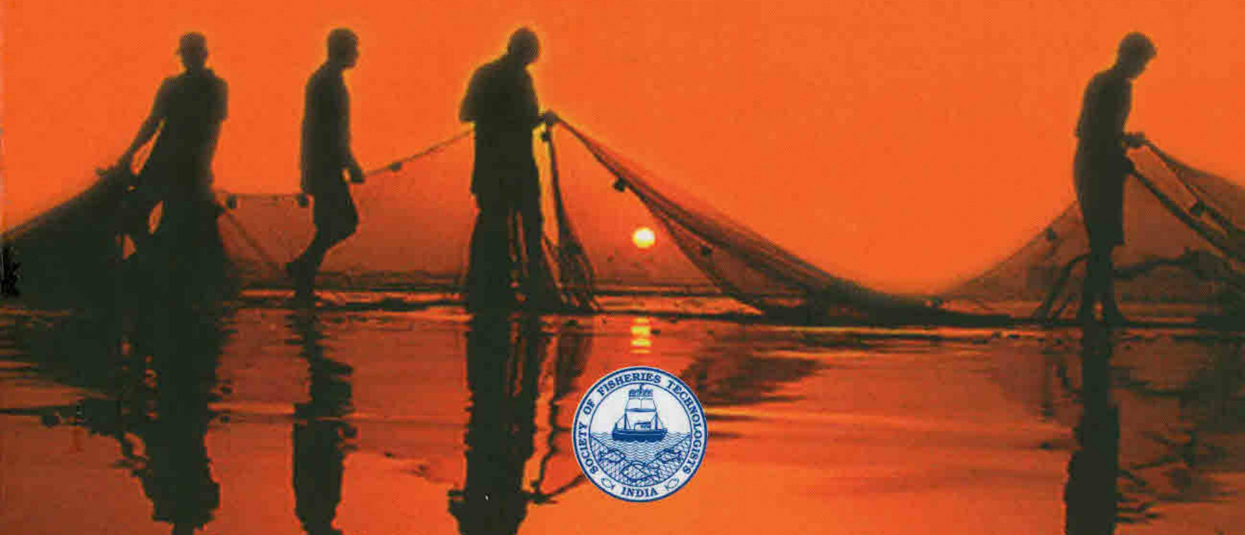
Coastal Fishery Resources of India

Conservation and Sustainable Utilisation



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URL : www.fishtech.org
Phone : 91 (0)484-2666845
Fax : 91 (0)484-2668212
Telegram : FISHTECH / MATSYAOUDYOGIKI
E-mail : cift@ciftmail.org
enk_ciftaris@sancharnet.in

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Editors

B. Meenakumari

M.R. Boopendranath

Leela Edwin

T.V. Sankar

Nikita Gopal

George Ninan

Society of Fisheries Technologists (India)

P.O. Matsyapuri, CIFT Junction, Cochin - 682 029, India

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Effect of Blanching on the Physical and Sensory Properties of Freeze-dried Indian White Shrimp

George Ninan, A.A. Zynudheen, Jose Joseph
P.T. Mathew and V. Geethalakshmi
Central Institute of Fisheries Technology
P.O. Matsyapuri, CIFT Junction, Cochin - 682 029, Kerala, India
**E-mail george66jiji@rediffmail.com*

Introduction

With changes in life styles, consumer perception of processed food is also changing. As a consequence there is an increasing demand for convenient, nutritious and safe foods all over the world. Value addition is an important term for the modern food business. It forms the most sought after technique in the food processing sector, in general, and fisheries sector, in particular. Freeze-dried items, particularly fish products form the high-end value added products which cater mostly the affluent class of consumers as these items have a high unit value.

Considerable changes in the physical structure of product, such as reduction in volume and decrease in porosity can be found during drying (Jankovie,1993; Ratti, 1994)). Shrinkage during freeze-drying is minimal (from 5% to 15%) while during air-drying is excessive, i.e., around 80% (Ratti, 2001). Compared to classical dehydration techniques, the main advantages of the vacuum freeze-drying process are: (i) the preservation of most of the initial raw material properties such as shape, appearance, taste, colour, flavour, texture, biological activity, etc. and (ii) the high rehydration capacity of the freeze-dried product (Dalgleish, 1990). This is largely because the structure of the food is not severely damaged as in other preservation procedures. Indeed, preliminary freezing of the product stiffens its structure and subsequently prevents solute and liquid motion during freeze-drying (Levine and Slade, 1989). When ice crystals form, a uniform network is created throughout the product that after sublimation yields a dense, homogeneous, porous matrix. Chemical and enzymatic reactions will thus be significantly limited and the phenomena of aroma loss and vitamin degradation will be reduced in comparison to classical drying techniques (Simatos *et al.,* 1974).

