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Effect of Pretreatments and Drying Methods on Quality Attributes and Safety of Dried Shrimp *(Pandalus borealis)*

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ABSTRACT

This study was conducted to evaluate the quality attributes and safety assessment of dried shrimp treatments as affected by immersion process, type of immersion solution(sodium bisulphate and sodium tripolyphosphate) and drying methods (sun and oven drying) during storage at room temperature (25ºC±2ºC) up to 6 months. Keeping quality of these treatments during storage was evaluated by studying chemical composition, physicochemical, organoleptic properties and microbiological aspects. Results indicated that, fresh shrimp contained 79.20% moisture, 17.63% crude protein, 0.98 % crude fat and 2.19 % total ash. Also, significant differences ($p< 0.05$) were recorded in both chemical composition and all physicochemical properties between different dried shrimp treatments either at zero time or along storage periods. Sun dried samples had higher moisture content, TVN, TMAN and TBA values and were slightly lower in each crude protein, crude fat and pH values than shrimp samples dried by oven drying. Also, chemical composition of dried shrimp samples was not significantly affected by the type of immersion solution. Dried samples which immersed in sodium bisulfate had slightly higher TBA values and lower moisture content, pH values, TVN and TMAN than dried samples which immersed in sodium tripolyphosphate. Also, microbial load of dried shrimp samples was slightly affected by immersion process and the type of immersion solution. Dried shrimp samples which immersed in sodium bisulfate or sodium tripolyphosphate were lower microbial load (TBC, HB and yeast & mold) than samples prepared without immersion process. Moreover, dried shrimp samples which immersed in sodium bisulphate were slightly lower in both TBC and HB than that immersed in sodium tripolyphosphate. During storage periods, pH values, TVN, TMAN and TBA values and microbial load progressively increased as the period of storage increased for all dried shrimp samples. Finally, Sensory properties of fried sun dried shrimp samples were lower than those oven dried samples. Also, immersion in both sodium bisulfate and sodium tripolyphosphate led to improve the sensory properties of fried shrimp samples.

Keywords: Shrimp, Sun, artificial drying, Sodium bisulphate, Sodium tripolyphosphate.

INTRODUCTION

Fish is a very important foodstuff in developing countries, due to its high protein content and nutritional value. Temperature being important factor accelerating the process of spoilage. The spoilage reactions connecting on the death of the fish proceed at very rapid rate. Fresh fish contains up to 80% of water. It is highly perishable material and having a short storage life (Bala and Mondol, 2001). Shrimp is a rich source of protein, and its lipids are highly unsaturated compared to those of red meat. The most important unsaturated fatty acids in shrimp are eicosapentaenoic (20:5, EPA) and docosahexaenoic (22:6, DHA), which are also considered as essential fatty acids. Moreover, shrimp is a good source of minerals such as calcium, and it is also considered a high cholesterol food (Moura and Tenuta-Filho, 2002).

Preservation methods for fresh shrimp have been applied to extend shelf- life and to avoid health hazards. Such methods include chilled storage in ice (Rogério *et al.,* 2001and Lakshmanan *et al*., 2002), in liquid ice (Huidobro *et al.*, 2002), modified ice storage (Jiang *and Lee.,* 1988), super chilled storage at 0° C ~ -4°C (Fatima *et al*., 1988), modified atmospheres packaging storage in ice (Lopez-Caballero *et al*., 2002), gamma radiation (Yeh and Hau, 1988), and treatment with organic acids and their salts (Mosffer *et al.*, 1999).

Among the many preservation methods, dehydration or drying is probably one of the earliest and most effective methods developed. Drying of relatively thin slices of meat over fire or under sunlight has been practiced since prehistoric times. The principle of this preservation method is based on reducing the water activity to a low level that will not support the growth of microorganisms. Dried foods are usually containing less than 25% moisture and have a water activity of 0.00–0.60. Another category is the intermediate-moisture food that contains between 15–50% moisture with a water activity of 0.60–0.85. Dried products produced by different processes remain of interest since they do not require refrigeration during distribution and storage (Jay, 2000). Also, FAO (2001) reported that in the absence of cold chain, meat drying remains the most practical way of preserving and storing meat in developing countries with warm climate. Beside the needs to high storage conditions expanses such as cold storage or freezing. Food dehydration is still one of the most relevant and challenging unit operations in food processing, although the art of food preservation through the partial removal of water content dates back several centuries (Vega- Mercado, *et al.,* 2001).

Shrimp has a rich flavor. The fresh shrimp has a sweet and unique like plants with iron smell, and fish flavor, which is generated by chain length of less than 10 carbon atoms, unsaturated alcohols and aldehydes. The dried shrimps produce the special smell, which is different from the fresh shrimp. During storage, flavors of shrimps may be changed and the shrimps can also develop distinctly off-flavors, which mainly come from the growth of microorganisms, oxidation of lipids, or endogenous enzymatic decomposition in shrimp (Wilkes *et al*., 2000).

