Review Article

Dehydrated Meat Products- A Review

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Abstract

The demand for processed meat products is increasing globally due to the rapid urbanization, improving living standards and changing life styles of the people. Processed meat products provide tasty and convenience foods to the meat consumers. The shelf life of meat products is limited to enzymatic and microbiological spoilages. Their high perishability causes their storage and marketing, demanding considerable amount of energy input, with regard to refrigeration and freezing, which is costly and inadequate in India and other developing countries. Dependence on cold chain for marketing resulted in slower growth of processed meat sectors in various countries. Therefore, development of technologies for production of low-cost, safe and acceptable shelf stable dehydrated meat products which can be stored / marketed without refrigeration facility is need of the hour. The review is intended to provide an overview of the present status of the dehydrated meat products as well as the effect of drying on physico-chemical, microbiological and sensory properties of dehydrated meat products.

Keywords: Dehydrated Meat Products, Microbiological Properties, Physico-chemical Properties, Sensory Properties, Shelf Stable

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Introduction

The health conscious consumers always demand nutritious and convenient food item which can be best suited for their busy life. Meat is a highly valued food product for human consumption because it is a good source of essential amino acids and B-complex vitamins and minerals. The unique composition and

structure of muscle gives rise to the characteristic properties of meat (Macrae *et al.,* 1997). Its distinctive flavour makes it one of the most preferred foods (Rahman *et al.*, 2005). However, due to the intrinsic properties of fresh meat like relatively high water activity (a_w), slightly acidic pH and the availability of carbohydrate (glycogen) and proteins, it becomes a good substrate for microbial growth and considered as a highly perishable commodity (Mishra *et al.*, 2013; Ayanwale *et al.*, 2007). Shelf life of meat and meat products can be enhanced by applying various preservation methods. The principle of meat preservation is concerned, mainly with preventing or delaying microbial spoilage, autolysis, avoidance of weight loss and any changes in taste or texture (Macrae *et al.*, 1997; Ayanwale *et al.*, 2007). Preservation methods include use of low or high temperatures, reduction of a_w or water contents or use of chemical preservatives. Drying is one of the oldest methods of food preservation and processing (Hotchkiss and Potter 1995; Ayanwale *et al.*, 2007; Vadivambal and Jayas 2007). FAO (2001) reported that in the absence of a cold chain, meat drying remains the most practical way of preserving and storing meat in developing countries with hot and humid climate. Drying is a process in which water is removed from a material by evaporation or sublimation (Lewicki, 2004). The advantages of dried products are shelf stability, less storage space, ease of transport and most importantly, convenience and useful in natural disasters such as cyclones, floods earthquakes etc. Dried meat and meat products may play a major role in providing protein rich food to under nourished people in underdeveloped and developing nations. These products are of much interest since they do not require refrigeration during marketing as well as storage. Drying of meat has been practiced since time immemorial. Sharp (1953) proposed that the term 'dehydrated' be used to denote drying carried out under technically controlled conditions independent of external climatic conditions. Traditional dried, desiccated or low moisture foods are those that generally do not contain more than 25% moisture and have a_w within 0.00 to 0.60. Whereas shelf stable foods known as intermediate moisture foods contain moisture between 15%-50% and a_w between 0.60-0.85 (Jay *et al.*, 2005).

Drying of Meat and Meat Products

In general, drying is the lowering of a_w of perishable products accomplished by removing water, which restricts the growth of micro-organisms (Thiagarajan, 2008). It is a complex operation involving transient heat and mass transfer along with physical transformations such as shrinkage, puffing, crystallization or glass transition and chemical or biochemical reactions which cause changes in colour, texture, odour etc. according to Mujumdar and Devahastin, 2000. Evaporation of water from the surface of food material takes place at any temperature, but at higher temperature, the rate of drying is higher, especially at the beginning of the process. Drying at a very high temperature results in an improperly dried product due to the case hardening effect. Nevertheless, temperature and relative humidity of the environment and