Freeze-drying process is not widely used in the food industry due to its high capital and operation costs. However, vacuum freeze-drying is the best method of water removal with final products of highest quality compared to other methods of food drying (Genin and René, 1995; Irzyniec *et al.*, 1995). The use of freeze-drying in food industries is therefore restricted to high added-value products such as coffee and tea, ingredients for ready-to-eat foods (vegetables, pasta, meat, fish, etc.) and several aromatic herbs. Although new improvements such as adsorption, fluidization, and microwaves have been researched in the last decade in order to reduce costs, vacuum freeze-drying is, up to now, the only technology used in an industrial scale to dry coffee, spices, meats, food ingredients and other high-value foods (Ratti, 2001). Rehydration ratio of freeze-dried foods is in general 4–6 times higher than air-dried foods, making freeze-dried products excellent for ready-to-eat instant meals or soups. There is a great scope for processing ready-to-consume freeze dried products incorporating fish mince.

The advantages of freeze-dried products include its light weight due to the loss of most of its water content. The final moisture content of freeze dried products that is being recommended is between 1-2%. This low moisture content results in an increase in the concentration of major nutrients such as proteins and fat in the remaining mass. Oxidative deterioration of the remaining fat during storage is one of the disadvantages of freeze-dried meat products. Shrimp constitute almost 100% of the freeze-dried products of aquatic origin from India, which exclusively caters to export market. The bulk of the export is AFD shrimp, which is peeled, deveined and blanched with or without spice. In the year 2005-06, India exported 659 t of AFD shrimp worth Rs. 2.84 million (Anon, 2006).

In India, only very few studies have been carried out on the freeze-drying of fish and shellfish. Govindan (1968) reported that prawn and lean fish yielded freeze-dried products with good reconstitution and organoleptic properties, whereas the high fat content in fish retards both dehydration and rehydration during freeze-drying. Pre-cooked ready to serve salads, instant fish soup mixes from fish and shellfish, and prawn cakes prepared using freeze drying technique were found to have good consumer acceptance (Govindan, 1969, 1970). There was minimum denaturation for water extractable proteins during freeze drying of prawns and salt extractable proteins were rendered insoluble to the extent of 21%. The storage life for freeze dried prawn was 32 months under ambient conditions (Govindan, 1974). Noomhorm and Vongsawasdi (1998) reported that freeze-dried giant freshwater prawns were found to retain good physical, chemical sensory qualities during six months storage at 25°C and rated better than IQF samples preserved at –25°C.

AFD shrimp is commercially prepared from Indian white shrimp (*Fennerapenaeus indicus*) by blanching prior to freeze-drying. The objective of this work was to assess the changes in physical and sensory properties of freeze dried Indian white shrimp under different blanching conditions.

Materials and Methods

Freshly caught shrimp (*Fenneropenaeus indicus*) having an average weight of 20±2 g procured from the Cochin fisheries harbour was used for the study. The shrimps were iced and brought to the laboratory in insulated boxes. The whole shrimp was washed in potable water, peeled & deveined (PD) and washed. It was then divided into three lots of 500g each. First lot was blanched in 1% boiling brine for 30 seconds, second lot was blanched in 1% boiling brine for 3 minutes, and both lots were drained & cooled. Third lot was kept as control without blanching. All the lots were frozen in an air blast freezer (Model Icematic T10, Italy) at -40°C as Individually Quick Frozen pieces for 40 minutes and stored at -20°C prior to freeze drying. The pre-frozen shrimp samples were loaded to the Freeze Dryer (Martin Christ, Gamma 1-16 LSC, Serial No.12546, Germany) and subjected to freeze drying for 24 h. Freeze drying was done in two steps, i.e., main drying for 20 hours at a set shelf temperature of 20°C and set pressure of 0.01mbar and subsequent final drying at 25°C for 4 hours and 0.001mbar pressure. The condenser temperature was - 55°C during the process.