Salting and sun-drying is a popular method of fish preservation throughout Asia and African countries. The dried salted fish are often processed by simple sun

drying via artisanal fishermen resulting in poor quality finished product with limited shelf life. Bill and Shemkai (2006) and Jain and Pathhare (2007) reported that sun- drying is one of the oldest and most important techniques of fish preservation, but the main problem is the lack of process control, which can lead to products with low microbiological and /or nutritional control. Therefore, artificial drying was designed to simulate the traditional sun –drying process and solve the problems inherent with sun-drying methods (Hillock, 1999 and Fan *et al.*, 2002).

Dried salted fish is produced from thoroughly washed, split or filleted fish, the fish is most often dry salted or brine cured for 48 hr and then it was dried with sun. The water content can be further reduced by drying and when it becomes less than 50 % so called dried salted fish is obtained (Tabiri-Dedeh, 2002). The production of dried shrimp can be mainly divided into two steps: boiling (in order to deactivate microorganisms) and drying (Tapaneyasin *et al.*, 2005)

It is notable that the price of dried shrimp, as examined by food technologists, largely depends on properties such as color (specially its redness), shape (size) and rehydration capacity which are determinant of the quality of the dried product (Karathenos *et al*., 1996; Queiroz and Nebra, 2001 and Tapaneyasin *et al.*, 2005). In the present study, experiments were performed to investigate the effects of immersion solution, i.e., sodium bisulfate and sodium tripolyphosphate as well as drying methods, i.e., sun drying and artificial drying on the quality attributes of dried shrimp viz. chemical composition, physicochemical, microbiological and sensory properties.

MATERIALS AND METHODS

Materials

Fresh pink shrimp (*Pandalus borealis*) was obtained from a local seafood wholesaler in Mansoura city, Egypt, with a small size (510-520 shrimp/kg). The average mass of each shrimp was 2.27 ± 0.5 g and the average equivalent diameter of shrimp was 1.85 ± 0.07 cm.

Sodium bisulfate and sodium tripolyphosphate were purchased from El-Gomhouria Co. for Trading pharmaceutical, Chemicals and Medical Equipments, Cairo, Egypt. Also, sodium chloride is a product of El-Nasr Company for Salinas. It was purchased from the private sector shop in the local market at Giza, Egypt.

Methods

Preparation of dried shrimp treatments

Immediately after purchasing, samples were transported using ice box to the laboratory of Meat and Fish Technology Research Department of the Food Research Technology Institute, Giza, Egypt. After grading and washing with tap water, raw shrimp was weighed; 7 ± 0.1 kg of raw whole-shelled shrimp was used in each treatment.

Boiling in salt solution

The quantity of the raw shrimp was divided into 6 portions each of 7 kilograms. Raw whole-shelled shrimp was boiled in salt solution (NaCl solution). The boiling conditions are as follows: Concentration of salt solution of 5% (w/v),mass ratio of shrimp to salt solution of 1:2 on the weight basis and boiling time of 7 min. These boiling conditions have been reported to give good qualities of small dried shrimp (Niamnuy *et al.*, 2007). After boiling, whole-shelled shrimp was left at room temperature to cool and then removed the shells to obtain the flesh (edible portion).

The following treatments were carried out on the boiled edible portion of shrimp:

1-Two portions were kept without treatments as control.

2-Two portions were kept immersed in 0.5 % sodium tripolyphosphate solution for 30 min.

3- Two portions were kept immersed in 0.5% sodium bisulphate solution for 30min.

Drying process.

After immersion process, the shrimp treatments were dried as follows:

1-One portion from each treatment was sun dried for 3 days in a layer of about half an inch thick and was turned every 2 hours and at night shrimp treatments were covered with a tarpaulin to protect them from moisture. Samples were daily exposed to sun for 9 hr every day during summer season.

2-The second part from each treatment was dried in oven for16 hours at 50˚c.

Storage period.

The dried shrimp samples were packed in polyethylene bags and stored for 6 months at room temperature (25ºC±2ºC). Samples were then taken for analysis every two month during the storage period**.**

1. Analytical methods

Gross chemical composition (moisture, crude protein, and crude fat and total ash) of both fresh and dried shrimp treatments were determined according to the methods described by A.O.A.C. (2000).

Total volatile nitrogen (T.V.N.) and trimethylamine nitrogen (T.M.A.N) of both fresh and dried shrimp treatments were determined according to the method described by Winton and Winton (1958).

Thiobarbituric acid (TBA) value of both fresh and dried shrimp treatments was determined colorimetrically by using the method outlined by Tarladgis *et al.* (1960).

The pH values of fresh and dried shrimp samples were measured by homogenizing 10 gm of the sample with 100 ml distilled water for 30 sec. The pH of the prepared sample was measured using a pH_meter (Jenway 3510 pH meter) at 20ºC according to the method described by Fernández-López *et al.* (2006).

2. Microbiological examination.

Twenty five gram of a representative and homogenized sample were mixed with 225 ml of sterile buffered 0.1% peptone water in a sterile blender, under sterile conditions, to give 1/10 dilution. Serial dilutions were prepared to be used for counting several types of bacteria and yeast and mold counts.

Total Bacterial Count (TBC), Halophilic bacteria and yeast and mold counts of dried shrimp samples were examined by using Nutrient agar, halophilic agar and Potato Dextrose agar media, respectively according to the procedures described by APHA (1976) and Difco

Manual, 1984). Incubations were carried out at 37ºC/48 h for TBC; at 37°C /24h for halophilic bacteria and 25°C/5 day for yeasts and molds counts.

