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Impact of Smoking Pretreatment on the Quality of Canned Mackerel *(Scomber scombrus)* in Oil or Ketchup During Storage

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ABSTRACT

Quality and acceptability of canned fish product could be shifted by different pretreatments, filling solutions, and storage conditions. The objective of the current research was to evaluate the effect of smoking pretreatment with filling oil or ketchup on the chemical, microbiological and organoleptic properties of processed canned mackerel. The results revealed that all canned mackerel samples increased crude protein contents to range from 55.67 to 56.45% (DW) and decreased lipid contents to range from 27.45 to 27.93, compared with raw frozen mackerel. Smoking pretreatment with filling oil (Sm-O) or ketchup (Sm-K) caused slightly increase in the total volatile basic nitrogen values (TVB-N) which reached to <35 mgN/100 g after storage for 3 months. The microbiological examinations indicated that steaming pretreatment was more effective than smoking pretreatment. All processed canned mackerel had total viable bacterial count ranging from 7.2 $\times 10^2$ (St-K) to 9.98 $\times 10^2$ (Sm-O) CFU/g at the end of storage for 3 months. Coliform group, anaerobic spore-forming producing H_2S, and *Staphylococcus aureus* bacteria were not detected in all samples. Panelists reported that canned mackerel with smoked flavour was extremely like. Results concluded that canned mackerel with smoking pretreatment with filling oil or ketchup were all compatible with the Egyptian standards.

1. Introduction

Canned products are one of the most common ways in food processing which seafood products are presented. About 87.5% of the total world fishery production was used for human consumption, and 13.0% of this production used in processing canned fish (FAO, 2014). Canned fish are frequently and largely eaten in Egypt, Due to their nutritional value and beside their beneficial to human health. Egypt is one of the largest importers of processed canned fish in the world which represent economic burden (FAO, 2019). So, it is necessary to introduce diversified canning products from low cost fish for export and local market having appealing characteristics to gain popularity and reasonable good shelf life to increase its consumptive sale.

Canning is considered an important way of fish preservation. It included different pretreatments such as steaming, frying, drying or smoking and filling solutions such as oil, brine, or sauce to improve the palatability and the quality of canned fish (Horner, 1997). Mackerel flesh is preserved in cans with oils or brine, and then sealed cans are exposed to sterilization. Different factors such as container type and shape, type of retort, packaging material, and filling media controls cooking time and quality of final canned products (Chia et al., 1983; Ramaswamy & Grabowski, 1999; Mohan et al., 2006; Srinivasa Gopal, 2006; Mohan et al., 2008, 2014).

The percentage of moisture (69.17%), protein (23.19%), fat (6.3%), ash (1.73%), saturated (1.86%), monounsaturated (2.23%) and polyunsaturated fatty acids (1.65%) for canned mackerel (USDA, 2011). Canned mackerel is considered a good source of protein, minerals, and omega-3 unsaturated fatty acids

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that should be contained in the human diet to improve the health (Odiko and Obirenfoju, 2017). Maximum total viable count (TVC) must not exceed the International Commission on Microbiological Specifications for Foods (ICMSF) maximum limit (1.0×10^6 CFU/g) and free from *Clostridium* or anaerobic spore-forming bacteria producing H_2S (Agwa, et al., 2018).

Quality changes of canned fish products like tuna and mackerel have been investigated (Mohan et al., 2014; Hesham et al., 2018; Ricardo et al., 2021). Oil and tomato sauce as filling media for canned mackerel were used from the 20th century but very limited information is available on the effect of pretreatments (steaming or smoking process) on mackerel quality. The aim of this study was to investigate the effects of smoking pretreatment with filling media (sunflower oil or tomato ketchup) on chemical, microbiological and sensory attributes of canned mackerel during storage for three months.