Appropriate quantities of homogenized samples were used for determination moisture, ash and total nitrogen by AOAC methods 950.46, 938.08 and 940.25 (AOAC, 2000), respectively. The samples were rehydrated in warm water at different time intervals. After rehydration for a fixed period of time, each individual piece was taken out, excess water was removed using a tissue paper and the parameters, rehydration percentage (R%), rehydration ability (Ra) (Eikevik *et al.*, 2005) and rehydration coefficient (RC) were estimated as given below:

$$\text{Rehydration percentage, R\%} = \frac{\text{Weight after rehydration}}{\text{Weight before rehydration}} \times 100$$

$$\text{Rehydration ability, Ra} = \frac{\text{Water content after rehydration}}{\text{Dry matter of the product}} \times 100$$

$$\text{Rehydration coefficient, RC} = \frac{\text{Weight of water absorbed during rehydration}}{\text{Weight of water removed during drying}}$$

Sensory evaluation of freeze dried shrimp sample was done by a group of five panelists by giving scores for appearance, color, taste, texture, and overall acceptability of the samples on the basis of nine-point hedonic scale as described by Peryam and Pilgrims (1957). The samples were rehydrated for 30 seconds in warm water containing 2% salt and presented to the panelists. A score of 4 was taken as the borderline for overall acceptability. Instrumental texture profile analysis was carried out using a Food Texture Analyzer (Lloyd Instruments, Model LRX Plus, UK). The test was done at a speed of 12 mm/min. using a 500 N load cell using a 50 mm diameter cylindrical probe. Uniform samples were allowed for a compression of 40% with a trigger force of 0.5 kg. From the double compressions, parameters such as hardness 1, hardness 2, Cohesiveness, Springiness, and Fracture force were determined. Texture Profile Analysis results was tabulated using Nexygen Software.

All the experiments were carried out in triplicates and the results are presented as means standard error of means (S.E.M). The significance of the differences between the mean values was determined by One-way Analysis of Variance (ANOVA), followed by Tuckey's test using SPSS software (Ver. 10) for Windows.

Results and Discussion

Proximate composition of fresh shrimp is given in Table 1. The yield of freeze-dried shrimps under different blanching conditions is given in Table 2. The yield from PD control (Lot I) was found to be higher due to less water and solid loss during the process. Since the control was not subjected to blanching, protein damage and the loss of water holding capacity will be minimum. Hence, the moisture content was found to be higher in this lot. The yield of lot II and lot III were found to be 17.36% and 13.07 % respectively. The low yield is due to hot blanching, which will render the protein structure to damage and result in loss of water holding capacity. An inverse relation of cooking time and yield can be obviously expected due to denaturation of protein and subsequent release of water. Consequently moisture levels of lot III was found to be the lowest, which could be due to the easy escape of water.

Rehydration percentage of the samples at different periods of time is given in Table 3. The rehydration percentage showed a steady upward trend in all the three lots with the increase in time. Within a rehydration time of 30 seconds, significant difference ($p<0.05$) was observed in the rehydration percentage between the three lots. This could be due to the

Table 1: Proximate composition of fresh Indian white shrimp

Proximate composition	%
Moisture	76.53±0.78
Protein	19.91±0.31
Fat	0.45 ±0.03
Ash	1.25±0.08

Table 2: Yield of freeze-dried shrimp

Raw material	Yield, %	Moisture, %
PD control	20.0%	2.50%
PC 30 sec	17.36%	0.73%
PC 3 min	13.07%	0.60%

PD: Peeled and deveined; PC: Peeled and cooked

lower moisture content in Lot III when compared with other two lots. Moreover, this lot was subjected to maximum blanching which could have done irreparable loss to the water holding capacity of the muscle and facilitated the easy absorbance of water as in the case of water filling up the spaces in a dry sponge. However, no significant difference in the rehydration percentage was observed after 30 minutes among the three lots indicating that a threshold point has been reached in the rehydration capacities of the samples.

Rehydration coefficient (CR) of different samples during different intervals of rehydration is given in Table 4. It is the ratio of the amount of water taken up by the product over the total amount of water removed by freeze drying from the product. Significant difference was observed in rehydration coefficient among the three lots. CR of PD shrimp (lot I) was found to be minimum when compared to cooked shrimps(II &III) since lot I had the maximum initial moisture content among the three samples. Within 60 minutes of rehydration, lot III, II and I had a CR% 0.996, 0.778 and 0.603 respectively, indicating that almost all the water lost is reabsorbed in cooked samples, particularly in lot III.

