 ab	0.74 ±0.02 b	0.74 ±0.03 b	0.78 ±0.03 ab	0.77 ±0.03 ab	0.85 ±0.04 a	0.82 ±0.04 a	0.75 ±0.03 b	0.75 ±0.02 b	0.80 ±0.04 a	0.81 ±0.05 a	0.84 ±0.05 a	0.80 ±0.05 a	0.75 ±0.03 b	0.74 ±0.03 b	0.79 ±0.04 ab	0.78 ±0.05 ab
	2	0.87 ±0.05 a	0.82 ±0.04 ab	0.78 ±0.03 b	0.75 ±0.02 bc	0.84 ±0.04 ab	0.80 ±0.03 b	0.92 ±0.05 a	0.88 ±0.04 a	0.79 ±0.03 b	0.79 ±0.02 b	0.85 ±0.03 ab	0.85 ±0.03 ab	0.89 ±0.05 a	0.85 ±0.04 ab	0.78 ±0.03 b	0.77 ±0.04 b	0.84 ±0.03 ab	0.81 ±0.03 b
	3	0.92 ±0.03 ab	0.87 ±0.04 ab	0.80 ±0.02 bc	0.76 ±0.02 bc	0.87 ±0.04 ab	0.82 ±0.03 b	0.96 ±0.04 a	0.90 ±0.04 ab	0.82 ±0.03 b	0.82 ±0.03 b	0.90 ±0.04 ab	0.89 ±0.04 ab	0.93 ±0.05 a	0.89 ±0.03 b	0.81 ±0.02 b	0.78 ±0.01 bc	0.88 ±0.04 ab	0.85 ±0.03 b
	4	0.98 ±0.05 a	0.92 ±0.03 ab	0.84 ±0.01 bc	0.80 ±0.01 bc	0.93 ±0.04 ab	0.89 ±0.03 b	1.03 ±0.05 a	0.95 ±0.04 ab	0.89 ±0.03 b	0.86 ±0.01 bc	0.97 ±0.04 ab	0.95 ±0.03 ab	1.00 ±0.04 a	0.93 ±0.04 ab	0.86 ±0.03 bc	0.83 ±0.03 bc	0.95 ±0.04 ab	0.92 ±0.02 b
	5	1.05 ±0.05 a	0.99 ±0.03 b	0.89 ±0.02 bc	0.83 ±0.02 bc	1.00 ±0.04 ab	0.95 ±0.04 b	1.09 ±0.05 a	1.01 ±0.03 ab	0.94 ±0.02 bc	0.94 ±0.02 bc	1.02 ±0.05 ab	1.00 ±0.04 ab	1.06 ±0.05 a	1.00 ±0.04 ab	0.91 ±0.02 bc	0.88 ±0.01 bc	1.00 ±0.03 ab	0.97 ±0.02 b
	6	1.13 ±0.04 a	1.05 ±0.03 ab	0.93 ±0.02 bc	0.89 ±0.01 bc	1.07 ±0.03 ab	1.00 ±0.02 b	1.17 ±0.05 a	1.07 ±0.04 ab	1.00 ±0.03 b	0.98 ±0.02 b	1.10 ±0.04 a	1.08 ±0.04 ab	1.14 ±0.05 a	1.05 ±0.04 ab	0.96 ±0.03 b	0.92 ±0.03 b	1.08 ±0.04 ab	1.04 ±0.03 ab

* Means within a raw with the same superscript are not significantly different ($P < 0.05$).

التغيرات في التركيب الكيميائي والمحتوى البكتيري خلال التخزين لأسماك التونة المعلبة فى محاليل التعبئة والزيوت المختلفة

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فى هذا البحث تم دراسة تعليب سمك التونة في أنواع مختلفة من محاليل التعبئة مثل "محلول نيسين، محلول عصير الليمون، المحلول الملحي المستخدم في المصنع فى وجود أنواع مختلفة من الزيوت" زيت الزيتون، زيت بذرة القطن، خليط مكون من (زيت الزيتون : زيت بذرة القطن ١ : ١ ح/ح) والتعقيم على درجات حرارة مختلفة ١١٠°م لمدة ٥٥ دقيقة، ١٢١°م لمدة ٤٠ دقيقة بعد عملية التعليب مباشرة. ثم خزنت العينات على درجة حرارة الغرفة لمدة ستة اشهر تم خلالها دراسة التغيرات فى التركيب الكيميائي والمحتوى البكتيري للعينات.

أوضحت النتائج المتحصل عليها انخفاضاً فى نسبة الرطوبة ، نسبة البروتين الكلى ، نسبة الدهن وارتفاعاً فى قيم الرماد، كما أوضحت النتائج زيادة العدد الكلى للبكتريا ولم يظهر نمولليكتريا المسببة للتسمم الغذائي وذلك فى جميع العينات خلال تخزينها على درجة حرارة الغرفة لمدة ستة أشهر. وبناء على نتائج هذا البحث يمكن التوصية بإمكانية تعليب أسماك التونة باستخدام عصير الليمون فى محاليل التعبئة كمادة طبيعية (عند رقم الأس الهيدروجينى ٤) لكي يتم اختزال مدة التعقيم دون حدوث فساد خلال التخزين.