Fishery Technology 52 (2015) : 157 - 163

Development of Ready to Drink Iron Fortified Shrimp Soup in Retortable Pouches

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Abstract

Soup prepared from Indian white shrimp (*Fenneropenaeus indicus*) was fortified with iron (0.024%) by incorporating sodium iron EDTA. The soup was thermal processed at F_0 6.0, at three different temperatures *viz.,* 110, 115 and 121.1ºC in retortable pouches. All the samples were found to be commercially sterile. Iron fortification did not show any significant difference in sensory acceptance of the product after thermal processing at different temperatures. A higher b* value was observed in fortified soup compared to that of control soup. Thermally processed fortified shrimp soup was in acceptable condition even after 90 days at ambient temperature with slightly higher sensory scores for the product processed at 121.1°C.

Keywords: Shrimp soup, ready-to-drink, iron fortification, thermal processing, retort pouch

Introduction

Fish and shellfish are highly nutritious and play a major role in human nutrition. Health benefits related to fish consumption are due to the presence of proteins, unsaturated essential fatty acids, minerals and vitamins. Additional health benefits from the consumption of fish or fish oil may be related to polyunsaturated fatty acids (PUFA), especially omega-3 PUFA. But these foods lose noticeable amount of nutrients during processing. Nutrient enrichment helps in retaining or increasing nutrient quality of food there by compensating losses during processing. Convenient food products are the most talked about in food processing industry, particularly in export oriented fish processing industry due to the increased realization of valuable foreign exchange. These products range from ready to cook, ready to fry and ready to serve/drink form. Soup is one such value added liquid foods that is made by combining ingredients, such as meat, vegetables and beans in stock or hot water, until the flavor is extracted, forming a broth.

Thermal processing is one of the most effective means of preserving food (Karel et al., 1975) and it can be used to enhance the shelf life of a variety of sea food products. Various researchers have proven the technical and commercial feasibility of using retortable pouches for thermal processing (Hu et al., 1995; Goldfarb, 1970; Ravishankar et al., 2002; Bindu et al., 2004). Advantages of retortable pouches include shelf stability, lower weight and storage space, ease of opening and preparation and reduced heat exposure resulting in improved quality. Iron fortification is done to improve nutritional value and increase iron bioactivity in food products. Fortification is widely considered to be the most practical and cost effective long-term solution to improve nutritional value of food products (Yip & Ramakrishnan, 2002; WHO, 2004). Lebrun et al. (1998) reported that sodium iron EDTA (NaFeEDTA) remains stable during processing and storage and causes fewer organoleptic problems than other water soluble iron compounds. International Nutritional Anaemia Consulting Group reports that NaFeEDTA was the only compound fulfilling all the criteria of an iron supplement, which did not have the problem of poor absorption and bioavailability.

So keeping these views in consideration, the present work was undertaken to process shrimp soup fortified with iron in a ready-to-drink form in retortable pouches. The shrimp soup was processed

Received 16 August 2014; Revised 14 January 2015; Accepted 21 March 2015

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at F_0 6.0 min at three different temperatures *viz.*, 110, 115 and 121.1°C to analyze the effect of temperature on organoleptic and physico chemical quality of shrimp soup.

Materials and Methods

Commercially important species, Indian white shrimp (*Fenneropenaeus indicus*) was used in the present study. Shrimps were collected from Fort Kochi fish landing center at Kochi, India. The samples were iced immediately at shrimp: ice ratio of 1:1 and brought to the laboratory in insulated boxes. After reaching the laboratory, samples were de-iced and washed in chilled potable water. They were then peeled and deveined. The samples were then washed in chilled potable water and drained for five min.

The ingredients used for shrimp soup are given in Table 1. Onion and ginger-garlic paste was fried in sunflower oil till it turns golden brown colour. To this, water and salt were added and boiled. Corn flour and 0.024% of sodium iron EDTA (Sigma Chemicals Co., St. Louis, USA) were mixed with potable water and added to the boiling solution. It was then stirred continuously to attain the required consistency. Control soup medium was made without adding sodium iron EDTA powder.