3. Organoleptic evaluation

Sensory evaluation of dried shrimp treatments after rehydration and frying was carried out at zero time and after storage at room temperature for 6 months. Fried shrimp was left to cool at room temperature for 5 minutes before being subjected to organoleptic evaluation as described by Watts *et al.* (1989). The fried samples were evaluated by a panel composed of 10 staff members from Meat and Fish Technology Research Department of the Food Research Technology Institute, Giza, Egypt. Panel members were asked to evaluate different fried samples treatments and requested to score their quality attributes: color, odor, taste, texture and overall acceptability on a 9 points hedonic scale as follows:

8-9 = very good 6-7 = good
4-5 = fair 2 -3 = poor
0-1 = very poor

4. Statistical analysis

Obtained data were subjected to analysis of variance (ANOVA). Means comparison were performed using Duncan's test at the 5% level of probability as reported by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

1- Gross chemical composition and physicochemical properties of fresh shrimp.

Data presented in Table (1) show the gross chemical composition and some physicochemical properties of fresh shrimp. From these data, it could be noticed that, fresh shrimp contained 79.20% moisture, 17.63% crude protein, 0.98% crude fat and 2.19% total ash on wet weight basis. However, on dry weight basis, it had 84.76% crude protein, 4.71% crude fat and 10.53% total ash. These results are in agreement with those obtained by Sriket, *et al.* (2007),who found that chemical composition of fresh shrimp ranged from 77.21to 80.4% moisture, 17.10 to 18.81% protein, 1.23 to1.30 % fat and 0.95to1.47 % ash. On the other hand Puga-lopez, *et al.*(2013) reported that, chemical composition of white shrimp ranged from 73.14 to 73.91% moisture, 19.93 to 20.10% protein, 1.27 to 1.34% lipid and 2.10 to 2.27% ash. Also, from the same table, it could be observed that total volatile nitrogen, Trimethylamine, thiobarbituric acid and pH values of fresh shrimp were 8.90 mg N/100 gm, 1.40 mg N/100 gm, 0.242 mg malonaldehyde / kg and 6.80, respectively. In this concern, Cobb *et al.* (1973) reported that, the initial TVB-N content of fresh shrimp tails from different batches of shrimp stored on ice ranged from 13.5 to 38.2 mg N/100 g.

2.Gross chemical composition of dried shrimp samples.

Chemical composition of different dried shrimp samples as affected by immersion solution (sodium bisulphate and sodium tripolyphosphate) and drying methods (sun and oven) during storage at ambient temperature (25±2ºC) up to 6 months was presented in Table (2). From statistical analysis of these data, it could be observed that, there were significant differences ($p< 0.05$) in all chemical composition between different shrimp samples either at zero time or along storage periods .Moisture content of all dried shrimp samples ranged from 18.37 to 18.89% at zero time. The highest moisture content (18.89%) was recorded for T_1 followed by T_3 being (18.82%) and finallyT_2 being (18.70%) with no significant differences ($p > 0.05$) between them at zero time and at any time of storage period. Meanwhile the lowest moisture content (18.37%) was found for T_5 followed by T_6 (18.41%) and finally T_4 (18.55%) with no significant differences between them. These values are in agreement with the desired quality of dried shrimp includes final moisture content not more than 20% (wet weight basis) or 25% (dry weight basis), which is equivalent to the water activity (a_w) not higher than 0.85 as reported by Goodwin (1984).

Table (1)Chemical composition and physico-chemical properties of fresh shrimp

Parameters	Fresh Shrimp	
	Ww	Dw
Moisture %	79.20	-
Crude Protein %	17.63	84.76
Crude Fat %	0.98	4.71
Total ash %	2.19	10.53
Total volatile nitrogen(mg N/100 gm)	8.90	-
Trimethylamine nitrogen(mg N/100 gm)	1.40	-
Thiobarbituric acid(mg malonaldehyde/ kg)	0.242	-
pH value	6.80	-

Ww : wet weight basis
Dw : dry weight basis

Moreover, sun dried samples had significantly higher moisture content than that of oven dried samples at either zero time or along storage periods. These results are in agreement with Abd El-Qader (2014) who reported that moisture content of oven dried chicken meat was lower than that dried by sun dryer. Similar trend was recorded by Moghazy and El-Seesy (2000), Galhom (2002) and Bellagha *et al* (2002). Also, regardless drying methods, moisture content of dried shrimp treatments which immersed in sodium bisulphate were insignificantly lower than that immersed in sodium tripolyphosphate. This may be due to sodium tri polyphosphate increase water holding capacity in order to lead to higher moisture content and yields (Sonlong, *et al*., 2011).

Also, by prolong of storage periods, moisture content of all dried shrimp samples was decreased. This decrease might be due to the partial evaporation of moisture through packaging (Abd El-Qader, 2014).In this concern, Rehab (2002) mentioned that the decrease in moisture content during the storage might be due to the reduction in protein solubility and subsequently the decrease in water holding capacity.

