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Research Article

Effect of freeze drying on quality of desalted tusk fish

Minh Van Nguyen[1,2,3*], Asbjorn Jonsson[2], Sigurjon Arason[2,3]

[1]Faculty of Food Technology, Nha Trang University, 02 Nguyen Dinh Chieu, Nha Trang, Vietnam.

[2]Matis ohf./Icelandic Food and Biotech R&D, Vinlandsleid 12, 113 Reykjavik, Iceland.

[3]Faculty of Food Science and Nutrition, University of Iceland, Dunhagi 5, 107 Reykjavik, Iceland.

Email: minh@matis.is

Abstract

In this study, influence of freeze-drying on the quality of desalted tusk was investigated. The changes in colour, water content and rehydration ratio were determined and mass balance of the process was also calculated. The results showed that the lightness of desalted tusk was the same with salted tusk. However, the lightness increased significantly after freeze-drying. The rehydration ratio of freeze-dried tusk was high, mainly due to the porous texture of the samples and unchanged structure of protein. The water content of freeze-dried desalted tusk was 1.4%, meaning that about 98% of water in the fish muscle was removed. The process yield was about 21.7%.

Keywords: *Brosme brosme*, rehydration ratio, colour, microstructure, seafood, Vietnam, Iceland.

Introduction

Drying is one of the most important methods for food preservation and has been shown to be an energy intensive unit operation. It has been used to preserve fish and fish products for a long time in most parts of the world. On the other hand, global demand for dried fish and fish products has also been driven by the colour and flavour of the products. In recent years, much attention has been paid to the quality of food during drying. Both drying methods and quality changes occurring in food muscle during drying affect the quality of dried products [1].

Conventional air drying is one of the most commonly used methods for food dehydration. However, this method has some disadvantages such as long drying time and high drying temperature, resulting in a low quality of the final product. Significant deterioration in quality occurs during the drying process, and the final product has low porosity, low sorption capacity and high apparent density [2]. Currently, there are some alternative drying methods such as heat pump drying, microwave drying and freeze-drying, that have been applied to dry food. These drying methods have different effects on microstructure and the quality of dehydrated products. Different drying methods produce amorphous materials with various physical properties, for example, particle size, structure, surface area and porosity may differ [3].

Freeze-drying is an innovative drying process and is based on sublimation of ice as its main drying mechanism; this differentiates the process from the conventional drying methods that rely on the capillary motion and evaporation of liquid water for drying. In freeze-drying, water in products is removed by sublimation at low temperature and pressure below the triple point of water. Firstly, water in products is frozen in the pre-freezing stage and it is then removed by sublimation of ice in the primary drying stage. The residual water after the primary drying stage is reduced by desorption in the secondary drying stage [4]. Free-drying provides dried products with porous structure, small or negligible shrinkage, superior flavour and aroma retention and improved rehydration capacity compared to products of other drying methods [2, 3]. It is the best method for preserving materials which are unstable in solution and to dehydrate high quality and heat sensitive products such as quality food, pharmaceuticals and biomedical products [2]. Furthermore, as much as 98% of the water can be removed, the food is lightweight, which reduces the cost of transporting and storage. However, it should be kept in mind that disadvantages of freeze-drying are its high costs, both for capital and running costs and long processing time [5]. These costs are usually passed on to the consumers, which makes freeze-dried food expensive when compared to food preserved by some other methods such as canning or freezing. In spite of this, freeze-drying has been applied in a variety of products from food ingredients and whole ready meals to biological and pharmaceutical products because of excellent quality. In the food processing field, freeze-drying has been applied in many products such as fruit [6], bulbs [7], vegetables and yoghourt [8]. However, in the seafood domain, there are only a few examples of research work that has been conducted, such as freeze-drying of tuna [9] and freeze-drying of cod fish [10].

The objective of this study was to investigate the effect of freeze-drying on the quality of desalted tusk fish. Better understanding about freeze-drying of desalted tusk could be applied to other fish products.

Materials and Methods

Sampling and freeze-drying process

The salted tusk was received from Visir hf., Djúpivogur, Iceland. The fish was desalted at 2^{o}C in an open plastic container by immersing in tap water without stirring. The tusk was desalted with water at ratio of 1:5 (fish:water) for 24 hours and then at ratio of 1:6 (fish:water) for 72 hours. The desalted fish was freeze-dried in a freeze dryer (VirTis Genessis 25 SQ EL, Gardiner, N.Y., USA) for about 120 hours in 8 different steps with different temperature and pressure in the compartment. The colour, rehydration and water content of final products were determined. The mass-balance for the process was also calculated.

The changes in chamber temperature, condenser temperature, probe temperature of the samples and chamber pressure during the drying process are shown in Figure 1.