Table 1. Ingredients for preparation of shrimp soup

Ingredients	Quantity added
Shrimp	100 g
Corn flour	40 g
Pepper	10 g
Ginger	10 g
Garlic	10 g
Butter	250 g
Onion	100 g
Water	1000 ml
Salt	To taste

100 g hot blanched shrimp (in 4% brine at 100°C for 1-2 min) was added to the pouches (12.5 μ polyester/ 12.5 μ aluminium foil/85 μ cast polypropylene of size 16X20 cm) along with the soup medium. The final weight of the pouches was maintained at 198±2 g. Air inside the pouch was exhausted by steam injection. The pouches were heat sealed and processed in a stationary overpressure retort (Model No 5682; John Fraser and Sons Ltd, Newcastle-upon-Tyne, UK) at three different temperatures *viz.*, 110°C, 115°C and 121°C to F_0 6 min. Time temperature data was collected during heat processing using thermocouple glands (Model no. GKJ 13009 C042, Ellab Co. Rodovre, Denmark) and thermocouple probe (Model no. SSA 12040 G700 TS, Ellab Co. Rodovre, Denmark). Heat penetration data were plotted on a semi logarithm paper with temperature deficit (RT-CT) in logarithmic scale on Y-axis against time in linear scale on X-axis. Lag factor for heating (J_h), lag factor for cooling (J_c), slope of the heating curve (f_h) and time in minutes for sterilization at retort temperature (U) were determined. The process time (B) was calculated by mathematical method (Stumbo, 1973). Actual process time (T) was determined by adding process time (B) and the effective heating period during come up time *viz.*, 58% of the come up time.

Thermal processed pouches were tested for commercial sterility (IS 2168, 1971). The proximate composition of the sample was determined by AOAC (2000) method. Indole content was analyzed spectrophotometrically by using Ehrlich's reagent (ρ-dimethylamino-benzaldehyde, Sigma Chemical Co., St. Louis, Mo., USA) (Cheuk & Finne, 1981). pH was determined according to APHA (1998) using a digital pH meter (Cyberscan 510, Eutech instruments, Singapore) after homogenizing 10 g of the sample with the same amount of distilled water. Total volatile base nitrogen (TVB-N) and trimethylamie (TMA) were estimated by the micro diffusion method (Conway, 1962). Thiobarbituric acid (TBA) value of the sample was estimated spectrophotometrically (Tarladgis et al., 1960) (Spectronic Unicam, Model-Genesys 10 UV, Rochester, NY, USA) and expressed as mg malonaldehyde kg^{-1} of sample. Free fatty acid (FFA) was measured and expressed as mg % oleic acid (AOCS, 1989). Peroxide value (PV) was analyzed and expressed as milliequivalent of O_2 kg^{-1} fat (AOCS, 1989). Iron content in the sample was assessed by using Atomic Absorption Spectrophotometer (AAS). The color of the soup of both fortified and control were measured with Mini Scan XE Plus (Hunter Laboratory, Virginia, USA). The parameters determined were CIEL* (L*=0 [black] and L*=100[white]), CIEa* (-a= greenness and +a* =redness), and CIEb* (-b* =blueness and +b* = yellowness). Sensory analysis of thermal processed shrimp soup was carried out by ten trained panelists consisting of scientists and researchers using a 9 point hedonic scale as prescribed by Meilgaard et al. (1999). Sensory evaluation was based on characterization and differentiation of the various sensory characters such as appearance, colour, odour, flavour, taste and consistency.

Experiments were carried out in triplicate. Results were expressed as mean values ± standard deviation (SD). Data were analyzed by using one way ANOVA and the least significant difference (LSD) was calculated at the probability level ($p<0.05$).

Results and Discussion

F_0 recommended for fish products ranges from 5-20 min (Frott & Lewis, 1994). Thermal processing of shrimp soup was done at F_0 6 at three different temperatures (110, 115 and 121.1°C). Various process parameters obtained by plotting the time temperature data on a semi-logarithmic paper are given in Table 2. Total process time taken for control samples processed at 110°C was 63.94 min, whereas iron-fortified samples processed at 110°C took 64.24 min. Total process time taken for samples processed at 121.1°C was only 15.58 and 17.82 min for control and iron-fortified samples respectively. Samples processed at 110°C showed higher cook value of 145.23 and 172.52 for control and iron-fortified samples respectively. A similar result was also reported by Sreenath et al. (2009) in mackerel canned in brine. When the processing temperature increases, the heat penetration to the product core occurs at a faster rate. According to Ramaswami & Grabowski (1999) the cook value is an important parameter to identify the quality retention of thermal processed food and should be minimum at any given level of lethality.