Also, from the same table, it could be observed that crude protein content of different dried shrimp samples immediately after drying ranged from 68.65-69.34%. The highest protein content (69.34%) was recorded for T5 followed by T6(69.31%) and T2 (69.09%) with non-significant differences ($p > 0.05$)

between them. On the contrary, the lowest protein content (68.65 %) was recorded for T1 followed by T4 sample (68.79%) and T3 (68.90%) with non-significant differences between them ($p > 0.05$). Sun-dried samples had slightly lower crude protein than that of artificial dried samples. Also, protein content not significantly affected by the type of immersion solution.

Table (2).Gross chemical composition of dried shrimp samples as affected by the type of immersion solution and drying methods during storage at ambient temperature(25±2ºC) for 6 months.

Chemical composition (%)	Storage period (month)	Sun drying			Oven drying			LSD at 0.05%
		T1	T2	T3	T4	T5	T6	
Moisture	0	18.89^{a}	18.70^{ab}	18.82^{a}	18.55^{bc}	18.37^{c}	18.41^{c}	0.19*
	2	18.58^{a}	18.45^{ab}	18.55^{a}	18.35^{bc}	18.26^{c}	18.29^{c}	0.15*
	4	18.27^{a}	18.18^{ab}	18.20^{ab}	18.11^{bc}	17.97^{c}	18.02^{c}	0.15*
	6	17.90^{a}	17.85^{a}	17.87^{a}	17.83^{ab}	17.71^{b}	17.78^{ab}	0.12*
Protein	0	68.65^{c}	69.09^{ab}	68.90^{bc}	68.79^{bc}	69.34^{a}	69.31^{a}	0.30*
	2	68.46^{c}	68.93^{ab}	68.78^{abc}	68.61^{bc}	69.20^{ba}	69.18^{a}	0.41*
	4	68.22^{c}	68.72^{ab}	68.53^{abc}	68.39^{bc}	68.97^{a}	68.92^{a}	0.42*
	6	67.94^{c}	68.46^{ab}	68.35^{abc}	68.23^{bc}	68.77^{a}	68.74^{a}	0.43*
Lipid	0	3.34^{c}	3.66^{ab}	3.55^{b}	3.40^{Ac}	3.71^{Aa}	3.68^{a}	0.11 *
	2	3.27^{b}	3.54^{a}	3.49^{a}	3.29^{ab}	3.59^{a}	3.57^{a}	0.20 *
	4	3.11^{c}	3.36^{ab}	3.34^{b}	3.16^{CDc}	3.45^{a}	3.44^{a}	0.09 *
	6	2.91^{b}	3.21^{a}	3.19^{a}	3.00^{b}	3.31^{a}	3.30^{a}	0.13 *
Ash	0	9.12^{a}	8.55^{b}	8.73^{b}	9.26^{a}	8.59^{b}	8.60^{b}	0.28*
	2	9.69^{a}	9.08^{b}	9.18^{b}	9.75^{a}	8.95^{b}	8.96^{b}	0.28*
	4	10.40^{a}	9.74^{bc}	9.93^{b}	10.34^{a}	9.61^{c}	9.62^{c}	0.28*
	6	11.25^{a}	10.48^{cd}	10.59^{c}	10.94^{b}	10.21^{de}	10·18^{e}	0.30*

Where: Mean values in the same row with the same letter are not significantly different (at p≥ 0.05). LSD: Least significant differences at 0.05 level.*: Significant differences.

T_1Sun dried shrimp Control
T_2Sun dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_3Sun dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate
T_4Artificial dried shrimp Control
T_5Artificial dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_6Artificial dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate

Total protein content of dried shrimp samples was slightly decreased during storage at room temperature (25±2°C) for 6 months. The decrement rate of crude protein content for sun-dried samples was higher than artificial dried samples during storage periods. These decreases in crude protein content of dried fish samples might be due to the action of internal enzymes and microorganisms which convert the protein macromolecule to smaller fractions of volatile nitrogenous substances as reported by El-Soaid Basuni (1993) and Bill and Shemkai (2006).

Table (2)showed that the fat content of all dried shrimp samples was slightly decreased after drying process (on dry weight basis) either those dried by sun-drying or by artificial drying as well as during storage period (for 6 months) at room temperature(25±2°C). The decrease of fat content of dried shrimp samples might be attributed to the lipid oxidation occurs during drying process and the storage period. These results were found to be within obtained by Shetti (1996) and Galhom (2002).In this concern, Abd El-Qader, (2014) reported that the decrease in fat content of dried chicken during storage period might be due to the hydrolysis of fat by some microorganisms or endogenous meat enzymes in addition to auto oxidation of fat by O_2.

Fat contents of dried shrimp samples which immersed in sodium bisulphate or sodium tripolyphosphate either at zero time or along storage periods were slightly higher than that untreated samples with immersion solutions(T1 and T4), this reflects the antioxidant effect of both sodium bisulphate and sodium tripolyphosphate to control lipid oxidation(Cheng and Ockerman, 2003 and Aksu and Alp, 2012). Moreover artificial dried samples had slightly higher fat content than that of sun-dried shrimp samples this might be due to the lower moisture content occurred by artificial drying than by sun drying. Similar trend was recorded by Abd El-Qader, (2014) on dried chicken meat.