2. Materials and methods

2.1. Materials

Ten kilograms (10 kg) of raw frozen mackerel (*Scomber scombrus*) with an average length of 30± 3.0 cm and weight of 300 ± 19.7g were used in this study. Fishes were procured from Al-Arish market, the biggest market of Al-Arish town in Egypt, and transported in cooled sterilized container (fish to ice ratio, 1:1) to the laboratory within 20 min and stored under -20°C. Other ingredients like double refined sunflower oil, tomato ketchup (24%), and commercial salt were purchased locally. Glass jars (capacity 250g) with screw metal lids and polyethylene bags were obtained from the commercial market.

2.2. Pretreatment, filling and thermal processing of canned mackerel

Fishes were washed after defrosted then be-headed, eviscerated, trimmed of fins and cut into steaks (3cm long) then quickly washed under running water. The steaks were immersed in 10% brine solution for 10 min.

2.2.1. Pretreatments: Brined steaks either steamed at atmospheric pressure for 15 min or smoked by exposed to sawdust in smoking oven at 60°C for 45min. The steamed or smoked steaks were packed into glass jars, then hot oil or tomato ketchup (8% Total soluble solids) was added before jars were exhausted and lids sealed immediately. The closed glass jars were transferred into a vertical retort and treated under pressure (15 lb/ in^2) for 60 min. After the heat processing step, the jars were cooled immediately and stored at room temperature for three months. Frozen raw mackerel and four treatments were obtained for analysis as the following:

1- Frozen raw mackerel (FR)
2- Steamed mackerel in ketchup (St-K)
3- Steamed mackerel in oil (St-O)
4- Smoked mackerel in ketchup (Sm-K)
5- Smoked mackerel in oil (Sm-O)

2.3. Quality assessment

2.3.1. Biochemical quality

Frozen raw mackerel (FR) and canned samples with different pretreatment media were analyzed for quality parameters.

Proximate analysis: Moisture content was determined by drying of homogenized sample (a known amount) to constant weight in an oven at 105 ± 1 °C for 16 hr (AOAC, 2000). Crude protein content was determined by the Kjeldahl method for total nitrogen procedure (AOAC, 2000). Crude fat was extracted with petroleum, while ash content was resolute by heating at 550 ± 2 °C in a muffle for 4-5 hr. (AOAC, 2000). Carbohydrate was calculated by difference.

pH value: Fish samples were blended with distilled water at a ratio (W/V) of 1:9 . The pH of the solution was determined by a calibrated pH meter (PH700 Benchtop, Apera Instruments, LLC) according to AOAC (1995).

Total volatile base nitrogen (TVB N): TVB-N was done according to the Conway method (1962).

2.4. Microbiological examinations:

Samples were opened under an aseptic conditions and 25g of each sample was diluted to 225 ml of sterile water, and handily shacked for 5 minutes. Further 1:10 dilutions were prepared as needed and plated in triplicate according to Özogul, et al. (2006).

2.4.1. Total viable bacterial count (TVBC):

Samples were serially diluted and transferred (1 ml) into sterile petri dishes in triplicates. About 10 ml of melted nutrient agar medium (Lab M, Lancashire, UK) (45-50°C) was poured in each plate, then thoroughly mixed and left 10 min for solidification (Anon et al., 1992). The plates were incubated at 35°C for 48 hrs. Colonies were calculated as average number of triplicate plates of the same dilution, and then multiplied by the dilution factor. The result was estimated as colony forming unit (CFU)/g sample.

2.4.2. Detection of coliform group:

Presumptive and confirmed tests were followed.

Presumptive test: was to detect the occurrence of acid and gas. Most probable number (MPN) method was used for calculating the presumptive number of Coliform, using Mc crady´s stalls.

Confirmed test: was to ascertain the presence of coliform bacteria. Positive tubes from the presumptive test were used to inoculate onto Eosin Methylene Blue (EMB) (Merck) sterile agar plates and identification was carried out (APHA, 1998).

2.4.3. Detection of *Staphylococcus aureus*:

Staphylococci were determined by inoculation of 1.0 ml sample on the surface of Staph medium No. 110 (Oxoid, 2006) plates. Plates were then incubated at 37°C for 24 hrs (APHA, 1998).