Different quality parameters of fresh shrimp are given in Table 3. Results showed that shrimps used for the present study were in good condition. Indole for raw fresh shrimp was 0.93 μg 100 g^{-1}. Indole is produced in shrimps enzymatically by bacteria. Proteolytic bacteria hydrolyze proteins into free amino acids using proteinase and peptidase enzymes. Free tryptophan residues then undergo decarboxylation and deamination reactions by the bacterial enzyme tryptophanase to produce indole and indole containing molecules (Snellings, 2003). A similar result was also observed by Mohan et al. (2006) in shrimp kuruma processed in retortable pouches and in Aluminum cans. TVB-N quantifies a wide range of basic volatile compounds including ammonia, methylamine, dimethylamine (DMA), trimethylamine (TMA) etc. The TVB-N and TMA content of raw shrimp was 11.25 and 1.48 mg N

Table 2. Heat penetration data for thermally processed control and iron fortified soups at F_0 6 at three different temperatures

Parameters	121.1°C		115°C		110°C	
	Control	Fortified	Control	Fortified	Control	Fortified
F_0 value	6.21	6.01	6.24	6.14	6.13	6.01
J_h	0.51	0.46	0.78	0.72	0.45	0.43
J_c	1.07	0.96	1.13	1.13	1.01	1.08
f_h	6.40	9.50	7.10	8.60	9.50	10.00
U	6.21	6.01	25.42	24.20	78.97	77.42
$F_h U^{-1}$	1.03	1.58	0.28	0.36	0.12	0.13
g	0.58	1.32	0.00	0.01	0.00	0.00
B	12.10	13.75	32.06	32.34	59.88	60.76
CUT	6.00	6.00	6.00	6.00	7.00	6.00
TPT	15.58	17.23	35.54	35.82	63.94	64.24
Cook value	40.31	49.29	80.97	83.80	145.23	172.52

*Each value is represented by average of three replications, where f_h is slope of heating curve, J_h is lag factor for heating, J_c is lag factor for cooling, U is time in minutes for sterilization at retort temperature, g is final temperature deficit, B is Ball's process time, CUT is retort come up time, TPT is total process time

100 g^{-1} respectively, which shows the freshness of sample used. Sterility test conducted for all samples showed that the products were sterile after thermal processing.

Table 3. Quality evaluation of fresh shrimp

Parameter	Value
pH	6.73±0.06
Indole (µg 100 g^{-1})	0.93±0.03
TBA (mg malonaldehyde kg^{-1})	0.49±0.06
TVB-N (mg N 100 g^{-1})	11.25±1.12
TMA (mg N 100 g^{-1})	1.48±0.07
Peroxide value	Nil
FFA (% oleic acid)	1.08±0.08
Total plate count (cfu g^{-1})	4.42x10^4

*Each value is represented by mean ± standard deviation of at least 3 determinations

Changes in quality parameters of shrimp soup after thermal processing at different temperatures are given in Table 4. Moisture content of raw soup was 94.82% while protein content was 3.67%. After thermal processing there was no significant difference in proximate composition. According to Castrillon et al. (1996) water holding capacity of myofibrillar protein fraction decreased after thermal processing leading to a reduction of moisture content and increase of protein content in muscle foods. Reduction in moisture content was also reported in thermal processed tuna (Mallick, 2003) rohu curry (Prasanna, 2004) and prawn kuruma (Mohan, 2004). pH of the product was slightly acidic and did not vary with thermal processing. A similar result was also reported by Mallick (2003) in rohu curry and Prasanna (2004) in sardine in oil and brine.

Overall quality and flavor of thermally processed product can be highly influenced by lipid oxidation products. The peroxide value which indicates primary oxidation products was not observed in raw and thermal processed soup. A similar result was also reported in thermal processed prawn kuruma by Mohan et al. (2004). Formation of secondary oxidation products was measured by means of thiobarbituric acid value showed significant difference ($p<0.05$) in thermal processed samples. Samples processed at 110°C showed higher values compared to the samples processed at 121.1°C and 115°C. It could be due to the effect of longer process time. A similar result was observed by Aubourg et al. (1997), Taneka & Taguchi (1985), Mallick (2003), Manju et al. (2004) and Prasanna (2004). However the values were below those reported as lipid spoilage indices, established at less than 3 mg malonaldehyde kg^{-1} of muscle TBA, (Huss, 1995).

