General Impact Factor (GIF): 0.875
Scientific Journal Impact Factor: 1.205
e- ISSN: 2394-5532
p- ISSN: 2394-823X
International Journal of Applied And Pure Science and Agriculture
www.ijapsa.com

Meat drying technology and drying characteristics of meat and meat products

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Abstract

In the last few years, the demands of the meat and meat dried products have increased tremendously. In the past drying was performed to preserve perishable foods with less emphasis on multidimensional quality attributes a recent trend is to develop dried meat products maintaining its quality, such as flavor, texture, convenience, and functionality with increased nutritional quality and reduced anti-nutritional factor. At present, drying of meat has extreme focus on maintaining its qualities and to increase the shelf life. The main purpose of this paper is to give an overview on the meat drying of meat and meat products and to provide basic concepts of meat drying, drying characteristics of dried meat products.

Key words: Meat drying technology, diffusivity, shrinkage, rehydration ratio.

I. Introduction

Drying is one of the oldest food preservation techniques used to prolong shelf-life of foods. It minimizes storage and transportation costs and makes handling easier by reducing size, weight, and risk of microbial contamination of foods. Although meat can currently be preserved by freezing, refrigeration, and thermal processing, some traditional meat products (fermented sausages, dry-cured hams, pastrami, jerky, Bresaola (Italy), Biltong (southern Africa), Odka (Somalia), Kuivaliha (Finland), Qwanta (Ethiopia), Kilishi (Nigeria), etc.), in which drying is one of the main processes, are still produced in large quantities due to their unique and popular flavor.(Rahman *et al*.2004) Primarily structures of meat are fiber muscles and connective tissues. A single muscle fiber consists of many myofibrils and contractile elements sheathed by the endomysium, which is a composite structure of collagen fibers. The muscle itself is composed of bundles of muscle fibers, each fiber (10–100 *m*m) (Bailey *et al*. 1989) holds together by a collagen network, called perimysium, and the whole muscle structure holds by a network called epimysium (Flint *et al.* 1994). When meat has undergone intensive drying, its primary structures are substantially changed and therefore the quality of the meat product also changes dramatically. Such structural changes may also affect the direction of moisture movement inside the meat and hence, the drying characteristic curve. Muscles of meat comprise of approximately 75% water, held by capillary forces and surface tension (Ofstad *et al*. 1993). To Preserve and add value to the fresh meat, several food processing techniques, i.e., drying, frying, and grilling have been used. Dried meat is also used as a aroma ingredient in the production of different foods, such as instant soup, baby food, pet food, etc. Therefore, it is key to understand the drying behavior of meat to improve the drying process and the quality of the dried meat product. Thus, the objective of this review paper is to study the application of different drying methods for producing dried meat consumed as a snack or an ingredient in the instant noodle. The effects of drying speed and drying temperature on the drying characteristics and physical properties in terms of effective diffusivity, shrinkages, and rehydration capacity of dried meat are studied.

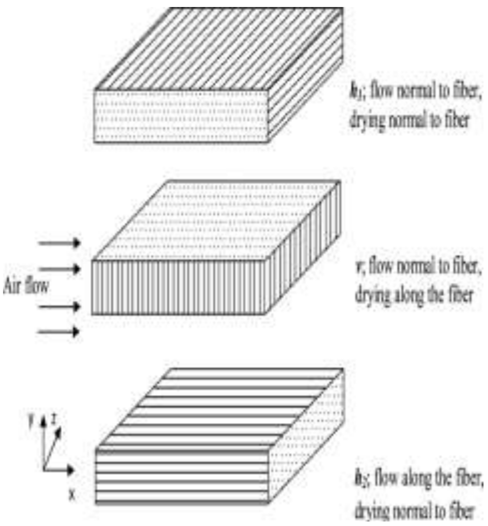

FIG. 1. Fiber directions in lean meat samples.

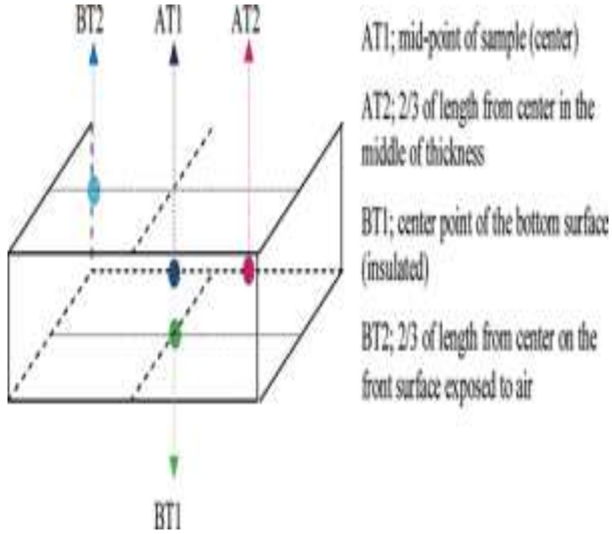

FIG. 2. Thermocouple locations on samples.