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characteristics of boundary layer are also important (Simal *et al.*, 2003). Predrying treatments like mincing, heating, cooking, freezing and thawing help to reduce the internal resistance to mass transfer. Cooking causes protein denaturation resulting in easier water movement and huge water losses from hydration shells (Mishra, 2012). Drying is an energy intensive food preservation process (Ratti, 2001). There are different types of dryers used in food industry. According to Vega-Mercado *et al.* (2001) dryer used in food industry falls into four generations. First generation dryers comprise of cabinet and bed type dryers (i.e. kiln, tray, truck tray, tunnel and rotary dryers) employ hot air, suited for fruits, vegetables, chunked products etc. Second generation dryers include spray and drum dryers, intended for dehydrated powders and flakes. Third generation dryers include freeze and osmotic dryers used for plasma and biological products. Fourth generation dehydration technology involves high vacuum, fluidization and use of microwaves, radio frequency, refractance window and hurdle approach which represents the latest advances in the area of food processing sectors. Bimbenet *et al.* (2002) concluded that food drying is achieved by means of different techniques such as utilizing heat or pressure sources to remove water from the interior of the product and mechanical energy to remove water from its surface (convection, drip etc). Sun drying is the oldest and widely used method of drying by many peasant farmers in recent times (Kuponiy *et al.,* 1984; Talib *et al.,* 2014). It is a longer process and exposes meat to an extensive contamination by micro organisms and dirts (Gailani 1988). This contamination can be avoided by drying of meat in mechanical dryers. The sun dried samples have higher functional properties, acceptability level, proteins and lower fat contents as compared to oven-dried samples. Sun drying of the meat samples is recommended provided it is done under hygienic conditions (Ayanwale *et al.,* 2007). Combinations of sodium chloride and sub inhibitory levels of anti microbial agents are highly effective in controlling/inhibiting microbial growth during sun-drying process (Brewer *et al.,* 1995; Talib *et al.,* 2007). Recent efforts to improve sun-drying have led to solar drying. It utilises the sun as the heating source, but specially designed dehydrator increases the temperature and air current to accelerate the drying time (Susan, 1993). Convention drying process of food products is extensively employed as a preservation technique but oven drying is the simplest and faster than the sun drying (Mishra *et al.,* 2013). Solar drying is considered as the best due to its low cost and less number of microorganisms as compared to oven drying process (Talib *et al*., 2014). Hot air convectional drying is a process where drying is achieved by circulating hot air in closed cabinets. In this process, heat is transferred from hot air to solid surface (Ratti, 2001; Lewicki, 2004; Mishra *et al.,* 2013; Nayar *et al.,* 2014) which is thus transferred from the surface to the interior by conduction and shrinkage is excessive, around 80% (Ratti, 2001). Microwave drying is a faster method because of volumetric heating. Here the microwave energy absorbed by the food material is converted into heat (Uprit and Mishra, 2003). Microwave heating produces significant advantages over conventional drying in reducing time and improving food quality (Dar *et al*.,

2010). Microwave dried meat products have better rehydration property and lower a_w and better microbial quality than hot air dried meat products (Nayar *et al.*, 2014). Higher microwave radiations increase the outward flux of vapour preventing the collapse of tissue structure and increasing the rehydration capacity of the dried products (Duan *et al.*, 2011).

Dried Meat Products

Dried meat and meat products can be defined as whole muscle or ground and formed meat products which have been subjected to dehydration, resulting in unique sensory properties and enhanced stability (Skandamis and Gounadaki, 2009). Most common cured air dried products include cured hams, biltong (South Africa), pastirma (Turkey), bundner fleisch (Switzerland), beef jerky (USA), rougan and shafu (PR China) etc. (Feiner, 2006). Jerky is classified by U.S. D.A. as a heat-treated and shelf stable ready-to-eat meat product with an a_w of 0.85 and moisture-to-protein ratio of 0.75:1 (Nummer *et al.*, 2004). Kilishi is an intermediate moisture meat product of the tropics prepared from sun dried lean beef infused with spices and defatted groundnut paste. It is a rich nourishing snack with extended shelf life at room temperature for several months (Ogunsola and Omojola, 2008). Kargyong (smoked and dried sausages), Satchu (air dried/smoked beef or yak meat) and Suka ko masu (air dried/smoked chevon/buffalo meat) were reported as the ethnic meat products of Eastern Himalayas (Rai *et al.*, 2010). A variety of dehydrated or shelf stable meat products such as dehydrated goat meat (Babji 1993; Rahman *et al.*, 2005), hurdle treated caprine keema (Karthikeyan *et al.*, 2000), chicken snacks (Singh *et al.*, 2002); chicken chips (Sharma and Nanda, 2002); dehydrated chicken pulav (Das and Jayaraman, 2003), popped cereal snacks with spent hen meat (Lee *et al.*, 2003), dehydrated chicken chunks (Hameed *et al.*, 2007), dehydrated chicken kebab mix (Modi *et al.*, 2007), shelf stable microwaved ready-to-eat snacks from spent animal meat of different species (Meshram *et al.*, 2012), dehydrated chicken meat rings (Mishra *et al.*, 2013), dehydrated meat rings (Soni *et al.*, 2013), extended and dehydrated goat meat cubes (Nayar *et al.*, 2014) etc. were also developed.