Colour measurement

The intensity of the flesh colour was measured by using the Minolta CR-300 chromameter (Minolta Camera Co., Ltd; Osaka, Japan) in Lab* system with CIE IlluminantC. The instrument records the $L*$ (lightness), $a*$ (redness) and $b*$ (yellowness) values on CIELAB colour scale. The $a*$ value describes the intensity in green colour (negative) and in red colour (positive). The $b*$ value describes intensity in blue colour (negative) and in yellow colour (positive).

Three positions (close to the head, in the middle and close to the tail) above the lateral line of the fillets (n=5) were measured. The average L^*, a^* and b^* values of three measurements for each fillet were used to calculate the mean and standard deviation.

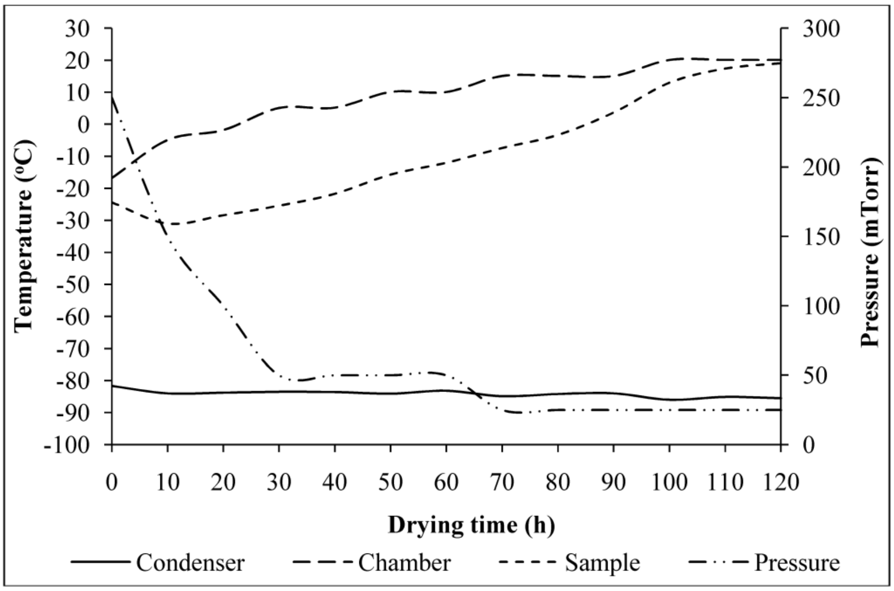

Figure 1. Temperatures and pressure profile during freeze-drying of desalted tusk.

Rehydration determination
The rehydration potential of freeze-dried samples was determined by the method of Nathakaranakule and co-workers [11]. About 10 g samples were immersed in 100°C water. After 2, 4, 6, 8 and 10 minutes of rehydration the samples were taken out and drained for 5 minutes at room temperature. The samples were weighed again and rehydration ratio was defined as the ratio of the weight of rehydrated samples to the weight of freeze-dried samples.

Water content
Water content was determined as weight loss after drying according to ISO 6496 [12].

Statistical analysis
Microsoft Excel 2007 (Microsoft Corp., San Leandro, Calif., U.S.A.) was used to calculate the means and standard deviations for all multiple measurements and to generate graphs. The data sets obtained were compared by multiple comparisons ANOVA by using all pair wise comparisons by SigmaStat 3.5 (Jandel Scientific Software, Ontario, Canada). Significance of difference was defined at $p<0.05$.

Results and Discussion

Mass balance and changes in water content during the process
The changes in mass and water content of the tusk during the process are depicted in Figures 2a and b, respectively. The mass of tusk varied from different processing steps. In desalting step, fish absorbed water, resulting in a significant increase ($p<0.05$) in mass (31.1%) (Figure 2a). This result was in accordance with the result of water content. The water content of tusk increased from 61.5% to 81.6% (Figure 2b). The skin removal proportion was 15.8% of desalted tusk. After freeze-drying step, about 98% of water was removed, leading to a significant ($p<0.05$) decrease in water content (from 81.6% to 1.4%). The process yield was 21.7% compared to the initial weight of the salted tusk.

