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Original Article

Production of a Semi Ready-to-Eat Shrimp Soup Powder and Assessment of Its Shelf Life

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ABSTRACT

Background and Objectives: *Macrobrachium nipponense* are wetland crustaceans. The shrimp is rich in protein and unsaturated fatty acids (FAs). Therefore, the aim of this study was to use *M. nipponense* as a supplement for the preparation of a new soup.

Materials and Methods: Nearly 40 kg of *M. nipponense* were harvested from Anzali Lagoon, Northern Iran. Shrimps were washed and dipped in NaCl solution (10% w/v) with a ratio of 1 to 2 at boiling temperature for 3 min. Then, these were cooled down for 10 minutes and dried by a cabinet-type air dryer at 70 ˚C for 6 h. Dried meats of shrimps were crushed using grinder. Nearly 4% of the crushes were combined with other ingreadients of the shrimp soup. Each 100 g of the soup powder was packed in a metalized film under vacuum and stored at room temperature for 6 months of storage.

Results: Results have shown that dried shrimp meats include useful compositions such as saturated FAs (ΣSFA; 33.36 ±2.5%), monounsaturated FAs (ΣMUFA; 21±1.6%) and polyunsaturated FAs (ΣPUFA; 38.92 ±2.1%). The protein content in dried shrimp meats was high (72.74 ±1.99% of dry weight). Chemical parameters of the samples such as thiobarbituric acid (TBA), peroxide value (PV), total volatile base nitrogen (TVB-N) and free fatty acid (FFA) increased and quality of the packaged soup color decreased with increased storage time ($P < 0.05$). The sensory evaluation (color, odor, flavor/taste and texture) of the samples has shown that these parameters are more acceptable during the first month of storage than other months. The total number of bacteria and fungi was respectively calculated as 4.1 and 3.79 cfu/g of sample during 6 months of storage.

Conclusions: In this study, use of 4% of the dried shrimp meats as supplement made a great taste in the soup. Furthermore, appropriate packaging under vacuum and use of metalized polyethylene films increased the shelf-life of the soup powder.

Keywords: *M. nipponense*, Semi ready-to-eat, Shrimp soup, Shelf-life

Introduction

Soup (e.g. fish and shrimp soups) is a popular nutritious food for people worldwide. Fishs and shrimps are rich in polyunsaturated fatty acids (PUFA) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (1). These PUFA are sensitive to environmental conditions during the storage time (2). Generally, preparation of shrimp soups in home kitchens is a time-consuming job. Furthermore, it is difficult to prepare soups with good flavors from raw shrimp meats in all seasons of the year. To solve these problems, ready-to-use soup mixtures are often served in restaurants as well as homes. However, these soups are not entirely satisfactory since their flavor is not interesting for the majority of Iranians. Hence, soup powders sold in Iranian markets are often prepared from red meat and chicken (3). *Macrobrachium nipponense* is a tiny shrimp that its population has recently been increased in Anzali Lagoon (north of Iran, Gilan Province) as well as many freshwaters of the world, especially East Asian rivers. The shrimp is a member of *Palaemonida* family. This decapod crustacean is one of the most

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important native shrimps in China, Korea and Japan (4, 5, 6). Presence of non-native *M. nipponense* in Iran rivers has been first reported by De Grave and Ghane (7). It is hypothesized that this shrimp has been introduced randomly or through fish transmission from their natural habitats such as China to Iran waters (6). Summer is the best season for the shrimp natural reproduction (8). Drying under sunshine is still a common method for the meat treatment in most of developing countries due to the low cost. However, this method cannot be used on cloudy days. Furthermore, this method can significantly reduce the quality of dried shrimps since they may be contaminated with dusts and insects. Teeboonma et al. (9) reported that the damage occured by insects, animals and weather was nearly 30–40%. Therefore, other methods must be used for drying shrimps. Namsanguan et al. (10) reported that features such as red-orange color and low shrinkage were preferred qualities in dried shrimps. The cabinet-type air dryer is one of the methods used to dry tiny shrimps under controlled conditions because this type of dryers includes sensors that control humidity and relative vacuum. Moreover, they are easily set up for each sample by the operator. Relatively, use of metalized polyethylene films can be helpful to increase the product shelf life. In fact, metalized polyethylene films are polymer films coated with a thin layer of metals, usually aluminum, and a thick layer of polyethylene. They are widely used for decorative and food packaging purposes. The vacuum packaging is an appropriate technic to prevent destructive microorganisms. Therefore, the aim of this study was to produce dried shrimp meats with high quality to using acuum packaging with metalized polyethylene films. Furthermore, meat chemicals such as thiobarbituric acid (TBA), peroxide value (PV), total volatile base nitrogen (TVB-N) and free fatty acid (FFA) were assessed to calculate meat shelf life at room temperature. Sensory evaluation and microbial characteristic investigation were carried out during 6 months of storage.

