Evaluation of bacterial and chemical quality of new manufactured pasted fish products in a large scale fish processing plant, Egypt

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A B S T R A C T

This study was conducted to evaluate chemical, bacterial and sensory characteristics of some novel fish paste products. Thirty samples of Salmon, Herring and Anchovy pastes were collected from different markets in Gharbia, Egypt. Proximate composition of fish pastes for crude protein, total lipids, moisture, ash, and salt percentages revealed high protein (42.66 to 57.55%) content. The changes in pH, TMA, TVB-N and TBA remained under the limit for edibility. The total aerobic and staphylococcal counts were within the range of specified microbiological limits for fish and fishery products; however, TAC values in some of Salmon and Anchovy paste samples were 6.62 and 7.72 log cfu/g respectively, and do not meet the microbial specification. Total anaerobic and halophilic counts were in range of >3 - >5 log cfu/g. The *Enterobacteriaceae* and coliform counts were at the range of <2 - >3 log cfu/g. The total Bacillus count for Salmon paste (4.38 log cfu/gm) was higher than those of Herring (3.31 log cfu/g) and Anchovy (2.26 log cfu/g) paste samples. Furthermore, B. cereus, which is a major food borne pathogen, was isolated from 30% of Herring paste samples; while other investigated pathogens such as *C. perfrengns, E. coli, Salmonellae, Shigellae, Pseudomonas aeruginosa and S.aureus* were not detected. According to sensory analyses, fish paste samples had very good and good scores in terms of taste, flavor, color, texture and overall acceptability. However, the sensorial scores of Herring paste color decreased to average quality. The study concluded that fish pastes have acceptable chemical and sensory quality. However, they may consider high-risk for microbial hazards, so, special attention should be taken from competent authorities and food business operators.

Keywords: Salmon, Herring, anchovy, fish paste.

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1. INTRODUCTION

Fish has been recognized as a high quality protein and fat that are completely digested and assimilated in the body than that of any other proteins and fat. Fish oils are a rich source of ω-3fatty acids those have beneficial health effects in the prevention of a number of diseases such as coronary heart diseases, inflammation, autoimmune disorders and cancer (Sahena et al., 2010). However, there is substantial evidence that fish and seafood are high on the list of foods associated with outbreaks of foodborne diseases (Huss, 1997). Increasing seafood is being used as the dish of choice owing to its healthy image and delicious taste. Fisheries play a very significant role in providing income, employment and food security to millions of rural poor (Zaling et al., 2001). In recent years, the increase of the world's population as well as various socioeconomic changes has caused to an increase of the consumer's preference for ready-to-eat foods. Fish paste products are of the most preferred ready-to-eat foods by consumers around the world and many studies have been conducted on the production, quality, and stability of these foods (Çaklı, 2008; Cakli et al., 2005). Fish paste products are believed to have originally come from China with fresh fish used as the raw material. Fish paste products are now widely consumed around the world (FAO, 2003). Several fish species around the world have been used for making fish paste products. It is usually produced from white-muscled fish species due to their white color and ability to produce a good gel consumed regularly in other parts of the world. Traditional seafood was originally developed to preserve fisheries products for a long storage life by either lowering water activity (aw) and/or changing pH of the products. In addition, preservation was also carried out by applying antibacterial activity of salt and/or smoke components or other preservative compounds to increase shelf-life and improve safety of such products. Therefore, it is important to know the shelf life and quality changes of different types of fish paste products produced by different methods. This can make contribution to seafood industry in selecting appropriate methods for producing readymade seafood such as fish paste products.

Fish paste products is traditional and popular food in the coastal area of East Asia. They are processed products maintain the characteristic flavor, taste, and nutrients of the raw materials (Giri et al., 2009). The nutrient analysis has revealed that they are rich in proteins with complete amino acids, unsaturated fatty acid and inorganic elements (Ibrahim, 2015). However, a quality standard based on the nutritional analysis has not been developed. There is very scarce information on the nutrient profiles, which determine the taste, appearance, and nutritional quality. However, fish and fish products can undergo undesirable changes during storage and deterioration may limit their storage time. These undesirable changes result from protein denaturation and lipid oxidation (Benjakul et al., 2005; Siddaiah et al., 2001; Tokur et al., 2006). Furthermore, processed fish products are reported to carry potential risk for human health for halophilic pathogenic bacteria, or associated with outbreaks of foodborne diseases (Kose, 2010). Although, such products are extensively studied for their health risks in Asia, limited studies occur on the traditionally processed products of Egyptian origin (Ibrahim, 2015; Salem, 2012).