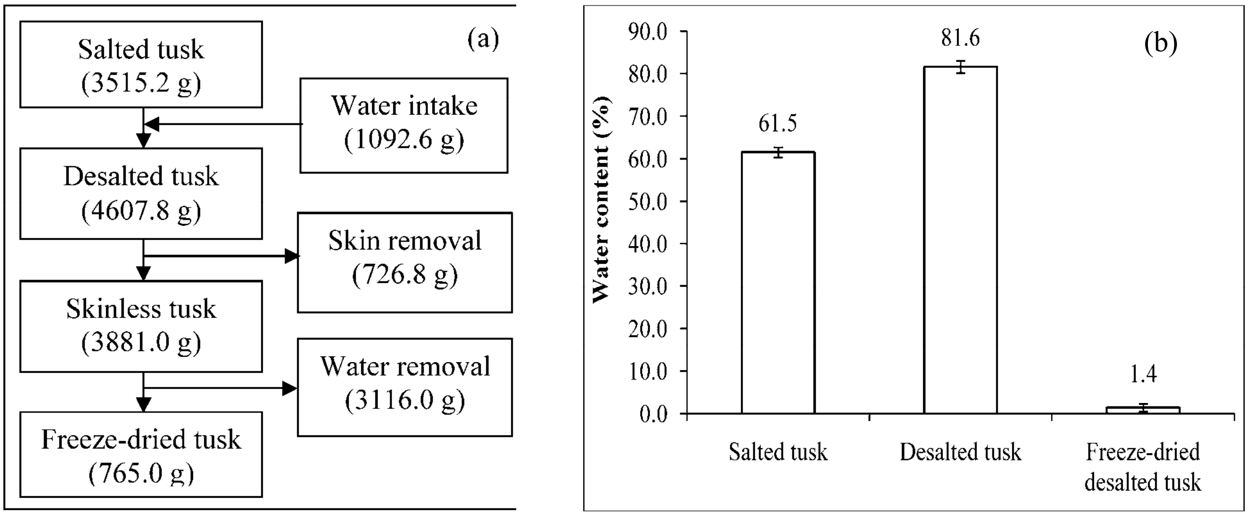

Figure 2. Changes in mass and water content of tusk fish during the process: (a) mass balance, (b) water content.

Colour measurement

The colour of food is one of the important criteria for their acceptability [1]. The changes in L^* values (lightness), a^* values and b^* values are presented in Figures 3a, b and c, respectively. The lightness of salted tusk and desalted tusk was similar. It can be explained that during the desalting process, two main simultaneous flows are generated; salt loss and water uptake, which do not affect the changes in colour of the product. However, L^* values increased significantly ($p<0.05$) after freeze-drying (Figure 3a). In general, the increase in L^* values is thought to be due to dehydration of almost all water by sublimation during freeze-drying, resulting in increasing in lightness. Whereas, an increase in a^* and b^* values after freeze-drying was observed. It may be due to the oxidation of pigments in the fish muscle. The observed pattern of colour changes in this study is in agreement with research of Babic and co-workers [13]. They reported that the redness and yellowness of broiler chicken breast meat increased after freeze-drying.

Rehydration determination

The rehydration ratio depends on the degree of cellular and structural disruption as well as the nature of internal porous structure and the mechanical properties of dried materials [14]; protein structure such as polarity and hydrophobicity groups [15]. In addition, the space in dried products is indispensable to rehydration ratio. It will provide necessary avenues for conveying water into the muscle fibres [16]. The results of this study show that the rehydration ratio of freeze-dried desalted tusk was high. A significant increase ($p<0.05$) in rehydration ratio was observed within the initial period of 2 minutes of rehydration and approached the equilibrium state after 4 minutes (Figure 4). Quick and high rehydration ratio can be explained by the porous texture of the samples and unchanged structure of protein after freeze-drying. Freeze drying at low pressure can reduce the shrinkage of a product and create porosity by vacuum that increases water uptake during rehydration [14]. The results are also supported by Eikevik and co-workers [10] on freeze-dried cod fish, Sablani and co-workers [7] on freeze-dried garlic and Karathanos and co-workers [6] on freeze-dried apple and potato.