Significant differences ($p<0.05$) were observed in ash content between different dried shrimp samples at any time of storage period as shown in Table (2). Immediately after drying (zero time), ash content of all dried shrimp treatments ranged from 8.57 to 9.30%.As storage time at room temperature prolonged, ash content of all dried shrimp treatments increased. This increase could be due to reduction in the moisture, protein and fat contents of all treatments during storage. At the end of storage period (at 6th month) ash content of all dried shrimp treatments ranged from 10.15 to 11.25%.These results are in agreement with those obtained by Shetti (1996) and Galhom (2002).

3. Changes in physicochemical properties of dried shrimp samples.

Data given in Table (3) show physicochemical properties of different dried shrimp samples as affected by immersion solution (sodium bisulphate and sodium

tripolyphosphate) and drying methods (sun and oven) during storage at ambient temperature (25±2°C) up to 6 months. From these results, it could be noticed that, there were significant differences ($p<0.05$) in all physicochemical properties between different dried shrimp treatments either at zero time or along storage periods. The pH values of different dried shrimp treatments ranged from 6.12 to 6.62 with significant differences ($p \leq 0.05$) between them at zero time. The highest pH value (6.62) was recorded for T6 followed by T3 (6.55) with no significant differences between them.

Table (3).Physicochemical properties of dried shrimp samples as affected by the type of immersion solution and drying methods during storage at ambient temperature(25±2ºC) for 6 months.

Physico-chemical properties	Storage period (month)	Sun drying			Oven drying			LSD at 0.05%
		T1	T2	T3	T4	T5	T6	
pH value	0	6.28^{b}	6.12^{b}	6.55^{a}	6.29^{b}	6.18^{b}	6.62^{Ea}	0.18*
	2	6.34^{b}	6.19^{b}	6.59^{a}	6.38^{b}	6.32^{b}	6.77^{a}	0.20*
	4	6.49^{bc}	6.30^{d}	6.67^{b}	6.55^{bc}	6.46^{cd}	6.89^{a}	0.17*
	6	6.65^{b}	6.37^{c}	6.96^{a}	6.69^{b}	6.61^{b}	6.98^{a}	0.17*
TBA	0	0.679^{a}	0.610^{ab}	0.529^{ab}	0.655^{ab}	0.547^{ab}	0.508^{b}	0.15*
	2	1.489^{a}	1.379^{ab}	1.219^{bc}	1.481^{a}	1.120^{c}	1.022^{c}	0.21*
	4	2.389^{a}	2.008^{b}	1.878^{bc}	2.301^{a}	1.725^{cd}	1.561^{d}	0.24*
	6	3.192^{a}	2.817^{b}	2.519^{c}	3.079^{a}	2.348^{cd}	2.115^{d}	0.25*
TVN	0	18.35^{a}	17.95^{c}	18.23^{b}	17.83^{d}	17.22^{f}	17.37^{e}	0.12*
	2	26.61^{a}	21.25^{d}	21.45^{c}	25.10^{b}	19.86^{f}	19.95^{e}	0.13*
	4	30.91^{a}	25.60^{d}	25.73^{c}	29.42^{b}	23.62^{f}	24.03^{e}	0.15*
	6	36.07^{a}	30.32^{d}	30.65^{c}	33.13^{b}	28.36^{f}	28.95^{e}	0.11*
TMN	0	2.78^{a}	2.47^{bc}	2.42^{ab}	2.61^{bc}	2.25^{c}	2.38^{bc}	0.22*
	2	7.66^{a}	5.30^{d}	5.46^{c}	6.84^{b}	4.51^{e}	4.93^{e}	0.25*
	4	10.62^{a}	8.42^{d}	9.12^{c}	9.87^{b}	8.04^{e}	8.09^{e}	0.12*
	6	13.79^{a}	11.46^{d}	11.63^{c}	13.00^{b}	11.15^{e}	11.28^{e}	0.13*

Where: Mean values in the same row with the same letter are not significantly different (at p≥ 0.05). LSD: Least significant differences at 0.05 levels.

***: Significant differences.**

T_1Sun dried shrimp Control

T_2Sun dried shrimp prepared by immersion in 0.5% Sodium bisulphate

T_3Sun dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate

T_4Artificial dried shrimp Control

T_5Artificial dried shrimp prepared by immersion in 0.5% Sodium bisulphate

T_6Artificial dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate

Also, sun died shrimp samples had slightly lower pH values than those of oven dried samples at either zero time or along of storage periods. Moreover, pH values were also affected by the type of immersion solution. Sodium tripolyphosphate solution was significantly increased the pH values compared with untreated shrimp samples (T1 and T3). On the other hand, sodium bisulphate solution led to slight decrease in the pH values compared with other dried shrimp samples. During storage period, the pH values for all dried shrimp samples were increased as the time of storage increased. The increase in pH value during storage might be attributed to the breakdown of protein macromolecule to small fraction of volatile nitrogenous substances(Bala *et al.,* 1979). Also, it is known that during storage period, denaturation of protein occurred with decreasing of moisture content may increase the pH value and lipid oxidation (Galhom, 2002).