Materials and Methods

Chemicals: Chemicals and media such as chlorideic acid, methanol, hexane, potassium chromate, acetic acid, potassium chromate, sodium sulfate, boric acid, sodium thiosulphate, potassium iodide, starch, silver nitrate, sulfuric acid, methyl red, TBA, yeast glucose chloramphenicol agar and plate count agar were purchased from Sigma (USA) and Merck (Germany). All consumable chemicals were high in purity.

Preparation of dried shrimp meat powder: Totally, 40 kg of *M. nipponense* tiny shrimps were harvested from Anzali Lagoon (Gilan Province, Iran) from 25 June to 20 August, 2016. Shrimp samples were washed with cold tap water (3 °C) to remove dust, sand and other potential contaminants. Then, cleaned samples were dipped in NaCl solution (10% w/v) with 1:2 ratios at boiling temperature for 3 min. After spreading the samples on mesh trays to remove the excess water, samples were cooled for 10 min and then dried using a cabinet-type air dryer (Osaw Industrial Products Pvt. Ltd, India) at 70 °C for 6 h. The moisture content of the samples was less than 10%. Boiled samples with initial moisture contents of 270–350% were thin-layer dried using hot airs of 40–90 °C with an inlet air-flow rate of 1.0 ±0.2 m/s. The inlet drying air temperature was controlled by a proportional-integral derivative (PID) controller with an accuracy of ±1 °C. During the drying time, Samples were weighed continuously using electric balance (A&D model GF3000, Japan) with ±0.1 g accuracy. Dried samples were ground using grinder (Cuisinart SG-10 Electric Grinder. USA) after removal of the shrimp shell, head and tail.

Preparation of uncooked semi ready-to-eat soup powders: The grounded shrimp meats used in soup preparation are shown in Table 1. Ingredients were perfectly mixed. After preparing the soup formulation, each 100 g of the preparations was packed in a vacuum metalized polyethylene film. These were stored at room temperature for 6 months. Each month, three packages were randomly selected and tested. Chemical preservatives were not used in this study.

Table 1. A new formulation of semi ready-to-eat soup powders

Formulation	%
Dry shrimp powder	4
Onion	5
Garlic	3
Solid vegetable oil	10
Milk powder	25
White pepper	0.1
Parsley powder	1
Peppermint powder	1
Wheat flour	35
Potato flour	10
Cornstarch	2
Turmeric	0.6
Granular carrot	0.5
Salt	2.8
Total	100

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Preparation of cooked semi ready-to-eat soup powders: Briefly, 100 g of the soup powder were dissolved in four glasses of cold water. After complete dissolving, the solution was warmed using gentle flame for 20 min to achieve an internal temperature of nearly 80 ˚C.

Fatty acid compositions of dried shrimp meats: The FA compositions of dried shrimp powders were assessed based on a protocol by Castro et al. (11). Briefly, 0.075 g of the sample was dissolved in 1 ml of toluene and 2 ml of 1% H_2SO_4 in methanol. After extracting the esters using 5 ml of hexane, organic layers were separated and washed with 4 ml of 2% $KHCO_3$. Mixture was dried using anhydrous Na_2SO_4 and filtered. After removing the organic solvent, the fatty acid methyl ester (FAME) was subjected to gas chromatography [GC Agilent Technologies, 6890 N system, USA]. The initial temperature was 70˚C and then increased to 250 ˚C. The injection temperature was 220 ˚C. Helium was used as the carrier gas at a flow rate of 1 µl/min.