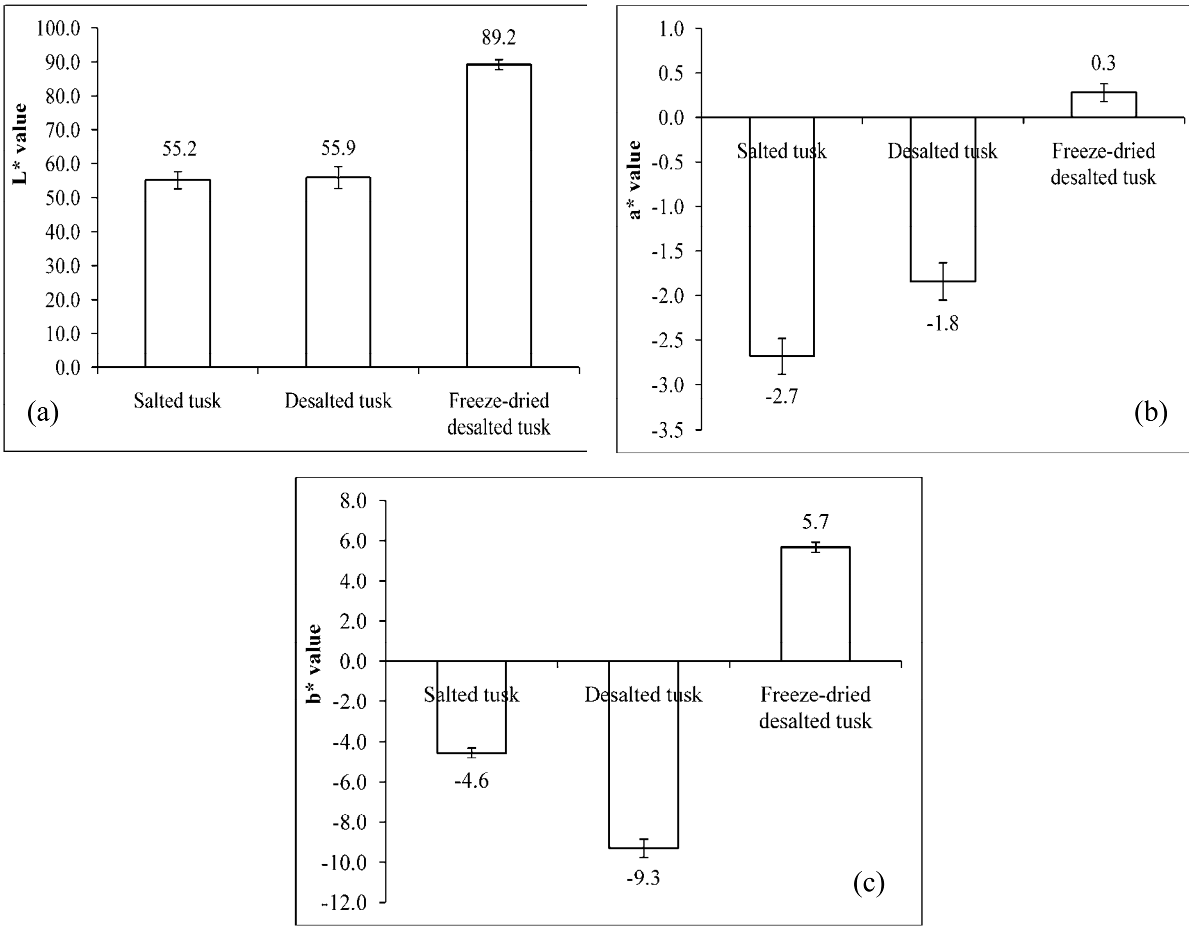

Figure 3. Changes in colour of tusk fish during the process.
(a) *L** values, (b) *a** values and (c) *b** values.

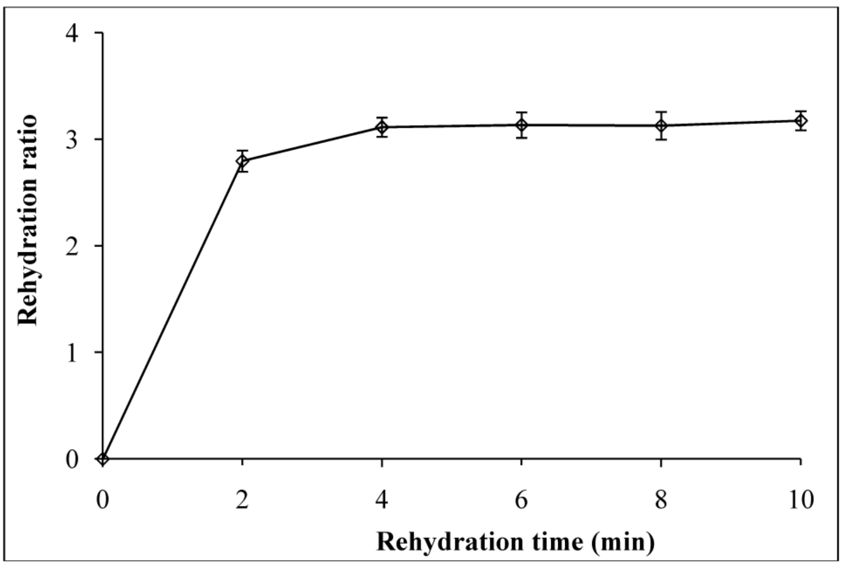

Figure 4. Rehydration ratio of freeze-dried desalted tusk.

Conclusion

The results of this study show that freeze-drying had a significant effect on quality of desalted tusk. The lightness of tusk increased thoroughly and most water was removed after freeze-drying. The rehydration ratio of freeze-dried product was high, meaning that the original structure of fish muscle was retained. However, the redness and yellowness values of fish muscle increased after freeze-drying. Therefore, an additional study on oxidative stabilities during freeze-drying needs to be done to clarify these effects.

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