Drying characteristics of meat and meat Products Effective diffusivity

An apparent or effective diffusion coefficient or diffusivity (Da, De) can be defined to describe the combined effects of the different transport mechanisms on the overall rate process from transient uptake measurements. Diffusivity is an important physical transport property which is useful in the engineering analysis of basic food processing operations such as drying, rehydration, mixing and storage. Diffusion phenomena are extremely complex due to the wide diversity of chemical composition and physical structure of food materials, so reliable data are scarce. More accurate data on food properties are needed for effective design and control. Limited data on apparent (or effective) diffusion coefficient or diffusivity are available, with a wide variation of the reported values, due to the complexity of the foods and the different methods of measurement (M. A. Rao. *et al.* 1986). There is a need for reliable diffusivity (Dm) data of processed food products and raw food material. The data are needed in process modeling, optimization, and controls. In solids, semi-solids and colloidal like foods, theoretical prediction of the engineering properties is not possible, and thus experimental data are needed. The variation of the diffusivity (Dm) with the food moisture in some cases can be expressed by an exponential model (K.H *et al.* 1983), a power law function (G. Meerdink *et al.* 1988)), or a gamma function (G. S. *et al.* 1986)). Porous and granular materials yield high diffusivity (Dm), while moisture diffusion in gelatinized and sugar-containing materials is much slower (G. D. *et al.* 1995)). Diffusivity (Dm) ranged from 0.1 $x10^{-10}$ m^2/s (for gelatinized material) to 50 $x10^{-10}$ m^2/s (for extruded products).

R. Jowitt *et al.* 1987 determined the moisture transport properties of slabs of raw minced lean beef and heat-treated minced lean beef at 85°C for 15 min and at air temperature of 30-75°C, air velocity of 2 m/s, RH of 30%, and initial moisture contents of raw and heat treated beef of 2.80 and 1.80 db, respectively. The Da for raw minced beef varied from 0.5 (10^{-10}) to 1.8 (10^{-10}) m^2/s at 30-60°C air temperature and 0.2-1.8 moisture content db. Similarly for heat treated beef, Da varied from 0.5 $x10^{-10}$ to 2.3 $x10^{-10}$ m^2/s at 30-75°C air temperature and 0.2-1.0 moisture content, db. For heat treated beef the activation energy was about 13 kJ/mol, and for raw minced beef depending on its moisture content varied from about 8 to 25 kJ/mol. Due to the irregular surface, a variation of 30% in the slab thickness was observed. M. O. Ngadi *et al.* 1995.determined the Diffusivity(Da) in rectangular muscle slices (65 x 25 x 3 mm) cut from chicken drum, during deep fat frying, as a function of moisture (0.06-3.33 db) and temperature (120-180°C) (173). The mean initial moisture content of muscle samples was 3.33 db, and frying was done for 1920 sec. Da, determined using regular regime theory, ranged from 1.3210^{-9} to 1.6410^{-8} m^2 /s. Trujillo *et al.* 2007 determined that diffusivity of water in meat perpendicular to the fibers was experimentally in the range 6.6–40.4ºC using a drying technique. Three different mathematical methods were used to determine the diffusivity from the drying data. The first assumes constant diffusivity, volume and temperature and zero surface resistance to mass transfer. The second assumes a convective boundary condition. The third also takes into account the shrinkage of the sample during drying. Important differences in the calculated diffusivity were found using these three different methods. The model that takes shrinkage into account fits the experimental data better than the other models because it is a better representation of the actual process; the average shrinkage of the meat during drying was 70.3%. The calculated diffusivity was fitted to an Arrhenius type equation to express its dependence with temperature. The correlation coefficient obtained is 0.9888 indicating a good fit.

Rehydration/Rehydration ratio of meat products

Moisture removal from solids is an integral part of food processing, with convective drying representing one of the most important techniques for preservation of biological products. However; removal of moisture during drying has detrimental effects on the physiochemical properties of the material. Deterioration of the physical attributes of the system was evaluated on the basis of rehydration characteristics, namely the coefficient of rehydration and rehydration ratio. The rate and degree of rehydration was dependent on the drying conditions, with the extent of cellular and structural disruption dictating the rehydration capacity (McMinn *et al.* 1997).

