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Significance of Processing in Current Meat Industry

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ABSTRACT

The concept of food quality varies dramatically according to the economic development of the human population. The development of food processing technology has been influenced by numerous factors . In the early 20th century the quality consciousness of the consumers in the developed world has further lead to the development of food processing with advance techniques as spray drying, juice concentrates, freeze drying and the introduction of artificial sweeteners. In the late 20th century, some products such as instant soups, reconstituted fruit juices, self cooking meals and ready-to-eat food rations are being developed. Foods need to be preserved since the tendency is to get spoilt when left at room temperature. Suitable techniques need to be adopted depending on the type of food. Perishable food includes fresh or processed meats, poultry, seafood, dairy products, egg in the shell, fresh fruits or vegetables and foods that have been packaged, refrigerated or frozen. Meat and meat products are a rich source of protein which are highly perishable and have a short shelf- life unless suitable methods are used. This article is focused on techniques intended to predict technological and sensory qualities of meat and meat products to extend its shelf life and its influence on the current meat industry. Consumers demand high quality, natural, nutritious, fresh appearance and convenient meat products with natural flavours, taste and extended shelf life. Changing consumer demands and increasing global competition are causing the meat product manufacturing sector to embrace new processing technologies and new ingredient systems, which is remarkable if one considers the historically traditional and long term approach to product and process development in the meat industry and also make the process cost-effective.

KEYWORDS: - Meat, Food, Drug Administration, Eating Quality, Dark cutting beef (DFD)

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INTRODUCTION

Meat is the edible part of the skeletal muscle of healthy animal that was healthy at the time of slaughter Meat is composed of four major components including water, protein, lipid, carbohydrate and many other minor components such as vitamins, enzymes, pigments and flavour compounds[1]. The relative proportions of all these constituents give meat its particular structure, texture, flavour, colour and nutritive value. Meat is a very good source of various micronutrients: low-fat pork contains 1.8 mg iron, 2.6mg zinc; and pigs liver contains 360 mg magnesium, 20 mg iron and 60 g selenium per 100 g. A daily intake of 100 g of meat and liver can supply up to 50% of the recommended daily allowance for iron, zinc, selenium, vitamins B1, B2, B6, B12 and100% of vitamin A[2]. The importance of meat as an essential source of some micronutrients is due to the fact that it is either the ironly source, or they have a higher bioavailability. Meat being a rich source of nutrients also becomes an excellent food for bacteria. Methods of meat preservation, however different superficially, are alike in that they employ environment conditions which discourage the growth of micro- organisms.

Shelf life and maintenance of the meat quality are influenced by a number of interrelated factors including holding temperature, which can result in detrimental changes in the quality attributes of meat [3]. Extension of the shelf-life of meat and meat products is one of the technology needs to meet the demands of consumers. All of the meat we eat is butchered, packaged, and prepared in some form or another. This processing occurs at meat processing facilities under microbiologically sanitary conditions[4]. Some meat products (e.g., hot dogs and chicken nuggets) are more processed than others (e.g., steaks and roasts). The methods used to produce these further-processed products are designed to improve efficiency and product yield for processors and to improve the eating quality, value, and convenience of products for consumers. Ingredients and processing aids used in or on meat and poultry products also must be approved. The Food and Drug Administration (FDA) must either approve a product prior to its use, or it must be generally recognized as safe (GRAS) for its intended use [5]. Currently, ingredients or processing aids may be declared as GRAS through documented scientific evidence [5]. These regulations exist to protect public health.

Meat processing industry is of enormous significance for India's development because of the vital linkages and synergies that it promotes. Meat processing covers a spectrum of products from sub-sector comprising animal husbandry and poultry farms, and bulk frozen meat, packaged meat, ready-to-eat processed meat products. While India has an abundant supply of meat, the meat processing industry is still nascent. Industry analysts say that the demand for meat products is bound to increase as they foresee a very good future for the take-away ready-to-eat dishes being sold in the super markets which are opening outlets in big metros. There is a rapidly increasing demand for processed food (meat) caused by rising urbanisation and income levels. This is supported by number of people preferring to live as nucleus family, rather than joint families. Rise in employment with more of adult working ratio and spending lesser time in the kitchen. In addition to prime factors like, change in consumer eating habits as well as rising demand for health, wellness and lifestyle products, together with inflated take-home packages, and rise in family income provides tremendous growth opportunities for the meat sector.