Proximate compositions of dried shrimp meats: Total protein contents of dried shrimp meats were calculated based on the nitrogen contents, analyzed using micro-Kjeldahl system (Techno Service Co, Behr, K 24, Germany). Nitrogen quantity was calculated by multiplying in a factor of 6.25 (12). Crude lipid contents were extracted from dried shrimp meats using Soxhlet extractor (Behr, Labor-Technik, Germany) and petroleum ether as solvent. Extracts were oven-dried at 105 ˚C overnight and then weighted (12). Ash contents of dried shrimp meats were estimated by heating the samples at 525 ˚C for 16 h using furnace (Muffle Furnace, SEF-202, Korea) (12). Residual moisture contents of the samples were calculated using oven drying at 105 ˚C to a constant weight (12). Carbohydrate and calorie contents of the shrimp meats were reported based on the methods by AOAC (12). To estimate the quantity of salts in dry shrimp meats, 5 g of the sample were weighted in a crucible and then converted to ash at 550 ˚C in a furnace (Muffle Furnace, SEF-202, Korea) until a constant mass was achieved. This was cooled down and transferred to a volumetric flask. The volume was adjusted to 100 ml using distilled water (D.W.) and filtered using Whatman No. 1 filter papers. Twenty milliliters of the filtered was titrated with 0.1 N of silver nitrate solution using a few drops of 10% potassium chromate as indicator. The proportion of salt was calculated as follows (13, 14, 15):

$$\text{Salt}_{\text{Value}} = \frac{\text{Volume (ml) of silver nitrate} \times 0.005845 \times 100}{\text{Sample mass (g)}}$$

Proximate compositions of uncooked semi ready-to-eat soup powders: Proximate compositions (protein, lipid, ash, moisture, carbohydrate and calorie) of the soup powder were analyzed based on methods by AOAC (12) described in Section of proximate compositions of dried shrimp meats.

Assessment of the shrimp meat shelf life: The following experiments were carried out to calculate shelf life of the samples during 6 months of storage at room temperature.

Calculation of water activity (a_w): Water activity (a_w) of uncooked semi ready-to-eat soup powders was calculated using decagon water activity meter (Aqua Lab Series 3, Decagon Devices, USA). Briefly, a_w of 2 g of the sample was automatically calculated by the instrument. The ratio of water vapor pressure in samples to pure water vapor pressureis a_w content (16).

Chemical analyses

Assessment of thiobarbituric acid (TBA): The TBA of the samples was assessed using the steam distillation method (17). Based on the method, 10 g of the soup powder were mixed with 97.5 ml of D.W. and shaked by hand for 2 min. While shaking, 2.5 ml of 4 N HCl were added to the mixture. Then, anti-bumping and antifoam granules were added to the mixture. Mixture was heated until 50 ml of distilled solution were achieved. The TBA of soup powder was repoted as mg of malondialdehyde per kg of sample. This was calculated using the following formula:

$$\text{TBA}_{\text{Value}} = 7.8 \times \text{Abs}_{538}$$

Assessment of peroxide value (PV): The PV of the samples was assessed using methods by AOAC (12). The value was reported as milli-equivalents of oxygen per 1000 g of oil. Briefly, 50 g of the soup powders were weighed in a ground glass. Then, 100 ml of chloroform were added to the powder and mixed well. The mixture was stored in a dark room for 2 h and then filtered. Filtered solutions (25 ml) were transferred into a glass jar undera fume hood to evaporate the solvent. After evaporating, the fat in the

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container was weighed. The remaining solution was added to 37 ml of acetic acid, 30 ml of D.W., 1 ml of potassium iodide and 1 ml of starch solution. The mixture was gently swirled and titrated using 0.01 N of $Na_2S_2O_3$. The PV was calculated using the following formula:

$$PV_{Value}\frac{V_2 \times N \times 1000}{W}$$

When V2 was volume of sodium thiosulfate for titration, N was normality of sodium thiosulfate and W was weight of lipid in gram.