Therefore, this study aims to identify certain chemical, bacterial and sensory quality parameters in some of Egyptian origin novel fish paste products in order to evaluate the control measures for food safety.

2. MATERIALS AND METHODS

2.1. Sampling:

Thirty samples of Salmon, Herring and Anchovy pastes (10 of each) were collected from different markets in Gharbia, Egypt. The products were manufactured by large scale fish processing plant. The samples were packed in glass jars in a pasted form. Collected samples were transported without delay to the laboratory for chemical, bacteriological and sensory examination.

2.2. Chemical analyses

Moisture, crude protein, crude lipids, total ash contents and sodium chloride were analyzed as described by AOAC (2005). pH value was carried out using pH meter Jenway 3510 pH meter (UK) according to AOAC (2005). Total volatile basic nitrogen (TVB-N, mg/100g) and Trimethylamine (TMA, mg/100g) value was determined according to FAO (Food and Agriculture Organization of the United Nation) (1980). Thiobarbituric acid (TBA, as mg malondialdehyde/kg sample) value was carried out according to the procedure of Vyncke (1970).

2.3. Bacteriological examination

Microbial counts were applied at every sampling time using standard methods (FDA, 2001). Ten (10) gm of product sample were thoroughly homogenized using 90 mL of sterile peptone water (0.1%). Ten-fold serial dilutions and specific media were used for enumeration and identification of microflora. Total aerobic count was carried out according to FDA (2001). Total halophilic count was determined according to FDA (2001). Total anaerobic count was done according to Oxoid (1986). *Enterobacteriaceae* count was performed according to ISO (International Organization for Standardization) (2004). Total Staphylococci count was carried out according to ICMSF (International Committee on Microbiological Specification for Foods) (1996). *Bacillus cereus* was isolated and enumerated according to the method recommended by Holbrook and Anderson (1980). *Clostridium perfringens* (C. *perfingens*) isolation and identification was performed according to ICMSF (International Committee on Microbiological Specification for Foods) (1978). *E. coli* were isolated and identified according to FAO (1992). *Salmonella* spp. were isolated and identified according to HPA (Health Protection Agency) (2007). *Shigella* spp. were isolated and identified according to HPA (2007). *Staphylococcus aureus* were isolated and identified according to Capita et al. (2001) and confirmed by the coagulase test as described by (Collins et al., 1989). *Pseudomonas aeruginosa* were isolated and identified according to FAO (1992). All microbial counts were converted to logarithms of colony forming units per gram (log CUF/g).

2.4. Sensory evaluation

The product quality characteristics were recorded by sensory evaluation which was given by 10 judges randomly selected from the regular consumer of fish pastes and the scores were given in 10-point Hedonic scale such as 10-Excellent, 9-very goods, 8-Good, 6-7-Average, $\leq$ 5-Lost property/ unacceptable (Muzaddadi, 2013). The mean value of the scores was taken and the results were supplemented by information provided by the fishers engaged in product preparation.

2.5. Statistical analysis

Statistical analyses were carried out using SPSS program (SPSS, 2009) using Completely Randomized Design and General linear models. Duncan's multiple range test was used for mean separation at p<0.05.

3. RESULTS

The contents of crud protein, total lipid, moisture, crude ash, and Nacl of Salmon paste, Herring paste and Anchovy paste were recorded in table (1). According to statistical findings, there were significant (P<0.05) differences in total lipids, moisture and crude ash among 3 fish paste products but no significant (P>0.05) differences was found in the crude protein or Nacl of the same fish pastes.