The world of meat faces a permanent need for new methods of meat quality evaluation. Researchers want improved techniques to deepen their understanding of meat features. Expectations of consumers for meat quality grow constantly, which induces the necessity of quality control at the levels of slaughtering, meat cutting, and distribution. In industrial societies, purchasers of any product are expecting an optimal quality/price relation and constancy in quality. This is true for the manufacturers who buy raw material for further processing as well as for the end consumers who purchase consumer goods. This has led to increasing demands, particularly in the last three decades for:

- Technological quality, due to the strong industrialization of meat processing;
- Guarantees of safety and eating quality, from consumers having an extensive choice of food commodities;
- Authenticity, a concept which includes many aspects such as adulteration, improper description of the products, origin designation.

While this view often neglects that meat is also an essential factor in maintaining human health, it nevertheless forces the meat and meat product industry to react. This change is by no means just affecting the meat processing industry. A similar process has been and continues to take place within the entire food manufacturing sector. This has led to the food industry paying an increased attention to the relationship between food consumption and human health and wellness. Consequently, a new class of foods, the so-called "functional foods" are being developed that either contain components that have beneficial physiological effects or that are void of components that depending on intake amounts may negatively impact consumers health. This approach has been strengthened by an increasing number of clinical research studies that have demonstrated tangible health benefits that may be derived from intake of bioactive compounds as part of consumers' daily diet.

The techniques intended to predict technological and sensory qualities include:

1. pH

pH measurement is widely used to assess the shelf life and quality of meat. It is the quality attribute most commonly measured in fresh meat, as it affects technological ability, keeping ability and most sensory traits. Dark cutting beef (DFD) possess a specific problem. The high ultimate pH of DFD meat boosts bacterial growth and shortens storage life considerably. Traditionally, pH is measured using a voltmeter equipped with a glass electrode.

Recent progress has consisted in a dramatic reduction of time needed for measurement, and in automation. Response-time of the most recent electrodes is less than 2 s, allowing on-line measurements at a rate of 1000 per hr. Automation of on-line pH measurements has been realized, with a potential rate of 1300 carcasses or 2000 hams/hr. The pH value of meat is also used in international meat trade. There are several works in which the authors have compared the precision of different methods used in Ph determination. Korkeala et. al found that the differences between the different electrodes used appeared to be greater than those due to the treatment of meat samples. When the ph value is used in the evaluation of meat quality, the recommendation of the ph determination should be included, due to greater differences in results obtained by different combinations of electrodes and ph meters[6].

2. Sensory quality

There is a wide variety of processed meat products and in fact, its quality varies according to ingredients and additives used in the formulation as well as the type of processing. So, the sensory characteristic varies according to the type of the product but, even for a given product particular characteristic may change depending on the geographical area, physical appearance, extent of drying and / or ripening, application of smoking, presence of external molds and so on. Understanding of the scientific basis of quality attributes in meat is becoming more advanced, providing more effective approaches to the control of meat eating and technological quality. This important collection reviews essential knowledge of the mechanisms underlying quality characteristics and methods to improve meat sensory and nutritional quality.

a) Appearance

Appearance determines how consumers perceive quality and significantly influences purchasing behavior. It is one of the main traits determining purchase decision and acceptability of meat. It relies on three main factors: colour, amount of visible fat (marbling) and wetness (exudation). Meat colour depends on pigment concentration, pH, amount of intramuscular fat (IMF) and oxide-reduction status. It is traditionally assessed by photometric or spectrophotometric methods (reflectance, CIELAB or chromatic coordinates), using external (surface spectrophotometers) or internal (optic fibres) measurements. Visible fat involves IMF (marbling) and intermuscular fat.

Marbling is an important indicator of meat quality, which is visually estimated in some carcass grading systems. Brewer, Zhu, and McKeith found that highly marbled chops with 3.46% fat appeared lighter colored, less lean, had a less acceptable appearance and were less likely to be purchased by consumers. However, they were rated higher in tenderness, juiciness and flavor than leaner chops in controlled studies. Intermuscular fat is important for consumer acceptability of meat commodities containing several muscles, as lamb legs, pork and lamb chops or ham slices. High amounts of intermuscular fat are undesirable. To our knowledge, no attempt has been made to quantify specifically the intermuscular fat in carcasses or joints[7].