Iron content did not vary in soups after processing and during storage (Fig. 1). Garby & Areekul (1974) reported that the addition of iron EDTA did not affect the visual appearance, pH or taste of the fish sauce. According to Hurrell et al. (1993), using NaFeEDTA as a food fortificant would have no detrimental effect on the metabolism of zinc, copper and calcium and in some circumstances could improve zinc absorption and retention from low bioavailability diets.

Table 4. Changes in different quality parameters of iron fortified shrimp soup

Parameters	Raw soup	121.1°C		115°C		110°C	
		Control	Iron fortified	Control	Iron fortified	Control	Iron fortified
Moisture (%)	94.82±0.64	94.55±0.51	93.48±0.54	94.72±0.58	92.52±0.91	94.76±0.42	92.88±0.61
Crude Protein (%)	3.67±0.9	3.60±0.64	3.93±0.26	3.50±0.24	4.2±0.51	3.17±0.68	4.82±0.49
Lipid (%)	1.004±0.36	1.02±0.69	1.01±0.47	1.01±0.61	1.02±0.64	1.05±0.26	1.01±0.25
Ash (%)	1.173±0.25	1.17±0.34	1.18±0.69	1.15±0.17	1.18±0.61	1.16±0.35	1.16±0.35
pH	6.53±0.36	6.64±0.26	6.63±0.25	6.68±0.61	6.64±0.47	6.66±0.48	6.59±0.85
TBA (mg malonaldehyde.kg^{-1})	0.035±0.57	0.27±0.14	0.23±0.26	0.34±0.39	0.32±0.51	0.55±0.64	0.52±0.72

* Each value is represented by average of three replications. TBA is represented as mg malonaldehyde.kg^{-1}

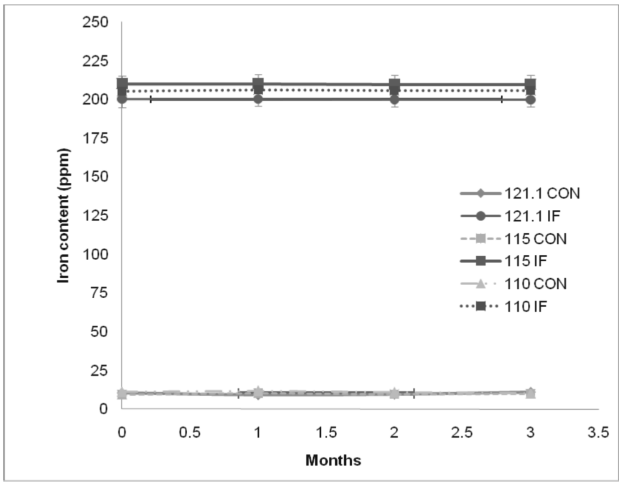

Fig. 1. Changes in iron contents of iron fortified and control soup. Each value is represented by mean ± standard deviation of at least 3 determinations, where CON is control and IF is Iron fortified soup.

Changes in colour values of shrimp processed at different temperature are given in Fig. 2, 3 and 4. Colour value varied significantly ($p<0.05$) with iron fortification. The L* value was found to decrease in all the samples after iron fortification. The samples processed at 110ºC showed least L* value, which could be due to the longer process time compared to the other samples. According to Charley & Weaver (1998), color of cooked foods depends on how quickly it reaches the core temperature and how long it is held at that temperature. The faster it reaches the set temperature, the better colour it has and the longer it is held at a temperature, the paler it becomes. As the processing temperature and time increases, the mailard reaction causes the formation of browning substances (Whistler & Daniel, 1985). It is reflected by decreased L* value and increased b* values in the present study. L* and b* of shrimp soup were significantly affected by both processing temperature and time ($p<0.05$) and longer processing time resulted in greater rates of decrease in these values. However, a* generally did not showed significant changes ($p>0.05$).