The chemical changes in pH, TMA, TVB-N and TBA parameters were demonstrated in table (2). No significant (P<0.05) differences were observed in pH, TMA and TVB-N among 3 fish paste products. Anchovy paste had lower pH mean value than Salmon paste or Herring paste. Salmon paste had TMA mean value (3.94 ± 0.22) higher than both of Herring and Anchovy paste which had nearly similar mean values of TMA (3. 63 ± 0.24, 3.62 ± 0.30); whereas the TVB-N value of Salmon paste (13.92 ± 0.10) was higher than both of Herring and Anchovy paste (13.80 ± 0.15, 14.36 ± 0.16, respectively). The TBA value of Herring paste was significantly higher than both of Salmon and Anchovy paste. Microbiological analysis of fish pastes was shown in table (3). Significant differences were observed in total anaerobic count, total bacillus count, total enterobacteriacae count and total staphylococcal count of the three fish paste products. Whereas no significant differences in total aerobic count and total halophilic count were seen among the three fish pastes. On other hand, isolation and identification of pathogenic bacteria from examined samples of fish pastes products indicated that *Bacillus cereus* was the only pathogenic bacteria isolated from 30% of Herring paste samples. Other investigated pathogens such as *C. perfrengns*, *E. coli*, *Salmonella*, *shigella, Pseudomonas aeruginosa and S.areus* were not detected in any examined samples. Changes in the sensory quality of fish pastes are shown in Table 4. The sensory grading of seafood freshness involves examination of the color, flavor, texture, taste, and additionally regards the overall acceptability of the product (Table 4). Although there were no significant differences in overall acceptability, results showed that Anchovy paste samples obtained the most acceptable scores on sensory evaluations.

Table (1): Statistical analytical results of chemical constituents of salmon, herring and anchovy paste samples. (n= 10).

Product	Salmon paste			Herring paste			anchovy paste		
Composition (%)	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
Crude protein	47.78	57.55	50.77±2.86	49.12	56.07	52.59±2.55	42.66	53.32	47.99±2.29
Total lipids	2.21	6.13	4.34±1.74*	2.32	5.77	4.05±1.54	2.18	5.33	3.76±2.16
Moisture	24.55	38.12	31.35±4.09*	26.32	33.76	30.04±3.66	25.42	34.08	29.1±4.75
Crude ash	2.56	4.04	2.9±0.63	2.35	3.75	3.05±0.33*	2.32	3.66	2.92±0.54
Nacl	0.66	2.69	1.68±0.71	0.74	2.19	1.47±0.47	0.81	2.56	1.69±0.53

* Significant level at P < 0.05 within the same row.

Table (2): Statistical analytical results of chemical quality of salmon, herring and anchovy paste samples. (n= 10).

Product	Salmon paste			Herring paste			anchovy paste		
Analysis	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
pH	5.44	6.73	6.09±0.43	5.23	6.33	5.78±0.33	5.56	5.71	5.64±0.12
TMA	3.32	3.95	3.94±0.22	3.45	3. 81	3. 63±0.24	3.51	3.72	3.62±0.30
TVB-N	3.81	14.02	13.92±0.10	13.77	14.83	13.80±0.15	13.24	15.47	14.36±0.16
TBA	1.08	1.86	1.30±0.29[b]	2.08	2.44	2.26±0.22[a]	1.12	2.34	1.73±0.43 [b]

a, b, c: Different letters in the same column are statistically important ($p < 0.05$).

Table (3): Statistical analytical results of bacterial quality of salmon, herring and anchovy paste samples. (n= 10).