Non Meat Ingredients in Dehydrated Meat Products

Spices and Condiments

Spice is any aromatic vegetable substance used as a whole, broken or ground form primarily to season food rather than contributing nutrients (Curry and Nip, 2008). Spice mix significantly reduces the thio barbituric acid value (TBA) in pre cooked dehydrated meat products (Kharb and Ahlawat, 2010). In addition to their flavoring effects, some have antimicrobial effects on plant and human pathogens (Brandi *et al.*, 2006). It can also improve shelf life of food products naturally and safely (Holley and Patel, 2005). Condiment is the dried green curry stuff like garlic, ginger and onion help to improve the flavour of dried

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meat and meat products. During the last decade, the antimicrobial activity of garlic and garlic derived organo-sulphur compounds were widely investigated against both food spoilage bacteria and food borne pathogens (Leuschner and Ielsch, 2003; Naidu, 2000; Unal *et al.,* 2001). In addition to its antimicrobial effect, garlic also showed effective antioxidant activity both in vivo and in vitro (Jackson *et al*., 2002; Prasad *et al*., 1995). Besides antibacterial, antiviral, antifungal and antiprotozoal, it also has beneficial effects on the cardiovascular and immune systems (Harris *et al*., 2001). Antimicrobial effects of several spices and condiments like garlic (Yadav *et al.,* 2002), cinnamon (Yadav *et al.,* 2002; Yadav *et al.,* 2004a), turmeric (Yadav *et al.,* 2004b), ginger and mint (Pappachan *et al.,* 2007) have been studied.

Common Salt

Sodium chloride (NaCl) is an essential ingredient which provides a number of different features and has been used as a preservative to prevent spoilage and to increase the shelf life of processed meat, in addition to providing characteristic flavour, colour and tenderness (Talib *et al.,* 2014). The major function of salt is to bind water molecules and to reduce the water activity (aw) of the product causing dehydrating effect (Henning, 2004). A high level of salinity may impair the conditions under which pathogens can survive (Thiagarajan, 2008). Salt added during processing has an influence in changing the ability of lean meat to retain water (Ranken, 2000). Addition of common salt to processed meat products influences not only flavour but also binding and preservation (Marsden, 1980; Hauschild, 1982). However, sodium chloride is considered as a pro oxidant in manufactured meat products which accelerates oxidative reactions leading to rancidity (Gray, 1978; Obanu *et al.,* 1980) and promotes the formation of metmyoglobin and causing meat discoloration (Gheisari and Motamedi, 2010).

Physico-chemical Characteristics

pH

pH is one of the most important quality parameters of meat which has a direct bearing on the functional properties, eating and keeping quality of meat. Different drying methods, packaging techniques, storage temperatures have significant influence on the pH of the dehydrated meat products. Air dried meat products show higher pH value than freeze dried meat products (Rahman *et al.,* 2005). The difference in pH values is due to loss of free acidic groups depending on drying procedures (Nayar *et al.,* 2014). Dehydrated meat products show higher pH value during storage at ambient temperature compared to storage at refrigerated temperature (Das and Jayraman, 2003) which is due to production of amines from meat proteins during storage. Precooking of meat also increases the pH value in dried meat products due to change in net charge of proteins during denaturization (Babu *et al.,* 1994; Kharb and Ahlawat, 2010).