Assessment of total volatile base nitrogen (TVB-N): The TVB-N of the samples was assessed based on a protocol by Woyewoda et al. (18). Briefly, 300 ml of D.W. and 10 g of the soup powders were added to a round bottom distillation flask and shaked by hand. Then, 2 g of magnesium oxide and anti-bumping granules were added to the flask. Twenty-five milliliters of 2% boric acid and a few drops of the indicator (1 g of phenolphthalein in 100 ml of 95% ethanol) were added to aglass flask. The distilling flask was heated to boil the liquid for exactly 10 min. The solutions were reheated and distilled for exactly 25 min. After the distillation, solutions were collected in receiver flasks and titrated to a purple endpoint of 0.1 N H_2SO_4. The TVB-N was reported as mg of nitrogen per 100 g of sample using the following formula:

$$TVB-N_{Value} = \frac{\text{volume (ml) of sulfuric acid} \times N \times 100 \times 14}{\text{Sample (g)}}$$

Assessment of free fatty acid (FFA): In general, 10 g of the soup powders, 50 ml of methanol and 50 ml of chloroform were added to a small blender jar and mixed for 1 min. This was filtered using Whatman No. 4 filter papers and rinsed with a small amount of chloroform in a flask. Then, 45 ml of D.W. were added to the filtrate to achieve a final chloroform/methanol/water ratio of 1:1:1 (v/v/v). the jar was swirled gently and the contents were transferred to a 250-ml separatory funnel. Flask was rinsed with chloroform and washings were added to a separatory funnel and left overnight at room temperature. After equilibrium, the lower chloroform layer was slowly filtered using a double 15-cm filter paper (Whatman No. 1 outter and Whatman No. 4 inner), half filled with anhydrous sodium sulfate, and rinsed with chloroform. Ten milliliters of the chloroform filtrate were transferred into pre-weighed aluminum drying dishes and allowed to evaporate the solvent. After evaporating, Dishes were heated in an oven at 103 ˚C for 1 hand then were cooled down and weighed. The remaining volumetric solution was transferred to a 250-ml flask and rinsed with 10 ml of chloroform. Solution was added with 70 ml of 2-propanol, 35 ml of methanol and eight drops of meta-cresol purple indicator and mixed well. This was titrated to violet endpoint of 0.05 N NaOH. The FFA was reported as percentage of oleic acid (14, 18).

Color assessment: The colorimeter (NR60CP Precision Colorimeter, 3nh, China) was used for measuring the color parameters such as L* (lightness), a* (redness) and b* (yellowness).

Sensory assessment: The sensory assessment was carried out using a method by Meilgaard (19). Sensory scores were calculated based on a 5-point system per sample to assign values for the statistical analysis. At the beginning of the test, 100 individuals of panel members were chosen. These individuals rinsed their mouth with water and then tasted the prototype samples. Scores included 0, very bad; 1, bad; 2, medium; 3, good; 4, very good and 5, excellent.

Microbial analysis: The microbial analysis was performed using pour plate method. Briefly, 45 ml of peptone water were bended with 5 g of the sample at various dilutions. One milliliter of this blend was transferred into the sterile plates. Plate count agar and yeast glucose chloramphenicol agar culture media were pre-sterilized. Generally, 15–20 ml of the media was added to each plate. Plates were thoroughly mixed using rotational movement. Plates were incubated at 37 ˚C for two days (bacteria) and at 23 ˚C for five days (molds and yeasts) (ISIRI, 2007). Colonies were counted using the following formula:

$$N_{Value} = \frac{c}{V(n_1 + 0.1n_2)d}$$

N: number of microorganisms; c: total number of colonies counted in all plates selected from two consecutive ranges; V, inoculated volume per plate (ml); n_1, number of plates counted at the first dilution; n_2, number of plates counted at the second dilution; d, dilution coefficient was selected based on the first dilution.