Significant differences ($p \leq 0.05$) were observed in TBA values between different dried shrimp samples at any time of storage as shown in Table (3). Moreover, sun-dried samples had higher TBA values than those of oven dried samples at either zero time or along storage periods. Thiobarbituric acid values were affected by immersion process and type of immersion solution. Untreated dried shrimp samples (T1 and T4) had higher TBA values than that treated by immersion in sodium tripolyphosphate (T3 and T6) and sodium bisulphate (T2 and T5), this may be due to the antioxidant effect of both sodium bisulphate and sodium tripolyphosphate (Aksu and Alp, 2012). Thiobarbituric acid values of dried shrimp samples which immersed in sodium tripolyphosphate were insignificantly lower than that immersed in sodium bisulphate. This might be due to STPP had higher antioxidant effect than sodium bisulphate.

During storage periods, TBA values progressively increased as the period of storage increased for all dried shrimp samples. This increase in TBA value during the storage could be indicated continuous oxidation of lipids and consequently the production of oxidative by-products (Smith and Hole, 1991 and Abd El-Qader, 2014). Moreover, this increase in TBA value during storage could be attributed to the psychrophilic bacteria producing lipases causing lipolytic activities of fats as well as increase the level of free fatty acid (Davies and Board 1998).

From data in Table (3), it could be noticed that drying process had a great effect on TVBN and TMA levels, sun drying process recorded higher increase in TVBN and TMA levels than that in artificial drying process (oven dryer) at zero time and during storage at

room temperature. Also, TVBN and TMA values of dried shrimp treatments which immersed in sodium tripolyphosphate or sodium bisulphate were lower than those of untreated dried shrimp samples, this reflects the antimicrobial effect of both sodium bisulphate and sodium tripolyphosphate. Dried shrimp treatments which immersed in sodium bisulphate (T2and T5) had slightly lower TVN and TMA values than those of immersed in sodium tripolyphosphate (T3 and T6). This might be due to sodium bisulphate had higher antimicrobial effect than STPP.

During storage, the total volatile nitrogen and trimethylamine for all dried shrimp samples progressively increased as the time of storage increased. These results are in agreement with those obtained by Ali *et al.* (2008) and Ali *et al.* (2010).The values of TVN and TBA for all dried shrimp samples at the end of storage were ranged from 28.36 -36.07 and 11.15 - 13.79 mg N /100g, respectively. The highest values of TVN (36.07 mg N /100g) and TMA (13.79 mg N /100g) were recorded for T1followed by T4 with significant differences between them. On the other the lowest values of TVN (28.36 mg N /100g) and TMA (11.15 mg N /100g) were recorded for artificial dried shrimp which immersed in sodium bisulfate (T5).

4-Microbiological examination of dried shrimp samples.

Microbial load represented in Total bacterial count (TBC), halophilic bacteria (HB) and yeast and mold counts (*cfu/gm*) of different dried shrimp samples as affected by immersion solution and drying methods during storage at ambient temperature (25±2°C) up to 6 months was shown in Table (4).The initial counts of total bacterial, halophilic bacteria and yeast and mold of all dried shrimp samples ranged from 3.65×10^3 to 9.98×10^3, $0.25\times10^2$to 2.55×10^2, and 0.1×10^2 to 1.30×10^2*cfu/gm*, respectively. The low initial counts of abovementioned microorganisms indicating good levels of hygiene during handling, processing and storage. Moreover, sun dried shrimp samples had higher microbial load than that artificial dried shrimp samples at either zero time or along storage periods. These results are in agreement with Abd El-Qader, (2014) who reported that total bacterial count of oven dried chicken breast meat samples was slightly lower than that of solar dried chicken breast meat samples. The highest counts of abovementioned microorganisms were recorded for sun dried shrimp control (T1).

Table (4)Microbial load(*cfu/g*) of dried shrimp samples as affected by the type of immersion solution and drying methods during storage at ambient temperature(25±2ºC) for 6 months.

Microorganisms	Storage period (month)	Sun drying			Oven drying		
		T1	T2	T3	T4	T5	T6
Total bacterial count	0	9.98×10^3	9.11×10^3	9.27×10^3	3.96×10^3	3.65×10^3	3.76×10^3
	2	4.87×10^4	2.45×10^4	3.76×10^4	9.51×10^3	6.71×10^3	8.28×10^3
	4	9.13×10^4	4.39×10^4	6.99×10^4	3.88×10^4	1.28×10^4	2.33×10^4
	6	6.92×10^5	8.61×10^4	2.72×10^5	1.59×10^5	7.14×10^4	9.37×10^4
Halophilic bacteria	0	2.55×10^2	1.15×10^2	1.80×10^2	1.42×10^2	0.25×10^2	0.55×10^2
	2	8.90×10^2	4.45×10^2	6.65×10^2	5.80×10^2	1.35×10^2	2.53×10^2
	4	6.67×10^3	2.19×10^3	4.42×10^3	4.12×10^3	1.78×10^3	2.25×10^3
	6	5.79×10^4	9.65×10^3	2.28×10^4	3.11×10^4	7.83×10^3	1.51×10^4
Yeast and Mold count	0	1.30×10^2	0.20×10^2	0.20×10^2	1.10×10^2	0.10×10^2	0.10×10^2
	2	1.4×10^2	0.20×10^2	0.20×10^2	1.10×10^2	0.10×10^2	0.10×10^2
	4	1.45×10^2	0.30×10^2	0.40×10^2	1.20×10^2	0.10×10^2	0.10×10^2
	6	1.70×10^2	0.4×10^2	0.50×10^2	1.35×10^2	0.20×10^2	0.30×10^2