2.4.4. Detection of anaerobic spore forming producing H2S:

It was determined by Peptone Iron Agar, (PIA) (Oxoid, 2006). The diluted tubes were inoculated and sealed

with 1:1 of Vaseline and Paraffin oil and incubated at 55 °C for 3-5 days.

2.5. Sensory evaluation of canned mackerel

To evaluate organoleptic properties; 15 panelists evaluated each of sample its appearance, colour, taste, flavor, and texture. The test was carried out using a nine-point hedonic scale (Rangana, 1977). Parameters were scored using a scale from 9 to 1 (Extremely like to Extremely dislike).

2.6. Statistical analysis

The software "Statistical Product and Service Solutions" (version 10.00) was used to analyze experimental data. Results are stated as mean ± standard deviation.

3. Result and Discussion

Chemical composition of frozen raw mackerel (FR) and all processed canned mackerel were tabulated in Table1. These data showed that moisture content of FR 65.3% while in processed canned mackerel samples ranged from 55.8 % in St-O to 59.5 % in Sm-K. From the same table, it could be noticed that the decreasing moisture content by steaming pretreatments (14.5-13.3%) were more than by smoking pretreatments (12.3-8.9%) in comparing with the moisture of FR.

On the other hand, all treatments of processed canned mackerel had a high percentage of crude protein ranged from 55.67% to 56.45% (DW) which exceeded FR by 6.11- 5.5%. These results could be attributed to the extent of drying which lowered moisture and concentrated proteins. Different canned mackerel from market confined a high percentage of crude protein ranged from 58.25% to 73.79% (DW) (Shady M. E. and Zeinab S. F.; 2019)

In all processed canned mackerel, Ash and carbohydrate contents were increased as pretreatments and processing by 11.9 – 18.44 % and 31.1 - 49.2 % (DW), respectively. In contrast, Lipid content were decreased by 20.3 – 18.9 % (DW) in comparing with FR.

Total volatile nitrogen values (TVB-N) of frozen raw mackerel and all processed canned mackerel samples at zero time of storage at ambient temperature ranged from22.26 and 28.28 to 35.33 mgN/100 g sample (Table. 2). Smoking pretreatments with filling in ketchup or oil (Sm-K, Sm-O) where bellow (<35 mgN/100g) than TVB-N values of steamed (St-K, St-O) (<40 mgN/100g) from zero time to 3 months of storage. Smoking compounds from smoking pretreatment may be protected thermal analysis of protein during retorting the

Table1: Proximate analysis of frozen raw and processed canned mackerel stored at zero time under ambient temperature:

Proximate composition %	Frozen raw (FR)	Treatments of processed canned mackerel			
		Steamed in ketchup (St-K)	Smoked in ketchup (Sm-K)	Steamed in oil (St-O)	Smoked in oil (Sm-O)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Moisture	65.3 ± 0.25	56.6 ± 0.37	59.5 ± 0.30	55.8 ± 0.40	57.3 ± 0.29
Based on dry weight (DW %)					
Protein	53.20 ± 0.12	56.45 ± 0.15	56.12 ± 0.16	55.67 ± 0.20	56.14 ± 0.19
Lipid	34.44 ± 0.22	27.93 ± 0.22	27.68 ± 0.15	27.60 ± 0.24	27.45 ± 0.12
Ash	4.61 ± 0.12	5.46 ± 0.19	5.16 ± 0.21	5.18 ± 0.20	5.18 ± 0.20

Table2: Total Volatile Basic Nitrogen (TVB-N) (mgN/100g) of frozen raw and processed canned mackerel during storage under ambient temperature.