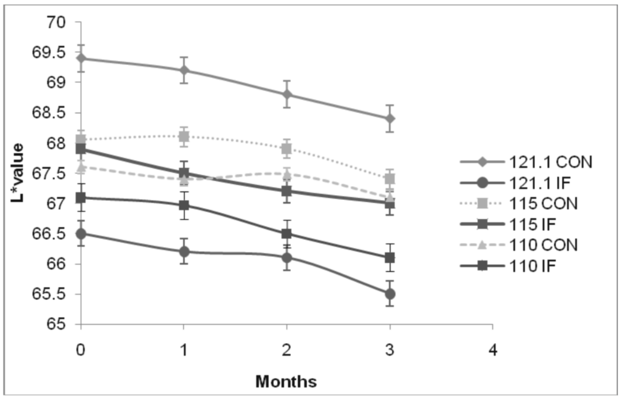

Fig. 2. Changes in L* value of soup during storage. Each value is represented by mean ± standard deviation of at least 3 determinations, where CON is control and IF is Iron fortified soup

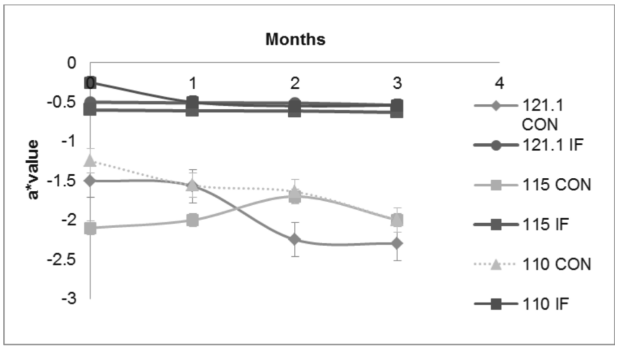

Fig. 3. Changes in a* value of soup during storage. Each value is represented by mean ± standard deviation of at least 3 determinations, where CON is control and IF is Iron fortified soup

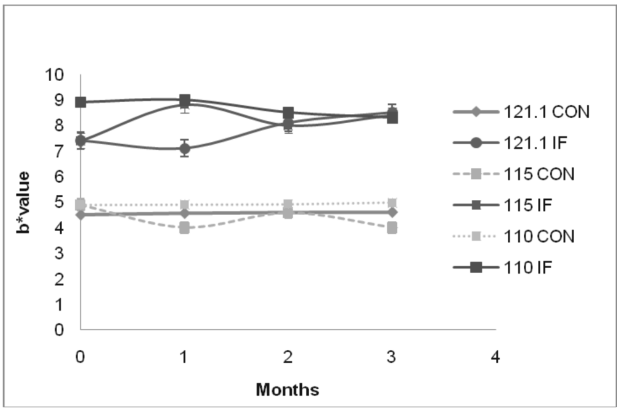

Fig. 4. Changes in b* value of soup during storage. Each value is represented by mean ± standard deviation of at least 3 determinations, where CON is control and IF is Iron fortified soup

Sensory evaluation of soup in retortable pouches were carried out every 30 days interval for 90 days using a 9 point hedonic scale (Table 5). Samples processed at 121.1ºC got maximum sensory acceptability irrespective of being either fortified or control soup. Iron fortification did not show any negative impact on sensory characteristics. During

Table 5. Changes in sensory scores during storage of iron fortified and control soup

Storage period	Overall acceptability					
	121.1°C		115°C		110°C	
	control	Iron fortified	control	Iron fortified	control	Iron fortified
0th month	8.2±0.54	8.1±0.23	8.1±0.4	8.0±0.3	8.0±0.14	7.9±0.3
1st month	8.0±0.6	8.0±0.24	7.9±0.6	7.8±0.6	7.8±0.4	7.8±0.4
2nd month	7.8±0.4	7.8±0.25	7.6±0.3	7.6±0.7	7.5±0.3	7.5±0.34
3rd month	7.6±0.1	7.6±0.25	7.4±0.6	7.4±0.5	7.4±0.4	7.3±0.1

*Each value is the average ±standard deviation of 10 replication

storage, the sensory scores decreased but the values were not significant and hence the soup was in acceptable condition even after 3 months of storage at ambient temperature.

Shrimp soup processed at 110°C and 115°C took about 4 and 2 times more time respectively compared to the product processed at 121.1°C. Quality attributes like TBA and colour values were affected by thermal processing. Changes in colour due to iron fortification did not affect the overall acceptability of shrimp soup significantly. Thermal processing of soup at 121.1°C at F_0 6 gave a higher sensory score and all other physico-chemical parameters. The study indicated that the soup processed with iron fortification resulted in better quality product which neither showed any adverse effect on appearance nor on any other physico-chemical attributes. Hence iron-fortified shrimp soup can be used as a tool to address iron deficiency.

Acknowledgement

Authors would like to thank the Director, Central Institute of Fisheries Technology, Cochin for providing facilities to carry out this work.

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