T_1Sun dried shrimp Control
T_2Sun dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_3Sun dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate
T_4Artificial dried shrimp Control
T_5Artificial dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_6Artificial dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate

Also, microbial load of dried shrimp samples was slightly affected by immersion process and the type of immersion solution. Dried shrimp samples which immersed in sodium bisulfate or sodium tripolyphosphate were lower microbial load (TBC, HB and yeast& mold) than that dried shrimp samples prepared without immersion process (T1 and T4). Moreover, dried shrimp samples which immersed in sodium bisulphate were slightly lower in both total bacterial count and halophillic bacteria than that immersed in sodium tripolyphosphate, this might be due to the higher antimicrobial effect of sodium bisulphate compared with sodium tripolyphosphate.

During storage period, it could be noticed that, TPC, HB and yeast and mold counts increased in all dried samples, these increases during storage might be due to increase in simple nitrogen compound (such as amino acids) and fatty acid when produced by hydrolysis of protein and fat during storage which consequently leads to suitable conditions for growth microorganisms as reported by El-Kordy, (2006). Also, Abd EL- Aziz (2000) reported that the increase in bacterial count at end of storage period could be attributed to increase in pH value at the end of storage consequently support the bacterial growth. Moreover, the increment ratio of yeast and mold counts for all dried shrimp during storage at room temperature was

lower than the increment ratio of both TBC and HB. Also, no obvious differences in yeast and mold counts between dried shrimp samples which immersed in sodium bisulfate and that immersed in sodium tripolyphosphate at either zero time or along storage periods.

5- Organoleptic evaluation of dried shrimp samples.

From the results in Table (5) it could be noticed that, there were significant differences between different shrimp samples in all sensory properties immediately after drying and at any time of storage periods at room temperature (25±2°C). The average scores of all sensory properties for fried shrimp samples ranged from 7.6-8.6 for taste; 7.4-8.3 for odor; 7.4-8.3 for texture; 7.5-8.5 for color and 7.4-8.3 for overall acceptability at zero time. These values decreased with increasing storage time, these decreases in sensory properties of fried shrimps samples which prepared after rehydration of dried shrimp might be due to chemicals produced by certain naturally occurring species of bacteria as well as lipid oxidation during storage.(Boyd, 2003).

Table (5).Organoleptic properties of dried shrimp samples as affected by the type of immersion solution and drying methods during storage at ambient temperature(25±2ºC) for 6 months.

Sensory properties	Storage period (month)	Sun drying			Oven drying			LSD at 0.05%
		T1	T2	T3	T4	T5	T6	
Taste	0	7.6^{b}	7.7^{b}	7.7^{b}	8.3^{ab}	8.5^{a}	8.6^{a}	0.73*
	2	6.9^{B}	7.0^{b}	7.0^{b}	7.9^{ab}	8.1^{a}	8.2^{a}	0.85*
	4	5.6^{b}	6.3^{b}	6.3^{b}	6.4^{b}	7.4^{a}	7.5^{a}	0.85*
	6	5.0^{b}	5.6^{b}	5.7^{b}	5.8^{b}	6.7^{a}	6.8^{a}	0.77*
Odor	0	7.4^{b}	7.9^{a}	7.9^{a}	8.2^{a}	8.3^{a}	8.2^{a}	0.37*
	2	6.8^{d}	7.3^{bc}	7.2^{cd}	7.5^{abc}	7.8^{a}	7.7^{ab}	0.44*
	4	5.9^{c}	6.6^{b}	6.4^{b}	6.5^{b}	7.4^{a}	7.4^{a}	0.48*
	6	4.3^{c}	5.9^{b}	5.7^{b}	5.7^{b}	6.7^{a}	6.6^{a}	0.50*
Texture	0	7.4^{b}	7.5^{b}	7.5^{b}	8.2^{a}	8.2^{a}	8.3^{a}	0.67*
	2	7.0^{c}	7.0^{c}	7.2^{bc}	7.4^{abc}	7.5^{ab}	7.7^{a}	0.82*
	4	5.8^{c}	6.3^{bc}	6.5^{abc}	6.3^{bc}	7.1^{ab}	7.3^{a}	0.44*
	6	4.5^{c}	5.8^{b}	6.0^{b}	4.9^{c}	6.7^{a}	6.8^{a}	0.50*
Color	0	7.5^{b}	7.6^{b}	8.0^{ab}	8.3^{a}	8.5^{a}	8.4^{a}	0.70*
	2	6.8^{c}	7.0^{bc}	7.0^{bc}	7.5^{ab}	8.0^{a}	7.7^{a}	0.82*
	4	5.9^{c}	6.3^{bc}	6.2^{c}	6.2^{c}	7.4^{a}	7.1^{ab}	0.57*
	6	4.5^{c}	5.5^{b}	5.4^{b}	4.8^{bc}	6.8^{a}	6.5^{a}	0.50*
Overall acceptability	0	7.4^{b}	7.6^{ab}	7.7^{ab}	8.2^{ab}	8.3^{Aa}	8.3^{a}	0.74*
	2	6.8^{b}	7.0^{ab}	7.1^{ab}	7.5^{ab}	7.8^{a}	7.8^{a}	0.76*
	4	5.8^{c}	6.3^{bc}	6.3^{bc}	6.6^{ab}	7.3^{a}	7.3^{a}	0.74*
	6	4.5^{c}	5.7^{b}	5.7^{b}	6.2^{ab}	6.7^{a}	6.6^{Ea}	0.57*