Statistical analysis: The statistical analysis was carried out using SAS software (Version 9.4, SAS Institute Inc., Cary, NC, USA). Duncan's Multiple

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Range and LSD tests (P = 0.05) were used to show significance of differences between the specific means. Data were reported as mean ±standard deviation (SD). All examinations were carried out in triplicate.

Results

Assessment of fatty acid compositions: The main FAcompositions of dried shrimp meat powders were shown in Table 2. Compositions consisted of ΣSFA, 33.36±2.5%;, ΣMUFA, 21±1.6% and ΣPUFA, 38.92 ±2.1%.

Table 2. Fatty acid compositions of dried shrimp meat powders using cabinet-type air dryer

	Fatty acid composition	Value (%)
		Dried shrimp meat
SFA	C14:0	0.31±0.01
	C16:0	18.49±0.14
	C18:0	13.02±0.01
	C20:0	0.41±0.01
	C22:0	1.13±0.01
MUFA	C16:1	1.13±0.01
	C18:1, n-9	19.28±0.01
	C20:1	0.59±0.01
PUFA	C18:2	19.67±0.01
	C18:3, n-3	1.05±0.01
	C20:5, n-3 (EPA)	9.69±0.01
	C22:6, n-3 (DHA)	8.51±0.01

Results are expressed as Mean ±SD (n = 3); SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; C, carbon; n, Number; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid

Assessment of proximate compositions: Results of proximate compositions of dried shrimp and semi-ready-to-eat soup powders are presented in Table 3. The protein content in dried shrimp was high (72.74 ±1.99%). The protein content in prepared soup powders was nearly 10% higher than that in other samples in the market (nearly 6%). However, fat, ash, moisture, salt and carbohydrate contents in dried shrimp meats were similar to those in other samples in the market. The fat, ash, moisture and salt contents in dried samples of shrimps respectively included 3.03 ±0.75%, 9.33 ±0.00%, 6.32 ±0.07% and 3.49 ±0.07% of the dry weight. The calorie of dried shrimps included 0.4 kj (95 cal.). This included 313.97 kj per 100 grams of sample in soup.

Table 3. Proximate compositions of dried shrimp meats and uncooked semi ready-to-eat soup powders

Composition	Dried shrimp meat	Soup powder
Protein	72.74±1.99%	10.00±0.01%
Fat	3.03±0.75%	14.33±0.01%
Moisture	6.32±0.07%	7.81±0.18%
Ash	9.33±0.00%	4.97±0.59%
Salt	3.49±0.07%	3.00±0.01%
Carbohydrate	-	36.25±0.01%
Calorie	0/4 ±0.02 kj/100 g	313.97±0.25 kj/100 g

Results are expressed as Mean ±SD (n = 3)

Assessment of water activity (a_w) during storage: Results of a_w in soup powders are shown in Table 4. The a_w increased with increased storage time at room temperature. a statistically significant difference was seen from the Month 4 to Month 6 (P<0.05).

Chemical analysis of samples during storage: Spoilage indicators such as TBA, PV, TVB-N and FFA were analysed during the storage. Results of the TBA analysis for the soup powders packaged in metalized polyethylene films during storage at room temperature are demonstrated in Table 4. The TBA content of the samples was significantly affected by the storage time (P<0.05). The TBA content in soup powders gradually increased during storage at room temperature. Results of peroxide value changes in soup powders during six months of storage at room temperature indicated that the PV increased with increased storage time (P < 0.05). Table 4 shows that TVB-N value included 13.30 mg N/100 g of sample in soup powders in the first month, and 20.30 mg N/100 g of sample after six months of storage. A significant difference (P<0.05) was seen between the Month 1 and Month 6 of storage. Results of FFA (percentage of oleic acid) content assessment showed that FFA slightly increased from an initial value of 0.27 to 9.69% of oleic acid during six months of storage at room temperature.