Product	Salmon paste			Herring paste			anchovy paste		
Analysis	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
TAC (log cfu/g)	4.00	6.62	5.34±0.68	5.08	5.78	5.35±0.23	3.78	7.72	5.53±1.15
TAnC (log cfu/g)	<2.00	<2.00	< 2.0±0.0[c]	5.04	5.60	5.31±0.22[a]	2.00	5.70	3.78±1.50[b]
THC (log cfu/g)	3.20	5.16	4.63±0.53	3.60	5.23	4.59±0.52	3.70	5.93	4.56±0.69
TBC (log cfu/g)	2.70	5.73	4.38±1.16[a]	2.48	3.85	3.31±0.54[b]	2.00	2.70	2.26±0.30[c]
TEC (log cfu/g)	<2.00	<2.00	< 2.0±0.0 [b]	<2.00	<2.00	< 2.0±0.0[b]	2.78	4.85	3.68 ±0.74
TSC (log cfu/g)	2.30	3.57	2.86±0.46[b]	3.48	4.00	3.62±0.18[a]	2.48	3.85	3.15±0.48[b]
TC (log cfu/g	<2.00	<2.00	< 2.0±0.0	<2.00	<2.00	< 2.0±0.0	<2.00	<2.00	< 2.0±0.0

a, b, c: Different letters in the same column are statistically important ($p < 0.05$). *TAC: total aerobic count, TAnC: total anaerobic count, THC: total halophilic count, TBC: total bacillus count, TEC: total enterobacteriacae count, TSC: total staphylococcal count, TC: total coliform count.

Table (4): Mean score value for all sensory attributes of fish paste products (n=10)

Product	Salmon paste	Herring paste	anchovy paste
Analysis	Mean ± SD	Mean ± SD	Mean ± SD
Color	8.54±0.23[a]	7.67±0.17[b]	8.77±1.19[a]
Flavor	9.33±0.14[a]	8.78±0.22[b]	9.21±0. 19[a]
Texture	8. 44±0.09	8.17±0.41	8.26±0.12
Taste	9.27±0.28[a]	9.06±0.23[ab]	8.84±0.42[b]
Overall acceptability	8.15±0.22	8.03±026	8.33 ±0.32

a, b, c: Different letters in the same column are statistically important ($p < 0.05$).

4. DISCUSSION

Fish is a source of high quality proteins, essential minerals, vitamins and polyunsaturated fatty acids. Some recent works concerned with the development of new products that ideally retain all the nutritional properties of fish, but not its typical odor, so they can be included, meat-based preparations (Mohamed et al., 2011). Several methods exist to assess the quality of seafood. However, there is much variation in the chemical, bacteriological, and sensory changes, between species and different fish products, depending on whether the product is fresh or processed and the type of processing that is carried out. Therefore, the acceptable limits for each quality criteria may vary greatly for each type of product (Botta, 1995; Huss, 1988; Köse and Uzuncan, 2000).

Table (1) shows the average crude protein, total lipids, moisture, ash, and salt percentages of investigated fish paste samples. The protein content of fish paste samples ranged from 47.78 to 57.55 % for Salmon paste, 49.12 to 56.07 per cent for Herring paste and 42.66 to 53.32 % for Anchovy paste (Table I). Although several studies recorded approximate protein per cent in various fish products (Adeyeye et al., 2016; Naila et al., 2011); however, lower protein %t was observed in some fish pastes and fish burgers from Iran (Mahmoudzadeh et al., 2010). The low protein content could be attributed to the processing conditions and the time of fish harvest (Kristinsson and Rasco, 2000; Rezaei and Hedayatifard, 2013). The previous proximate composition of raw fish indicated that protein content of Salmon, Herring and Anchovy fillets was 21.5%, 16.0-19.0% (Murray and Burt, 2001) and 20.87% (Inanli et al., 2011) respectively. Comparing with aforementioned raw fish, the fish pastes investigated here had high protein content. So, manufacturing of such fish products is of great attention in developing African countries where protein energy malnutrition has become a public health issue. The mean values of Total lipids analyzed in Salmon, Herring and Anchovy paste samples were 4.34±1.74, 4.05±1.54 and 3.76±2.16 respectively. Lipid content of fish paste could affect the peroxide and TBA values in the product. Additionally, fat oxidation may be responsible for bitter taste and off odor characteristic for product spoilage (Thanonkaew et al., 2006).