Storage period (months)	Frozen raw (FR)	Treatments of processed canned mackerel			
		Steamed in ketchup (St-K)	Smoked in ketchup (Sm-K)	Steamed in oil (St-O)	Smoked in oil (Sm-O)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0	22.26 ± 0.18	33.08 ± 0.18	28.28 ± 0.18	35.33 ± 0.18	29.9 ± 0.18
1	-	35.3 ± 0.33	31.6 ± 0.17	37.4 ± 0.23	32.9 ± 0.61
2	-	37.5 ± 0.21	32.5 ± 0.25	39.2 ± 0.28	34.2 ± 0.35
3	-	38.8 ± 0.22	33.80± 0.19	40.5 ± 0.21	34.9 ± 0.21

cans. Results indicated that all samples were in acceptable boundary of processed mackerel (<40 mgN/100g) according to EOS (2005). In agreement with the results of El-Dengawy et al., (2012), all canned fish samples had low profile of TVB-N, which might be due to low counts of total viable bacterial count.

The pH value (Table 3) of frozen raw mackerel (FR) was 6.4 which didn't affected in canned mackerel Sm-O and St-O and ranged from 6.4 to 6.6 while it decreased in Sm-K and St-K and ranged from 5.9 to 6.3 during 3 months of storage period. When pH value of Sm-K and St-K products was low, the preservative effect of thermal process increased (Maheswara et al., 2011; and Uriarte-Montoya et al., 2010). Smoking compounds found in Sm-K and Sm-O products could cause slightly decrease in pH value as it used a short smoking period pretreatment for fish.

Table3: pH value of frozen raw and processed canned mackerel during storage under ambient temperature.

Storage period (months)	Frozen raw (FR)	Treatments of processed canned mackerel			
		Steamed in ketchup (St-K)	Smoked in ketchup (Sm-K)	Steamed in oil (St-O)	Smoked in oil (Sm-O)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
0	6.4 ± 1.18	6.0 ± 0.08	5.9 ± 0.18	6.5 ± 0.28	6.4 ± 0.31
1	-	6.0 ± 0.23	6.0 ± 0.34	6.6 ± 0.15	6.4 ± 0.25
2	-	6.2 ± 0.31	6.1 ± 0.23	6.6 ± 0.19	6.5 ± 0.14
3	-	6.3 ± 0.12	6.2 ± 0.27	6.6 ± 0.13	6.5 ± 0.29

Microbiological evaluation of frozen raw and all processed canned mackerel during storage under ambient temperature was shown in Table 4. From microbiological results, FR had the highest value of total viable bacterial count (TVC) (7.9 $\times 10^4$ CFU/g), while St-K and St-O samples had the least value during 3 months of storage. It was observed that steaming pretreatment and filling in ketchup were more affected on TVC than smoking pretreatment and filling in oil.

Similarly, FR sample had the highest value (1.2×10^2) of anaerobic spore-forming bacteria producing H_2S, in agreement with results found by Özogul *et al*., (2004) and Kilinc and Cakli (2004). According to EOS, frozen fish shouldn't have *Clostridium* and *E. coli*, while aerobic bacteria and *staphylococcus aureus* shouldn't exceed 10^6 and 10^3 CFU/g (EOS, 2009). Anaerobic spore-forming bacteria producing H_2S, *Staphylococcus aureus*, and coliform group were not identified in all processed canned mackerel. These results agreed with EOS and GCC Standardization Organization (EOS, 2005; GCC, 2012, 2013 and 2016).

Organoleptic properties of all processed canned mackerel samples during storage for 3 months are shown in Table 5. Data showed that all canned mackerel samples were acceptable. However, the average scores of appearance, colour, taste, flavor, texture of canned mackerel samples were ranged from 8.5- 9; 8.5- 9; 8.4-9; 8- 9; and 8- 9, respectively which means that the panelists preferred them from very like to extremely like. From these results, smoking pretreatments enhanced the organoleptic properties more than steaming. These results agreed with Maheswara et al. (2011).

Table4: Microbiological evaluation (CFU/g) of frozen raw and processed canned mackerel during storage under ambient temperature.

