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The effects of freeze-drying process parameters on *Broiler* chicken breast meat

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A R T I C L E I N F O

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A B S T R A C T

Freeze-dried meat can be stored for unlimited periods retaining the majority of their physical, chemical, biological and sensorial properties as in the fresh state. However, adequate process conditions must be applied to prevent quality problems in the product.
The aim of this work was to study the effect of freeze-drying process parameters on the quality of *Broiler* chicken breast meat. Therefore, different meat thicknesses, speed of freezing, time of drying phases and pressure were assayed. Physical and sensory analyses were carried out on treated meat samples. Results showed that sample thickness was critical for the determination of process conditions. The study has demonstrated that it is possible to obtain freeze-dried poultry meat that looks and tastes similar to fresh poultry meat when the right process conditions for the sample's thickness are applied.
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1. Introduction

Poultry meat is very perishable and its stability and microbiological security is based on the combination of various factors (hurdles) in order not to be contaminated by microorganisms. In the design of new raw products, the three following barriers were considered (ozonization, freeze-drying and packaging of the product in modified atmospheres), in order to obtain a new food product from chicken by using gas ozone, first to get a very hygienic product, with a high nutritional value. Afterwards, freeze-drying would be applied to avoid cold chain, reduce sample-size and extend the lifespan of these products, which might be used in the making of soups, consommé, sauces such as Bolognese, in stews and casseroles, etc. In this case, the energy costs would be reduced, because time for cooking products would be shorter than in the case of traditional foods. Afterwards, the products would be packaged in modified atmosphere to obtain enough safety factors for these new products to guarantee the consumption of chicken that is safer, longer lasting and accepted by consumers. To achieve this, the conditions which most affect freeze-drying were studied with the aim of optimizing each treatment separately and, afterwards, combined.

Freeze-drying (lyophilization) has been extensively used to process food since the end of the nineteenth century. Freeze-drying is an effective method to extend the average lifespan of food, given that it prevents the deterioration due to microbial growth or oxidations (Barbosa & Vega-Mercado, 2000). Besides, the characteristics of rehydrated freeze-dried products could be similar to those of fresh ones.

The process takes place in three distinct stages: pre-freezing, sublimation or primary drying and desorption or secondary drying (Baker, 1997), in which drying continues until the desired moisture content of the product is achieved.

These products do not require cold chain and only have 10–15% of original weight that makes their storage, distribution and commercialization easy. However, the deep freezing and low pressures applied along with the duration (1–3 days) of the process make freeze-drying treatments very expensive. The use of freeze-drying in food industries is then restricted to high added-value products such as coffee, tea and infusions, ingredients for ready-to-eat foods (vegetables, fruit powders, pasta, meat, cheese starter cultures, fish, shrimps, etc.) and several aromatic herbs (Adam, 2004; Hammami & Rene, 1997; Stawczyk, Sheng, & Romuald, 2004).

The freeze-dried meat products, which have been adequately packaged, can be stored for unlimited periods retaining the majority of their physical, chemical, biological and sensorial properties as in the fresh state (Girard & Omolosho, 1983).

Freeze-drying takes place at low temperatures and the drying is produced mainly by direct sublimation of ice, avoiding the translocation of salts, creating a honeycomb texture and relatively little histological change.

Freeze-drying does not alter the biological value of the meat proteins and, indeed, may enhance it. Nevertheless, there is a loss of

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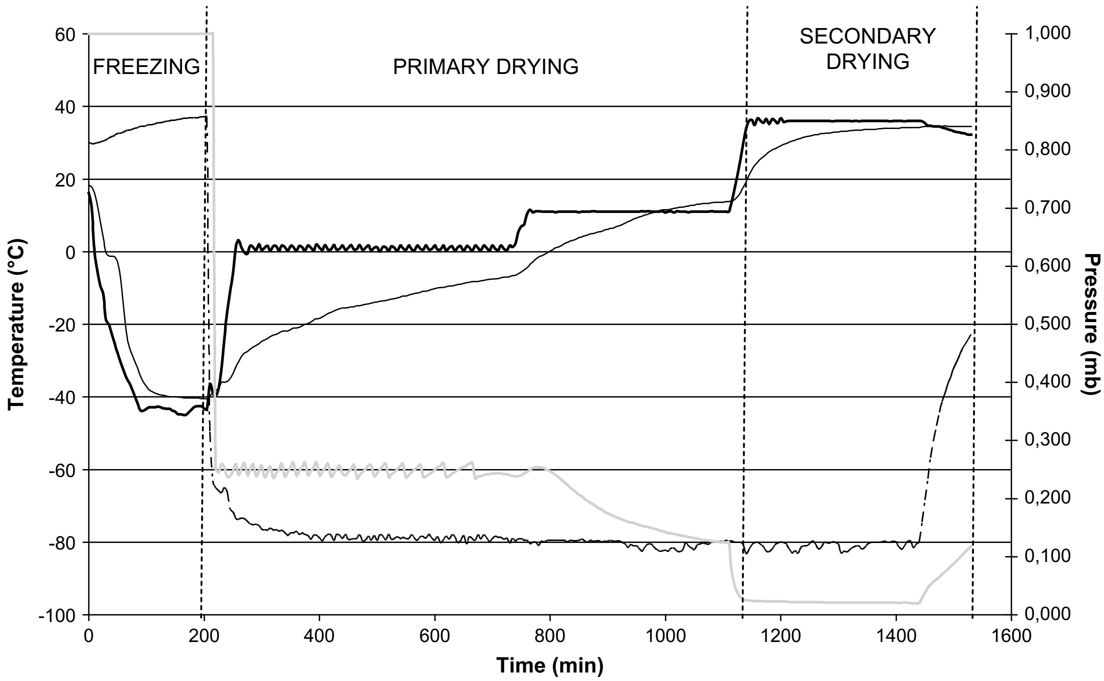