Color and sensory analyses of the samples during storage: Table 4 shows results for the assessment of of color values (L^*, a^* and b^*) in uncooked and cooked soup powders. As the storage time increased, L^* value increased in cooked soup powders while a^* and b^* values decreased. Therefore, the storage time was significant (P<0.05) on L*, a* and b* values. Figure 1 demonstrates results of the sensory assessment (color, odor, flavor/taste and texture) of the soup powders by the panel members. Sensory evaluation values in the first month were significantly higher than those in the end of storage (P<0.05).

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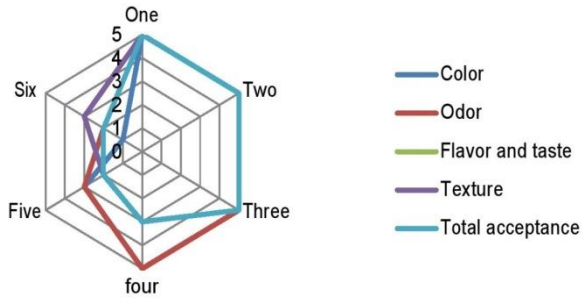

Fig 1. Sensory analysis of cooked semi ready-to-eat soup powders during 6 months of storage at room temperature

Microbial analysis of samples during storage: For the microbial analysis, three packs of the soup powders were randomly chosen (Table 5). The count of total bacteria and mold and yeast contents in soup powders included 4.1 and 3.79 cfu/g of sample during 6 months of storage. Therefore, the microorganism counts increased during the storage. The lowest numbers of bacteria and fungi (molds and yeasts) were recorded in Month 1 with 1.2 and 1.4 cfu/g of sample and the highest numbers recorded in Month 6 with 4.1 and 3.79 cfu/g of sample.

Discussion

The PUFA content is reported to decrease during drying in fish species (20). In fact, the lipid content in shrimps is mainly formed by phospholipids (72–74%) and triacylglycerols (16%). However, PUFA are mostly esterified to phospholipids rather than triacylglycerols (21). Marine phospholipids are more resistant to oxidation than bulk fish oil (mostly triacylglycerols) from the same sources are (22). This could explain the insignificant changes observed in the content of EPA and DHA during the drying process of shrimps.

Table 4. Water activity, chemical analysis and color change of uncooked and cooked semi ready-to-eat soup powders during 6 months of storage at room temperature

Chemical analysis	Soup powder	Storage time (month)					
		1	2	3	4	5	6
a_w %	Uncooked	0.30±0.01^{a}	0.30±0.01^{a}	0.32±0.01^{a}	0.35±0.02^{ab}	0.37±0.02^{b}	0.45±0.03^{c}
TBA (mg malondialdehyde /kg sample)	Uncooked	0.16±0.02^{d}	0.57±0.00^{c}	0.88±0.00^{b}	0.89±0.01^{b}	1.00±0.00^{a}	1.22±0.00^{a}
PV (meq/kg lipid)	Uncooked	0.09±0.00^{d}	0.14±0.00^{d}	0.65±0.00^{c}	1.65±0.00^{b}	1.69±0.00^{b}	3.14±0.00^{a}
TVN (mgN/100 g of sample)	Uncooked	13.30±0.07^{c}	13.29±0.07^{bc}	16.25±0.00^{b}	16.80±1.40^{ab}	18.90±0.70^{a}	20.30±4.20^{a}
FFA (% of oleic acid)	Uncooked	0.27±0.01^{d}	3.16±0.39^{c}	3.25±0.68^{c}	7.16±0.73^{b}	8.10±0.75^{a}	9.69±0.38^{a}
L^*	Uncooked	82.69±0.96^{a}	84.18±0.19^{a}	75.00±0.18^{b}	77.14±0.12^{c}	77.50±0.21^{c}	77.23±0.31^{c}
	Cooked	61.20±0.16^{f}	64.15±0.14^{e}	66.50±0.11^{d}	68.24±0.22^{c}	74.30±0.2^{b}	82.07±0.45^{a}
a^*	Uncooked	2.71±0.88^{c}	3.31±0.47^{bc}	3.58±0.03^{b}	4.38±0.23^{b}	4.38±0.21^{b}	5.87±0.19^{a}
	Cooked	4.00±0.01^{a}	3.37±0.00^{ab}	3.18±0.03^{b}	2.38±0.03^{c}	2.35±0.01^{c}	2.45±0.01^{c}
b^*	Uncooked	37.29±0.73^{b}	42.96±0.94^{a}	40.52±0.15^{a}	38.62±0.08^{b}	38.30±0.21^{b}	38.58±0.61^{b}
	Cooked	55.26±0.23^{a}	52.16±0.14^{a}	52.12±0.05^{a}	46.78±0.09^{b}	40.50±0.01^{c}	39.42±0.04^{c}