Tested bacterial groups	Storage period (months)	Frozen raw (FR)	Treatments of processed canned mackerel			
			Steamed in ketchup (St-K)	Smoked in ketchup (Sm-K)	Steamed in oil (St-O)	Smoked in oil (Sm-O)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total bacterial count	0	$7.9 \pm 1.18 \times 10^4$	$2.5 \pm 0.08 \times 10^2$	$6.4 \pm 0.18 \times 10^2$	$4.6 \pm 0.28 \times 10^2$	$7.72 \pm 0.31 \times 10^2$
	1	-	$3.3 \pm 0.23 \times 10^2$	$7.8 \pm 0.34 \times 10^2$	$5.2 \pm 0.15 \times 10^2$	$8.2 \pm 0.25 \times 10^2$
	2	-	$5.1 \pm 0.31 \times 10^2$	$8.1 \pm 0.23 \times 10^2$	$6.9 \pm 0.19 \times 10^2$	$8.99 \pm 0.14 \times 10^2$
	3	-	$7.2 \pm 0.12 \times 10^2$	$9.6 \pm 0.27 \times 10^2$	$7.9 \pm 0.13 \times 10^2$	$9.98 \pm 0.29 \times 10^2$
Anaerobic spore forming bacteria producing H_2S	0	$1.2 \pm 0.04 \times 10^2$	nd*	nd	nd	nd
	1	-	nd	nd	nd	nd
	2	-	nd	nd	nd	nd
	3	-	nd	nd	nd	nd
Staphylococcus aureus	0	nd	nd	nd	nd	nd
	1	-	nd	nd	nd	nd
	2	-	nd	nd	nd	nd
	3	-	nd	nd	nd	nd
Coliform group	0	nd	nd	nd	nd	nd
	1	-	nd	nd	nd	nd
	2	-	nd	nd	nd	nd
	3	-	nd	nd	nd	nd

*nd: not detected

Table5: Organoleptic properties of processed canned mackerel during storage under ambient temperature.

Organoleptic properties	Storage period (months)	Treatments of processed canned mackerel			
		Steamed in ketchup (St-K)	Smoked in ketchup (Sm-K)	Steamed in oil (St-O)	Smoked in oil (Sm-O)
		Mean	Mean	Mean	Mean
Appearance	0	9	9	9	9
	1	9	9	9	9
	2	8.5	8.8	9	9
	3	8.5	8.8	9	9
Colour	0	8.9	9	8.9	9
	1	8.8	9	8.9	9
	2	8.5	8.8	8.6	9
	3	8.5	8.8	8.5	9
Taste	0	8.4	8.8	8.6	9
	1	8.5	8.8	8.6	9
	2	8.5	8.7	8.5	8.8
	3	8.5	8.7	8.5	8.9
Flavour	0	8.8	9	9	9
	1	8.7	9	8.6	9
	2	8.2	9	8.4	8.8
	3	8.0	8.8	8.0	8.6
Texture	0	8.7	8.7	9	9
	1	8.5	8.6	8.8	9
	2	8.2	8.5	8.8	9
	3	8.0	8.5	8.8	9

4. Conclusion

All processed canned mackerel samples were agreement with their specifications, EOS and GCC Standardization Organization (EOS, 2005; GCC 2012, 2013 and 2016) from view of some parameters of chemical, microbiological and sensorial. Smoking pretreatment with filling in ketchup and oil was compatible with steaming effect especially on protein and lipid contents. TVB-N was less than 35 mg/100g in canned mackerel treated in smoking pretreatment after 3 months of storage in ambient temperature. The effect of smoking pretreatments on pH was less pronounced.

Steaming pretreatment with filling in ketchup and oil was less in TVBC than smoking one. All processed canned mackerel in this study were safe for human health from microbiological view where anaerobic spore-forming bacteria producing H_2S, *Staphylococcus aureus*, and coliform group were not detected.

Smoking pretreatments enhanced the organoleptic properties more than steaming one. Therefore, the authors support the use of smoking pretreatment to improve acceptability of canned mackerel. However, the authors suggest additional detailed studies related to the effect of smoking compounds on fish lipid in these canned mackerel.

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