Table 3: Rehydration percentage (%) of freeze dried shrimps

Time	I	II	III
30 sec	159.44±1.1[a]	164.72±1.1[b]	193.88±3.1[c]
1 min	171.28±0.54[a]	180.42±1.9[b]	213.65±1.9[c]
2 min	200.13±0.9[a]	197.44±0.4[a]	227.34±2.8[b]
4 min	228.20±3.5[a]	211.66±1.9[a]	230.18±2.0[a]
7 min	234.32±4.0[a]	218.88±4.1[b]	239.08±3.5[a]
11 min	256.33±5.5[a]	225.94±2.[b]	244.74±3.7[c]
16 min	261.36±5.3[a]	231.86±2.7[b]	246.45±2.1[c]
20 min	263.61±3.3[b]	241.55±3.9[a]	249.19±3.6[a]
30 min	265.00±5.3[a]	266.25±3.6[a]	261.77±4.6[a]
60 min	265.85±2.8[a]	266.80±3.7[a]	265.93±1.7[a]

Means within a row with different letters are significantly different ($p < 0.05$)

Table 4: Rehydration coefficient (CR) of freeze-dried shrimp

Time	I	II	III
30 sec	0.321±0.002[a]	0.373±0.004[b]	0.696±0.003[c]
1 min	0.365±0.004[a]	0.437±0.001[b]	0.769±0.002[c]
2 min	0.339±0.004[a]	0.524±0.003[b]	0.758±0.005[c]
4 min	0.483±0.019[a]	0.507±0.04[b]	0.781±0.004[c]
7 min	0.504±0.001[a]	0.511±0.004[a]	0.839±0.003[b]
11 min	0.510±0.01[a]	0.652±0.001[b]	0.952±0.003[c]
16 min	0.550±0.025[a]	0.659±0.002[b]	0.899±0.005[c]
20 min	0.567±0.003[a]	0.684±0.002[b]	0.959±0.003[c]
30 min	0.586±0.003[a]	0.754±.01[b]	0.994±0.01[c]
60 min	0.603±0.002[a]	0.778±0.05[b]	0.996±0.003[c]

Means within a row with different letters are significantly different ($p < 0.05$)

Rehydration ability (Ra) during different intervals of rehydration is given in Table 5. Rehydration ability indicates the ratio of water content in the product after rehydration and dry matter of the product in freeze dried samples. Ra was found to be proportional to the rehydration coefficient in all the samples. Ra showed significant differences among the three lots over the period of time and lot I increased to 250.6 in 60 minutes while it was 259.2 and 280.3 in case of lot II and lot III respectively. The dry matter content was maximum in the samples of lot I and hence minimum Ra was observed in the same.

Table 5: Rehydration Ability (Ra) of freeze-dried shrimp

Time	I	II	III
30 sec	133.6±1.5 [a]	124.3±3.0 [b]	195.8±1.6 [c]
1 min	141.0±4.3 [a]	145.6±2.0 [a]	216.4±3.0 [b]
2 min	151.8±2.9 [a]	168.7±3.9 [b]	219.9±4.5 [c]
4 min	201.0±2.9 [a]	174.7±3.6 [b]	213.3±1.8 [c]
7 min	209.6±4.2 [a]	170.3±4.5 [b]	236.1±3.2 [c]
11 min	212.1±4.1 [a]	217.2±2.9 [a]	252.9±2.3 [b]
16 min	228.6±4.1 [a]	219.6±4.1 [b]	267.9±3.0 [c]
20 min	235.6±2.2 [a]	227.9±3.0 [b]	269.9±5.1 [c]
30 min	243.6±2.3 [a]	251.0±1.2 [a]	280.3±2.3 [b]
60 min	250.6±3.5 [a]	259.2±3.3 [b]	287.7±4.1 [c]

Means within a row with different letters are significantly different ($p < 0.05$)

The texture profile analysis of the shrimp samples is given in Tables 6 and 7. Texture ranks high among the factors that determine the consumer acceptance of a product. The most important parameters of texture with reference to the product, *viz.* hardness, cohesiveness, springiness, gumminess, chewiness, fracture force and stiffness are described. Hardness is the force necessary to create a given deformation in the product. Significant difference in hardness was observed between the raw PD shrimp and the cooked shrimps. The hardness of freeze-dried PD shrimp (lot I) was significantly high compared to other two lots indicating