The lowercase letters in each row indicate significant differences ($P < 0.05$); results are expressed as Mean ±SD ($n = 3$); a_w, water activity; TBA, thiobarbituric acid; PV, peroxide value; TVN, total volatile nitrogen; FFA, free fatty acid; L^*, lightness, a^*; redness; b^*, yellowness

Table 5. Microorganism counts of uncooked semi ready-to-eat soup powders during 6 months of storage at room temperature

Microorganism count (cfu/g of sample)		Storage time (month)					
		1	2	3	4	5	6
Soup powder	Total bacteria	1.4±0.00^{d}	2.8±0.00^{c}	2.8±0.01^{c}	3.5±0.01^{b}	3.2±0.02^{b}	4.1±0.01^{a}
	Mold and yeast	1.2 ±0.00^{c}	2.7±0.00^{b}	2.7±0.01^{b}	2.7±0.01^{b}	2.1±0.02^{b}	3.79±0.01^{a}

The lowercase letters in each row indicate significant differences ($P < 0.05$); results are expressed as Mean ±SD ($n = 3$)

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Sampaio et al. (23) compared FA profile of the dried shrimp species in various seasons (summer, autumn and winter). They reported that shrimps contained a total of SFA of 27.49%, MUFA of 43.73%, PUFA of 28.79% and EPA and DHA of 19.96%. Therefore, Results of this study and other studies indicated that dried shrimp meats included sufficient contents of FAs, which are necessary to prevent many diseases. Dried shrimp meats are rich sources of protein and can be used as healthy foods. Based on the results, protein contents in dried shrimp meats were high (72.74 ±1.99% of dry weight). Akonor et al. (24) studies on marine shrimp of *Penaeus notialis* showed that protein contents in air-oven-dried (85.64 ±0.26%) and solar-dried (84.89 ±0.51%) shrimps were high. Differences in protein contents of dried shrimps might be attributed to differences in species, growth stages and seasons. Shrimp fats are mainly consist of polyunsaturated FAs (24). Fat contents in this study were lower than the fat contents of studies by Akonor et al. (24) and Wu and Mao (25) on dried shrimps of *P. notialis* and grass carp (*Ctenopharyngodon idellus*) dried fillets, respectively. Ash is the remaining minerals in foods. The ash contents of dried samples in the present study were higher than the ash contents in studies by Wu and Mao (25) and Akonor et al. (24). For the moisture, Kamalakar et al. (26) reported that drying characteristics of prawn and fish meats showed that increased drying temperature and time decreased primary moisture of the samples. Therefore, moisture contents less than 10% included further effective roles in sample shelf life. In the current study, salt adsorption was assessed after processing of dried shrimp meats. Niamnuy et al. (13) studies on quality changes of shrimp meats during boiling in salt solutions showed that the salt absorption in shrimp meats increased with increased boiling time (min). After adding shrimp meats to other soup ingredients, the proximate composition results of soup powders proved the nutritious values for the consumers.

Ensure of safety and food quality during production and storage processes is a major challenge. One of the critical factors to be continuously measured and controlled in production, distribution and storage of foods is w_a. In this study, w_a increased with increased storage time at room temperature. This increase in w_a could occur due to bacterial growth in soup powders. Modi et al. (27) reported w_a of dehydrated chicken kebabs 0.31–0.42% during 6 months of storage. Therefore, effects of time on soup powders are significant during storage at room temperature. The TBA index shows the secondary oxidation products, especially aldehydes (28). The presence of such compounds results in changes in sensory characteristics, including flavor and odor. Analysis of TBA showed that soup powders with higher TBA values showed further lipid oxidation after 4 months of storage at room temperature. In 2008, the National Iranian Standards Organization (IRI) has suggested the maximum 1–2 mg of malondialdehyde/kg of sample as an acceptable limit in soup powders (29). Hence, Month 4 was the last month of storage in this study.