Moisture content of Salmon, Herring and Anchovy paste samples were 31.35±4.09, 30.04±3.66 and 29.1±4.75, respectively (Table I). This result agrees with the one reported by Salem (2012). Higher results were recorded in cooked Anchovy cake (46.59±0.79) by Inanli et al. (2011), ln fish paste (77.23±0.04) and fish burger (65.58±0.46) by Mahmoudzadeh et al. (2010). Lower results were recorded in smoked spotted tilapia fish samples (Adeyeye et al., 2016). Moisture content of fish is necessary for a number of biochemical reactions and physiological changes that could affect the stability and quality of fish. Therefore, the decrease of moisture content may improve the keeping quality of the fish product, while high moisture content promotes microbial growth. Ash content of Salmon, Herring and Anchovy paste samples were 2.9±0.63, 3.05±0.33 and 2.92±0.54%, respectively (Table I). Lower result (1.4%) was recorded in fish paste from Iran (Mahmoudzadeh et al., 2010) while high ash content (7.9-8.6%) was reported in fish paste from the Maldives (Naila et al., 2011). The increase in ash content could be attributed to water loss during processing (Koral et al., 2009). Salt concentration (Nacl%) was determined as 1.68±0.71, 1.47±0.47 and 1.69±0.53% for Salmon, Herring and Anchovy paste samples, respectively (Table I). Similar salt content (1.4-1.6%) was determined in fish paste samples from the Maldives (Naila et al., 2011). The concentration of salt in fish product has important effects in reducing the risk of deterioration (Ahmed et al., 2011; Kaya and Erkoyuncu, 1999).

The changes in pH, TMA-N, TVB-N and TBA for the three fish paste products are shown in table (2). pH is an important critical factor affecting microbial growth and spoilage of foods. The present study showed non-significant variation ($p < 0.05$) of pH values between the three fish paste products (Table 2); the lowest acidic value (5.23) was recorded in Herring paste. The highest value (6.73) was recorded in Salmon paste. According to EOSQC guidelines the pH value of canned Salmon should be approximately 6.7 (EOSQC (Egyptian Organization for Standardization and Quality Control), 2005). In general, the mean pH values were 6.09, 5.78, and 5.64 for Salmon paste, Herring paste and Anchovy paste respectively. These results were lower than that recorded in Anchovy cake (6.93±0.15) by Inanli et al. (2011).

Further, TMA is a reduction product of TMAO (Trimethylamine oxide) decomposition due to bacterial spoilage and enzymatic activity (Serdaroğlu and Deniz, 2001). TMAO is present in marine fish and it is the most commonly used chemical method for evaluating fish quality (Magnusson and Martinsdottir, 1995). It is reported that 10–15 mg TMA-N/100 g is generally regarded as the limit of acceptability for human consumption (Huss, 1988). Meanwhile, Aurand et al. (1987) considered The TMA value are within the range of<3 mg N/100 g for fresh fish, >8 mgN/100 g for spoiled fish and ≥5 mg N/100 g for doubtful quality specified USFDA. In the current study, TMA content ranged from 3.32 – 3.95 mg N/100 g for Salmon paste, 3.45 – 3. 81 mg N/100 g for Herring paste and 3.51 – 3.72 mg N/100 g for Anchovy paste. TMA-N value was detected as 3.14 mg/100 in the raw Anchovy material, which was used in the cake, and as 4.11 mg/100 g in the cake at the end of the storage time (Inanli et al. 2011). The values presented in this study are lower than TMA values observed in other several fish species, such as fesiekh and mullet roe spread (Salem, 2012), blue whiting (Rey-Mansilla et al., 1999) and trout (Chytiri et al., 2004).

The mean concentrations of TVB-N in the present study were 13.92 ± 0.10 mg /100g in the Salmon paste, 13.80 ± 0.15 mg /100g in Herring paste and 14.36 ± 0.16 mg /100g in Anchovy paste (Table 2). The present results did not exceed the limit of acceptability (35 mg /100 g fish flesh) for fish regarded by EOSQC guidelines **(**2005**).** The TVB-N, a measure of decomposed protein and non-protein nitrogenous compounds (Huss, 1995) increased with storage time, which was probably caused by bacterial and endogenous proteolytic enzymatic actions (Hernandez-Herrero et al., 1999). Therefore, it is widely employed for freshness assessment. Increase in TVB-N content with storage can be attributed to the breakdown of TMAO and some amino acids.