Rehydration Ratio

Rehydration is a complex process aimed at the restoration of raw material properties when dried material is contacted with water. During rehydration, the ratio between the dry material mass and water mass varies from 1:5 to 1:50, temperature of rehydrating water is from room temperature to boiling and time of rehydration varies from 2 min. to 24 h and the rehydrating water is either still or occasionally stirred (Lewicki, 1998). Different drying techniques have also significant effects on the rehydration capacity of dehydrated meat products. Drying techniques have significant role in the development of porosity in the meat samples. Higher the porosity in meat structure, higher will be the rehydration ration in the dried meat product (Rahman *et al.*, 2005). Rehydration depends on the water absorption capacity, water holding capacity of muscle fibres and the formation of spaces within muscle fibres, affecting dehydration, rehydration and textural quality of meat (Laopoolkit and Suwannaporn, 2011). The lower water absorption capacity of dried samples of chicken, chevon or beef is due to the low carbohydrate content of the dried samples, which usually resulting in lesser starch swelling, due to structural change in the starch and proteins present in the meat samples. The size and shape of the starch granules as well as the distribution of the protein clusters have an important effect on the Water Absorption Capacity (WAC) (Muir *et al.*, 2000; Ayanwale *et al.*, 2007).

Water Activity (a_w)

The water in food, its location and availability, is one of the most important factors influencing microbial growth and enzymatic activity (Frazier, 1991).The state of water in food is expressed by its activity coefficient, a measure of the thermodynamic chemical potential of water in the system. Activity coefficient or water activity (a_w) is expressed as the ratio of vapour pressure of water in food (p) to the vapour pressure of pure water (p_0) at the same temperature (Scott, 1957). Dried products usually have a_w below 0.7 (Lewicki, 2004). Lower the water content, lesser is the water activity, but water content and a_w is not directly proportional. Addition of sodium chloride not only helps in drying but also depresses the a_w level of food (Lewicki, 2004; Rahman and Labuza 2007). Active water could be more important for the stability of foods than the total amount of water present (Rahman and Labuza, 2007). Lipid oxidation is highest at very high and very low water activities, because there is increased movement of pro-oxidants in the former and oxidation increases in the later case (Weiss *et al*., 2010). Water inhibits incipient oxidation of lipids but promotes secondary reaction of lipid degradation products with protein at increasing a_w (Mgbemere *et al.*, 2011).

Lipid Oxidation

The oxidation of lipids leading to rancidity is one of the most important changes during food storage and production (Melton 1983; Rosmini *et al.*, 1996). Lipid oxidation may change the colour, aroma, flavor,

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texture and even the nutritive value of the food (Fernandez *et al.,* 1997). Lipid oxidation is initiated during cooking and storage. During cooking the level of ferrous ion is greatly increased due to increase of non-heme iron and breakdown of heme pigments catalysing auto oxidation leading to rancidity in cooked or dehydrated meat and meat products. The development of lipid oxidation is accelerated by cooking (Abd El-Alim *et al*., 1999) and rate of cooking (Dunlavey and Lamkey, 1995). There is also protein denaturation, loss of antioxidant and enzyme activity which explores oxidation (Jayathilakan *et al.,* 2007). Poultry meat with higher percentage of unsaturated fatty acids is more susceptible to rancidity than pork which is more susceptible than beef and lamb (Wilson *et al.,* 1976). The TBA assay is reported to be the most popular method for measuring the oxidative deterioration of lipids in muscle foods (Ockerman 1981; Melton, 1983). Increase in storage temperature has also a tendency to increase thio barbituric acid reacting substance (TBARS) (Abd El-Alim *et al.,* 1999). The TBA value increases with the increase in fat content (Jo *et al.,* 1999). TBARS value remains higher in dehydrated meat products as compared to fresh and smoked meat products (Sampels *et al.,* 2004). Freeze drying has significant effect in enhancing the peroxide value of dehydrated meat products (Rahman *et al.,* 2005). Lipase action in meat products during storage causes a gradual increase in FFA values in dehydrated meat products (Modi *et al.,* 2007, Chukwu and Imodiboh 2009). Low fat content and good storage conditions slow down the rate of production of TBA in dehydrated meat products (Singh *et al.,* 2009). Pre cooking also increases the TBA value in dehydrated meat products (Babu *et al.,* 1994; Kharb and Ahlawat, 2010). Initially the TBARS value shows higher in dehydrated meat products due to mincing, mixing, cooking and drying processes resulting in extensive destruction of cellular structures, allowing mixing of various meat constituents and pro- oxidants (Rhee and Myers, 2003).