The PV indicates the total quantity of hydroperoxides (the initial product of oxidative changes). It is one of the most widely used indicators for oxidative rancidity in oils and fats (1). The PV of soup powders in Months 5 and 6 of the storage showed further changes. This was similar to results by Xue-Yan et al. (30) on effects of processing conditions on nutritional values of fish soups. The TVB-N is an indicator of the freshness analysis in food products (31). This indicator includes a wide-range of volatile compounds such as ammonia, methylamine, dimethylamine and trimethylamine (32). Large quantities of TVB-N can result in enzyme activity, proteolysis and protein degradation (33). Hence, increases in TVB-N during the storage can be attributed to spoilage activitiesy of bacteria. High activities of such bacteria break down compounds such as trimethylamine oxide, peptides and amino acids into volatile species (34). The TVB-N values increase during storage and the spoilage limit includes 25–30 mg N/100 g of sample (35, 36). In 2005, Mol (36) studied shelf life of ready-to-eat fish soups and reported TVB-N from 5.26 in the first and more than 10 mg N/100 g after 15 weeks of storage. Chacko et al. (37) recorded the TVB-N in squid soups as 7.20 in the first day to more than 21 mg N/100 g after five months of storage; similar to those from the current study.

The FFA is a quality index in foods. In this study, Month 4 was the beginning of the most changes in FAs of the soup powders as the quality decreased. Chacko et al. (37) studies on the shelf-life of soup powders from squid *Sepioteuthis lessoniana* showed that the FFA increased slowly during the storage. In

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general, increases in FAs indicate decreases in quality of the products. One of the reasons for increasing FAs in this product can be due to the vegetable oils added to the soup formulation. The first and most important quality features of foods for the consumers include appearance and color. Therefore, color affects the consumer acceptance. In this study, increase in L^* parameter could be due to decrease in quality of soup powders during storage at room temperature. However, the most important criterion of the food quality for the consumers is sensory evaluation because peoples really care about the good sense of eating pleasure. Results of sensory evaluations showed that color and odor indices in cooked soup powders included the best grade (Grade 5) by trained panel members during 4 months of storage. Flavor and taste of cooked soup powders were good as well. Hence, most panel members enjoyed the soup until the end of Month 6. Results of this study were similar to studies by Chacko et al. (37) on soup powders prepared from squids and those by Mol (36) on ready-to-eat fish soups. In total, the sensory quality of cooked soup powders was excellent (Grade 5) at the beginning but descended during the storage. The value was lower than two in Month 5 of storage. As a result, samples were not accepted for the consumption after this time. Fish contain suitable compounds for the growth of microorganisms. Therefore, presence of bacteria is one of the reasons for decreased quality of fish during the storage (38). Indeed, primary microbial contamination, storage status and packaging play important roles in shelf life of fishery products (39). The maximum suggested limit for TVC in fish is 7 (40). Microbial results from the present study were similar to results from Mol (36) studies on fish soups. In the present study, number of microorganisms increased with increased storage time. However, this increase was in a satisfactory range. This could occur due to the gradual increase in w_a of soup powders. Generally, the best time for use of soup powders in terms of quality and microbial loads included Months 1 to 4.

Conclusion

In general, soup powders prepared using 4% dried shrimp (*M. nipponense*) meats were excellent in taste with high nutritional values. Furthermore, the spoilage indicators such as TBA, PV, TVB-N and FFA were analyzed during six months of storage at room temperature. Results showed that the soup powder chemical analysis seen acceptable for consumption until Month 6. However, the sensory analysis was acceptable until Month 4. Until this month, the sensory score was acceptable and no significant changes in color, odor, flavor and other characteristics were observed.

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