The TBA test is widely used to measure lipid oxidation in food products. The present study determined that the mean amount of TBA was 1.30 ± 0.29 mg MDA/kg in the Salmon paste, 2.26 ± 0.22 in Herring paste and 1.73 ± 0.43 mg MDA/kg in Anchovy paste (Table 2). The results in this study are parallel to previous studies where TBA values of Anchovy cake, fesiekh and mullet roe spread products were < 2 mg MDA/kg (Inanli et al., 2011; Salem, 2012). The permitted level for TBA is known as 7.8 mg MDA /kg. According to researchers, TBA number should be less than 3 in a very good material and should not exceed 5 in a good material (Sinnhuber and Yu, 1958; Varlik et al., 1993). TBA values, which were obtained in our study, were within the very good material class. The increase of the TBA value during storage of fish products has been demonstrated (Boran and Köse, 2007; Izci, 2010; Tokur et al., 2006; Yanar and Fenercloglu, 1999).

The bacterial quality of examined fish paste samples was illustrated in table (3). The mean Total aerobic count (TAC) of Salmon, Herring and Anchovy paste samples were 5.34±0.68 log cfu/g, 5.35±0.23 log cfu/g and 5.53±1.15 log cfu/g, respectively. The TAC values obtained for the pasted fish samples were within the range of specified microbiological limits recommended by ICMSF (1986) for fish and fishery products; the maximum recommended bacterial counts for good-quality products is 5.7 log cfu/g. However, the maximum TAC values of Salmon and Anchovy paste samples were 6.62 and 7.72 log cfu/g respectively (Table 3). So, some of the pasted samples do not meet the microbial specification recommended by ICMSF (1986), and therefore, are not of good quality. Thus, TAC is considered a quality indicator for food samples. Although there is not direct correlation between this and the presence of pathogenic microorganisms, TAC is an indicator of the shelf-life of products, and also the potential for growth of the microorganism that is present (Arvanitoyannis et al., 2005).

The mean values of total anaerobic count (TAnC) of Herring and Anchovy paste samples were 5.31±0.22 log cfu/g and 3.78±1.50 log cfu/g, respectively. No anaerobic organisms (< 2 log cfu/g) were recorded in Salmon paste samples. The microbial contamination is likely to reflect heat-resistant species that survived the cooking and salting process or post-process contamination (Köse et al., 2007a). The microbial load of halophilic bacteria in the examined fish pastes is shown in table (3). The mean THC of Salmon, Herring and Anchovy paste samples were 4.63±0.53 log cfu/g, 4.59±0.52 log cfu/g and 4.56±0.69 log cfu/g, respectively. The results in this study are lower than THC found in fesiekh (6.59±4.21 log cfu/g) and mullet roe (5.24±1.35) spread products (Salem, 2012); and parallel to the results of total halophiles obtained in several fish products (Köse et al., 2007). It is important to point out that some halophilic bacteria are able to produce histamine by enzymatic activities during ripening process under poor hygienic and processing conditions (Visciano et al., 2012). Therefore, traditional fish products are usually under risk for pathogenic halophilic bacteria (Kose, 2010). The mean values for total bacillus count of Salmon, Herring and Anchovy paste samples were 4.38±1.16, 3.31±0.54 and 2.26±0.30 log cfu/g, respectively (Table 3). The count of *Bacillus* of Salmon paste (4.38 log cfu/gm) was higher than those of other pasted samples. Nearly similar count (2.60 ± 0.14 log cfu/g) was observed in Egyptian samples of mullet roe spread product. In previous study, 25 Bacillus spp. were isolated from one of the two Rihaakuru (tuna-based paste) samples. The enterobacteriaceae counts were detected only in Anchovy paste samples at the range of 2.78 - 4.85 log cfu/g with a mean value of 3.68 ±0.74 log cfu/g. Meanwhile enterobacteriaceae counts were not determined (< 2 log cfu/g) in examined samples of Salmon or Herring pastes. Higher counts were previously observed in fesiekh (3.97±1.42 log cfu/g) and mullet roe (4.64±1.81) spread products (Salem, 2012). Certain species of Enterobacteriaceae, produce the enzyme histidine decarboxylase during growth (Lehane and Olley, 2000). Enteric bacteria have been found to be the most important histamine forming bacteria in fish. Enterobacteriaceae in fish products often result from post-harvest contamination as these histamine-producing bacteria are found in water, baskets and floors/equipment at fish processing plants and fish markets (Ryder et al., 2014). Data from several studies have shown that enterobacteriaceae were isolated from surface swabs and muscle samples of marine fish species and fresh water species (Mohamed et al., 2011). The mean values of Staphylococcal count obtained for Salmon, Herring and Anchovy paste samples were 2.86±0.46, 3.62 ±0.18 and 3.15 ±0.48 log cfu/g, respectively (Table 3). Nearly similar counts were observed in Egyptian fesiekh (2.72±0.59 log cfu/g) and mullet roe (3.54±0.08 log cfu/g) spread product samples (Salem, 2012). The Staphylococcal count values obtained for the fish paste products were low and below the specified recommended value for all fish (FDA, 2001). Staphylococci have been isolated at levels of 2–10% in fish, especially in warm waters (Gram and Huss, 2000; Jablonski and Bohach, 1997) Adeyeye et al., 2016). However, enterotoxigenic strains are typically transferred by cross contamination from different sources and from food handlers with hand infections or with a cold or a sore throat (Docarmo et al., 2004). Furthermore, canned fish has been the cause of outbreaks of staphylococcal enterotoxin poisoning (Ababouch, 2002).