Proximate Composition

Dehydrated meat products with higher meat content have higher moisture and bound water (Sharma and Nanda, 2002, Singh *et al.,* 2002). Drying process also significantly affects the total moisture content, total fat and fatty acid composition of dried meat and meat products. Sun dried meat products have higher moisture content than air dried meat products and air dried meat products have higher moisture content as compared to freeze dried meat products. Vacuum drying significantly increases the total fat content whereas freeze and modified atmosphere drying reduces it (Rahman *et al.,* 2005). Pre cooked dehydrated meat products have lower moisture, fat and ash content than raw dehydrated meat products (Kharb and Ahlawat, 2010). An increase in meat content in dehydrated meat products also increases the fat and protein content of the products (Lee *et al.,* 2003, Berwal *et al.,* 1996)). Use of condiments in dehydrated meat products also increases the ash content of the products (Chukwu and Imodiboh, 2009). The dry

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matter and protein contents are lower in the fresh meat than the dried samples while fat, carbohydrates and energy are higher in the fresh meat than the dried samples (Ayanwale *et al.,* 2007).

Colour

The drying methods have significant effect on the lightness (L), redness (a) and yellowness (b) values, which reflect the degree of browning during drying as well as being a cause of variation in light scattering from the surface of the meat (Van Oeckel *et al.,* 1999). A higher meat percentage in the product increases Hunter a and b value and decreases L value in the dehydrated meat products (Lee *et al.,* 2003). Addition of grains (potato starch, corn starch and rice flour) in the formulation of dehydrated meat products also decreases the L value of the product (Lee *et al.,* 2003). Different drying methods also have significant effect on the colour of the product. Freeze dried meat samples have a whiter colour, completely different from sun/air/vacuum/ modified atmosphere dried samples and it is mainly due to uniform light reflection from the surface due to high pores (Rahman *et al.,* 2005). The microwave drying of meat produces darker brown colour as compared to conventional air-dried ones; the increase in redness indicative of browning reactions (Nayar *et al.,* 2014). Chicken based dehydrated meat products have comparatively lower values for redness, yellowness and chroma than chevon, mutton and pork based dehydrated meat products (Meshram *et al.,* 2012).

Sensory Characteristics

Drying of meat with 5% salt and 1% agar prevents the development of case hardening and improves the texture of the dehydrated product (Babji *et al.,* 1993). Storage of dehydrated meat products at ambient temperature significantly decreases colour, flavour and overall acceptability of the product as compared to storage at chilling temperature (Das and Jayaraman, 2003). Different packaging methods, packaging materials and days of storage (Modi *et al.,* 2007; Mishra, 2012) have also significant effects on the sensory qualities of the products. All the sensory characteristics of aerobically packaged dehydrated meat products decrease with increase in the storage period as compared to vacuum packaged products (Singh *et al.,* 2009). In micro wave drying of meat products, final product temperature is difficult to control and excessive temperature along edges & corners of products lead to overheating, scorching and development of off flavours (Zhang *et al.,* 2006). Texture and flavour scores of micro wave treated dehydrated meat products are usually lower as compared to other drying methods (Nayar *et al.,* 2014).

Microbiological Characteristics

Hurdle technology treated foods are microbiologically stable, safer during storage, especially at ambient temperature due to auto sterilization (Leistner, 2000). Many pathogenic bacteria like *Salmonella, Staphylococcus aureus, Clostridia* etc. originating from raw meat may survive the drying processes.

However, the main spoilage organisms associated with dried meat & meat products are molds requiring low a_w (Skandamis and Gounadaki, 2009). Precooking of meat causes thermal destruction of microbes. So, dried meat products obtained from precooked meat are generally lower in bacterial counts and absence of coli forms during the storage as compared to raw dehydrated meat products (Kharb *et al.*, 2008). Micro-wave dried meat products have higher microbial quality as compared to dried by conventional methods as the destruction of bacteria occurs by microwaves (Decareau 1995; Nayar *et al.*, 2014,).

Conclusion

Meat products during storage are highly liable to quality deterioration through enzymatic and microbiological spoilage. Due to high a_w, slightly acidic pH and the availability of carbohydrate (glycogen) and proteins, meat becomes a good substrate for microbial growth and causes these products to have a relatively short shelf life. Shelf life of meat and meat products can be enhanced by applying drying or dehydration technology, which causes in the lowering of water activity of the product accomplished by removing water, where micro-organisms would not be able to get sufficient water for survival. Shelf stability, less storage space, ease of transport and most importantly, convenience and nutritional self sufficiency has made the dehydrated meat its own image today in the society. The further technological developments in production and processing of dehydrated meat products can fetch extreme popularity in coming future.

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