Where: Mean values in the same row with the same letter are not significantly different (at p≥ 0.05).
LSD: Least significant differences at 0.05 levels.
T_1Sun dried shrimp Control
T_2Sun dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_3Sun dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate
T_4Artificial dried shrimp Control
T_5Artificial dried shrimp prepared by immersion in 0.5% Sodium bisulphate
T_6Artificial dried shrimp prepared by immersion in 0.5% Sodium tripolyphosphate

Also, from the same table, it could be noticed that, sensory properties of fried sun dried shrimp samples were lower than that oven dried samples. Moreover, immersion in both sodium bisulfate and sodium tripolyphosphate led to improve the sensory properties of fried shrimp samples. Furthermore, no obvious differences in sensory properties between shrimp samples which immersed in sodium bisulfate and that immersed in sodium tripolyphosphate at any time of storage periods.

Finally, it could be concluded that ,the use of oven drying and treatments able to increase the time for keeping quality of these treatments during storage period at room temperature compared to drying at other conditions(sun drying). Also, shrimp samples which immersed in sodium tripolyphosphate showed best results.

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تأثير المعاملات الأولية وطرق التجفيف علي صفات الجودة والسلامة للجمبري المجفف

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قد أجريت هذه الدراسة لتقييم خصائص الجودة والسلامة لعينات الجمبري المجفف المتأثر بعملية الغمر، نوع محلول الغمر (باي سلفيت الصوديوم ، تراي بولى فوسفات الصوديوم) وطرق التجفيف (الشمسي وفرن التجفيف الصناعي) أثناء التخزين في درجة حرارة الغرفة (٢٥°م ± ٢°م) مدة ٦ أشهر. وللبقاء علي جودة هذه العينات أثناء التخزين تم تقييم التركيب الكيميائي، الخواص الفيزيائية، الحسية والميكروبيولوجية خلال هذة الدراسة.أشارت النتائج أن الجمبري الطازج يحتوي على ٧٩.٢٠٪ رطوبة، البروتين الخام ١٧.٦٣٪، والدهون الخام ٠.٩٨٪ والرماد الكلي ٢.١٩٪. أيضا، تم تسجيل فروق ذات دلالة إحصائية في كل من التركيب الكيميائي وجميع الخصائص الفيزيائية بين المعاملات للجمبري المجفف المختلفة إما بعد التجفيف أو طول فترة التخزين. وكانت العينات المجففة تجفيف شمسي أعلى نسبة في الرطوبة،وقيم المركبات النيتروجينية الطيارة، تراي مثيل أمينوحمض الثيوباربيوتريك وكانت أقل قليلا في كل من البروتين الخام، الدهن الخام ودرجة الحموضة من عينات الجمبري المجفف بواسطة التجفيف الصناعي. أيضا،التركيب الكيميائي لعينات الجمبري المجفف لا تتأثر كثيرا بنوع الغمر. كانت العينات المجففة المغمورة في باي سلفات الصوديوم أعلى قليلا فى قيم حمض الثيوباربيوتريك وانخفاض نسبة الرطوبة، ودرجة الحموضة ،وقيم المركبات النيتروجينية الطيارة وكذلك التراي ميثيل أمينمن العينات المجففة المغمورة في تراي بولى فوسفات الصوديوم. أيضا، الحمل الميكروبي لعينات الجمبري المجفف تأثر قليلا قبل عملية الغمر ونوع محلول الغمر. وكانت عينات الجمبري المجفف المغمورة في ثنائي سلفات الصوديوم أو تراى بولى فوسفات الصوديوم اقل فى الحمل الميكروبي (العد الكلى للبكتريا ،والبكتريا المحبة للملوحة وكذلك الخمائر والفطريات) من عينات الكنترول . وعلاوة على ذلك، كانت عينات الجمبري المجفف المغمورة في باي سلفيت الصوديوم منخفضة انخفاض طفيف في كل من العد الكلى البكترى والبكتريا المحبة للملوحةمن ذلك المغمورة في تراى بولى فوسفات الصوديوم. خلال فترات التخزين .زادت درجة الحموضة،وقيم حمض الثيوباربيوتريك ، المركبات النيتروجينية الطيارة وحمض الثيوباربيوتريك والحمل الميكروبي زيادة تدريجيه مع زيادة فترة التخزين لجميع عينات الجمبرى المجفف. وأخيرا، كانت الخصائص الحسية للعينات المجففة شمسي (عينات الجمبري المقلي) أقل من تلك العينات المجففة بالتجفيف الصناعى. أيضا، أدى الغمر في كل من ثنائي سلفات الصوديوم وتراى بولى فوسفات الصوديوم لتحسين الخواص الحسية لعينات الجمبري المقلي.