Fig. 1. Process scheme: evolution of temperature of chicken breasts samples and some of the process parameters during the freeze-drying in the freeze drier Lyobeta 25. —— Temperature of the fluid, — · · temperature of the condenser, —— temperature of the product and —— pressure in the process chamber.

about 30% of the thiamine content of the meat during freeze-drying, but this would also occur when cooking in any case. The process causes similar loss of riboflavin in mutton, but not in beef or pork (Lawrie, 1985).

A major defect of freeze-dehydrated meats is the typical deterioration of texture (Bird, 1965). The loss of textural qualities in meats and fish is often difficult to explain. In comparison with fresh or frozen meat, freeze-dried meat is somewhat lower in tenderness and juiciness (Karel, 1968). The changes in texture may be due to one or all of the following events in the actomyosin complex: aggregation or cross-linking of proteins; denaturizing of proteins, followed by aggregation; interaction of the native or denaturized proteins with lipids or carbohydrates (Connell, 1957). Harper and Tappel (1957) also reported that texture and poor rehydration were the principal problems in freeze-dried meat. They studied the effects of time and temperature of cooking on freeze-dehydrated chicken and observed that fresh meat was significantly more tender than that obtained after freeze-dehydrated treatments. These results agree with those of Seltzer (1961), Sosebee, May, and Powers (1964), Sosebee, May, and Schmittle (1964), and Wells, May, and Powers (1962) who noted toughening effects due to freeze dehydration.

Likewise, porosity of freeze-dried meat samples is much higher than the air-dried and vacuum dried samples (Maurer, Baker, & Vadehra, 1972). King, Wing, and Sandall (1968) studied the effects of freezing rate on rehydration of freeze-dried turkey meat with results ranging from 87 to 95% of rehydration. The effect of freezing rate on the structure of the samples was clearly seen, being

Table 1
Experiment design to study: (a) the effect of sample thickness; (b) freezing rate, total time of freeze-drying and pressure; (c) different time of primary drying at 0 °C and 10 °C.

(a)							
	Thickness (cm)	Freezing rate	Primary drying at 0 °C (h)	Primary drying at 10 °C (h)	Total primary drying (h)	Secondary drying (h)	Pressure (Pa)
Treatment 1	Thin (0.7 ± 0.2) Thick (1.3 ± 0.2)	Slow (6 h)	8	10	18	–	25
Treatment 2	Thin (0.7 ± 0.2) Thick (1.3 ± 0.2)	Fast (3 h)	12	12	24	7	30
(b)							
	Thickness (cm)	Freezing rate	Primary drying at 0 °C (h)	Primary drying at 10 °C (h)	Total primary drying (h)	Secondary drying (h)	Pressure (Pa)
Treatment 3	Thin (0.7 ± 0.2)	Slow (6 h)	12	6, 8.5, 11	18, 20.5, 23	7	25
Treatment 4	Thin (0.7 ± 0.2)	Slow (6 h) Fast (3 h)	12	6, 8.5, 11	18, 20.5, 23	7 7	30 30
(c)							
	Thickness (cm)	Freezing rate	Primary drying at 0 °C (h)	Primary drying at 10 °C (h)	Total primary drying (h)	Secondary drying (h)	Pressure (Pa)
Treatment 5	Thin (0.7 ± 0.2)	Slow (6 h)	12	8.5	20.5	–	30
Treatment 6	Thin (0.7 ± 0.2)	Slow (6 h)	8	12.5	20.5	–	30

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