Table 6: Texture profile analysis of raw and cooked shrimps

Textural parameters	I	II	III
Hardness, N	53.6 ±2.9 [a]	51.21±1.4 [b]	47.81 ± 1.5 [b]
Cohesiveness	0.12±0.02 [a]	0.27±0.01 [b]	0.40±0.03 [c]
Springiness, mm	1.21±0.13 [a]	1.7±0.11 [b]	1.86±0.07 [c]
Chewiness, $kgf.mm^{-1}$	1.77±0.18 [a]	2.39±0.2 [b]	3.53±0.59 [c]
Fracture force, kgf	0.50± 0.0 [a]	0.49±0.01 [a]	0.49±0.01 [a]
Stiffness, $kgf.mm^{-1}$	2.46±0.11 [a]	2.18±0.18 [a]	2.36±0.17 [a]

Means within a row with different letters are significantly different ($p < 0.05$)

Table 7: Texture profile analysis of freeze-dried shrimp

Textural parameters	I	II	III
Hardness, N	3.92±0.4 [a]	2.84±0.2 [b]	2.83±0.2 [b]
Cohesiveness	0.39±0.02 [a]	0.43±0.02 [a]	0.44±0.03 [a]
Springiness, mm	2.11± 0.3 [a]	1.1±0.3 [b]	1.2±0.2 [b]
Chewiness, $kgf.mm^{-1}$	1.30±0.6 [a]	1.30±0.5 [a]	1.41±0.4 [a]
Fracture force, kgf	0.52±0 [a]	0.52± 0 [a]	0.51±0 [a]
Stiffness, $kgf.mm^{-1}$	2.11±0.2 [a]	2.14±0.4 [a]	2.23±0.2 [b]

Means within a row with different letters are significantly different ($p < 0.05$)

a correlation between the final moisture content and hardness. Cohesiveness show the extent to which a sample can be deformed before it ruptures vary significantly in raw and cooked samples indicating a disruption in the internal bonding of the products. However in the case of freeze-dried samples there was no significant difference in this parameter. Springiness is the rate at which a deformed material goes back to its non-deformed condition after the deforming force is removed which is the elastic recovery of the meat. Significant increase in springiness was observed in lot I samples, indicating that the elastic property of the product increased due to the freeze denaturation. In case of lot II and lot III samples springiness has decreased on freeze-drying since these samples were already denatured during precooking. On freeze-drying when the moisture was lost, the elasticity of the materials might have reduced. Chewiness is the energy required to masticate a solid food to a state ready for swallowing. Chewiness values in freeze-dried samples decreased indicating the brittle nature of the product. Fracture force and stiffness does not show any significant change in all the samples.

The sensory evaluation of freeze-dried shrimps is given in Table 8. All the samples were rated good in overall acceptability on a nine point hedonic scale. The texture of the samples in lot II and III varied significantly from lot I and was rather 'spongy' and inferior to that of the original juicy and succulent texture of the freshly cooked shrimps. Blanching prior to freeze-drying could have affected the texture of lot II and III adversely; however, there was a significant improvement in colour in these lots compared to lot I.

Table 8: Sensory evaluation of freeze-dried shrimp

Sensory parameters	I	II	III
Appearance	7.6 ± 0.49^a	7.7 ± 0.6^a	7.9 ± 0.58^a
Colour	7.6 ± 1.14^a	8.3 ± 0.84^b	8.4 ± 0.55^b
Flavour	8.8 ± 0.84^a	7.9 ± 0.55^b	7.8 ± 0.84^b
Texture	6.9 ± 0.74^a	4.7 ± 0.67^b	4.8 ± 0.57^b
Overall acceptability	7.2 ± 0.66^a	6.8 ± 0.72^a	6.9 ± 0.77^a

Means within a row with different letters are significantly different ($p < 0.05$)

Conclusion

It can be seen from the present study that irrespective of pretreatment methods, freeze dried shrimp samples had shown very good rehydration characteristics and had good overall acceptability scores in sensory evaluation. However, it is to be noted that blanching of shrimps prior to freeze-drying for three minutes has significantly reduced the yield of the product. Shorter duration blanching resulted in better yield and colour at low moisture level. Blanching time of 30 seconds can be recommended as an ideal pretreatment for commercial freeze-drying of Indian white shrimp.

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