Isolation and identification of pathogenic bacteria from examined fish paste samples revealed that *B. cereus* was isolated from 30% of Herring paste samples, while it was not detected from any of Salmon or Anchovy paste samples. Similar prevalence of *B. cereus* was discovered in fesiekh spread samples. *Bacillus cereus* was previously isolated from traditionally fermented fish product (Kejeik), produced in Sudan (Sulieman et al., 2014). Based on FAO published notes, *Bacillus cereus* is a major etiological agent of food-borne outbreaks associated with fish and shellfish (Ryder et al., 2014). Food borne illnesses represent a serious but often unnoticed problem. Available reviews indicate that seafood is implicated in 10–25% of outbreaks (Nilsson and Gram, 2002). So, fish products should be processed in certified plants that have good requirements in hygiene and sanitation to avoid health risks and control critical points in the production process (Ababouch, 2006).

The mean scores of sensory attributes viz., colour, flavor, texture, taste and overall acceptability of Salmon, Herring and Anchovy pastes is given in Table 4. The sensory scores of fish pastes obtained from Salmon, Herring and Anchovy in the present study revealed that the panellists liked fish pasts in terms of colour, flavor, texture, taste and overall acceptability. The mean scores of acceptability were good (≥ 8) for all examined products. Generally, fish paste samples had very good (≥ 9) and good (≥ 8) scores in terms of taste flavor, colour and texture. However, the sensorial scores decreased to average quality (score 7) in term of colour for Herring paste samples. Sensory evaluation is the most important method for freshness and quality evaluation in the fish sector and fish inspection services. A product cannot be marketed unless sensory analysis results are favorable (Uzunlu and Yildirim, 2003). However, FDA (2001) pointed out that although sensory evaluation is generally used to screen fish for spoilage odors, such examination alone is ineffective control for histamine. Moreover, toxic histamine levels can also be observed in fish despite their acceptable sensory quality (Köse et al., 1997). It was reported that the used ingredients, microbiological load of the product, hygienic conditions during process and initial case of the fish affected shelf life of fish product (Kaba et al., 2012). Fish safety and quality assurance in the new millennium will require enhanced levels of international cooperation in promoting harmonization, equivalence schemes and standards setting mechanisms based in scientific understanding

5. CONCLUSION

The study concluded that fish pastes, which are ready for immediate human consumption, have acceptable chemical and sensory quality. However, they may consider high-risk for microbial hazards, so, special attention should be taken from competent authorities and food business operators. Moreover, consumers are increasingly aware of the dangers of pathogens in RTE seafood.

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