Chabbouh *et al.* 2011 examined the beef dehydration during the salting and the drying steps of Kaddid’s production. Salting of beef was run at different brine concentrations (15 and 26.5%) and by dry salting. Experimental drying kinetics were measured at three air temperatures (30, 40, and 50C) and two air velocities (1.5 and 2.5 m/s). Salting method and brine concentration affected water exudation during salting. Salting at the lower brine concentration (15%) allows beef rehydration and dry salting leads to more meat dehydration comparing to salting at saturated brine (26.5%). Drying rate was affected by brine concentration and air temperature. Hence, pretreatment at higher brine concentration decelerates meat drying kinetics. Higher air temperature increased the drying rate of meat salted at the lower brine concentration (15%). For 26.5% brined meat, air temperature effect on the drying rate is reversed. Further, Peleg’s model and Jason’s model were satisfactorily tested for the description of water loss during the salting and drying process, respectively. Proteins’ denaturation due to dry salting combined to drying at different temperatures was investigated by electrophoresis studies of sarcoplasmic and myofibrillar proteins. Sarcoplasmic and myofi- brillar proteins were affected by salting and less by drying. In addition, no effect was found of air drying temperature on proteins’ denaturation. Microbiological and physicochemical characteristics were evaluated for fresh, salted, and dried meat. Drying, when combined with dry salting, leads to higher salt content at the equilibrium and allows more dehydration in the product. The absence of true lactic fermentation after salting and drying was confirmed by the small change in pH and lactic acid bacteria proliferation during salting and drying.

C. L. Hii *et al.* 2014 investigated that effects of convective air drying on the quality of raw and cooked chicken breast meats at 60, 70, and 80C. Raw samples were cut into sizes of 20 mm 20 mm 7 mm and cooked samples were precooked in hot water and cut into similar sizes. It was observed that cooked samples had a lower initial moisture content and dried faster than the raw samples. The thicknesses of raw samples were observed to increase in the first 2 h due to internal water vapor generation. The rigid structure of the cooked samples resulted in a lower degree of shrinkage compared to the raw samples. Rehydration capacity was lower in the cooked samples, which could be due to the rigid structure resulting from the precooking process. This further reduced the imbibition of water into the sample. Hardness values of dried cooked samples were significantly higher ($p< 0.05$) than the dried raw samples, whereas elasticity was significantly lower ($p< 0.05$).

Shrinkages/volumetric shrinkage of meat products

Agricultural food products and specially root vegetables undergo several physical and structural modifications during the drying process. Shrinkage of root vegetables during drying is important not only from the viewpoint of material end-use but also for simulation problems. In this paper the shrinkage of root vegetables is studied in a pilot-scale, inert medium fluidized bed dryer. Cylindrical carrot samples were utilized as the test media, providing simulants for high moisture content food systems. The effects of various parameters such as air temperature, air humidity, sample diameter, sample initial moisture content, existence of inert particles and air velocity were investigated. It was found that the shrinkage of root vegetables during drying in a fluidized bed could be well correlated with moisture content of the sample during drying. Air velocity, temperature and presence of inserts did not show significant effects on shrinkage in this system (M.S Hatamipour, *et al.* 2002).

Sa-adcom *et al.* 2011 studied the drying of pork meat slice by superheated steam. Sirloin muscle pork meat was sliced parallel and perpendicular to the fiber direction with thicknesses of 1 and 2 mm. The sliced samples were divided into two groups; unseasoned and seasoned pork, and were dried by superheated steam at a temperature of 140 ºC. The experimental results showed that thicker pork slice needed more drying time, which led to more shrinkage, darker and redder dried product as compared to the thinner pork slice. Seasoning also extended the drying time of the seasoned pork slice and made the dried seasoned pork slice darker and yellower, but less in the values of hardness, toughness and shrinkage. Slicing directions did not have any significantly effect on drying time and color of dried pork slice. The parallel slice, however, lowered the values of hardness, toughness and shrinkage of dried pork. Clemente *et al.* (2009) measured the shrinkage of pork meat cylinders and correlated with moisture content. Samples of different sizes were dehydrated under different drying conditions: forced convection (25º C and 0.6, 2.0, and 2.8 m/s) and natural convection (5, 10, 15, and 20º C). A linear relationship was found between the quotients R/R_0 and V/V_0 and the moisture content. This linear relationship was not found to be dependent on the size of the samples, their salt content, or drying conditions. For the experimental conditions in this study, water losses are responsible for shrinkage.

II. Conclusion

This is concluded that meat drying is a very efficient techniques to preserve of the meat and meat products. Meat drying is preservation techniques used to prolong shelf-life of raw meat. It reduces storage and transportation costs and makes handling stress-free by reducing size, weight, and risk of microbial contamination of meat and meat products. Meat drying characteristics such as shrinkages/volumetric shrinkage, rehydration ratio, apparent or effective diffusion coefficient or diffusivity, affects the drying behavior of the meat,

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