Fernandez, Monin, Talmant, Mourot, and Lebret demonstrated that increased levels of intramuscular fat in muscle longissimus lumbarum could have detrimental effects on meat acceptability by consumers, due to the influence of visible fat on the willingness to eat and to purchase the meat .As long as the fat was not visibly detected, consumers were willing to purchase and eat the meat. Quantification can be performed rather easily in cuts using video-image analysis. Fluid exudation is particularly detrimental to commercial appearance of prepackaged meat, firstly pork but also beef and veal. Water holding capacity of fresh meat is assessed with methods which basically have not changed since decades[8].

b) Flavour

Flavour is an important sensory aspect of the overall acceptability of meat products. The effect of flavour volatiles has a tremendous influence on the sensory quality of muscle foods. However, the taste properties of high molecular weight components and contribution of non-volatile precursors to the flavour of meat should also be considered. As flavour develops during cooking as a consequence of a complex set of reactions, it is difficult to predict it from analysis of raw meat. It is known, however, that IMF, peptides, glucides and volatile compounds play a prominent role in flavour development. Numerous proteolytic and lipolytic reactions are involved in the generation of flavour and/ or flavour precursors in meat and meat products. Most of these reactions are known to be due to endo-/exo-peptidases and lipases, respectively. The origin of these enzymes may be either from muscle and/or from microorganisms, although their relative relevance for a given meat product strongly depends on the manufacture and distribution.

c) Toughness

Meat is a fibrous composite material at any level of its structure and as such its macroscopic properties depend on characteristics at all these levels. Several of these characteristics are modified during cooking. Some characteristics which contribute to determine the mechanical strength of raw meat have a low or no effect on cooked meat strength. Moreover, depending on the thermal treatment, the influence of each characteristic on meat toughness may change. Toughness of meat depends on the connective tissue, the state of the myofibrillar structure and the structural interactions between fibres and extracellular matrix[9]. Numerous tentatives have been made to estimate toughness directly through mechanical measurements, or indirectly through its relations with meat components.

ADVANCES IN MEAT PROCESSING

There are many new processing approaches for the industrial manufacturing of meat products are being developed. This is because the meat manufacturing sector is becoming increasingly more industrialized.

1. Incorporation of functional food

The manufacturing, storage and distribution of functional or novel foods that contain bioactive food components pose significant challenges to the food industry as a whole, and by virtue of its portfolio of traditional products to the meat product manufacturing sector in particular. This has led to the food industry paying an increased attention to the relationship between food consumption and human health and wellness. Consequently, a new class of foods, the so-called “functional foods” are being developed that either contain components that have beneficial physiological effects or that are void of components that depending on intake amounts may negatively impact consumers health. This approach has been strengthened by an increasing number of clinical research studies that have demonstrated tangible health benefits that may be derived from intake of bioactive compounds as part of consumers' daily diet.

In Europe, these new food products have been labeled “novel” foods and food ingredients and by definition contain food ingredients that have not been used for human consumption to a significant degree. The Foundation for Innovation in Medicine in 1991 defined bioactives as “any substance that may be considered a food or part of a food and provides medical or health benefits, including the prevention and treatment of disease”. Most bioactives are naturally occurring compounds and can be extracted from plant and animal sources thereby adding value to the commodities from which they have been derived. Examples of prominent bioactive compounds include phytosterols which may help to prevent the accumulation of cholesterol. A prerequisite for physiological action of many bioactives is that:

(a) Sufficient quantities of components are present in the food systems

(b) The compounds remain physically and chemically stable throughout production, storage and consumption (Schmidl & Labuza, 2000) and

(c) Upon consumption pass through the human digestive system in a physical form that allows the compounds to be optimally absorbed in the intestinal tract.

Ideally, the bioavailability of the administered bioactive compound that reaches the systemic circulation, should be as high as possible. However till date, the bioavailability of many compounds once incorporated in a food matrix is extremely low. This is because the compounds may not be stable during processing and/or the compounds may physically and chemically interact with the multicomponent, multiphase food. In this respect, meat products are particularly complex because of their high content of proteins, lipids, and minerals that may lead to a multitude of physical interactions and chemical reactions that cause changes in flavor, taste and appearance thereby potentially reducing consumer acceptance of functional meat products[9].

2. *Changes in Fat profile*

According to joint statements by the WHO and FAO, the recommended ratio of polyunsaturated fatty acids (PUFAs) and saturated fatty acids (SFAs) in diets should be between 0.4 and 1.0 while ω-6/ω-3 PUFA ratio should be between 1 and 4, respectively. For this reason, a dietary supplementation of food products with ω-3 PUFAs, and especially long chain ω-3 PUFAs such as eicosapentaenoic acid (EPA; 20:5) and decosahexaenoic acid (DHA; C22:6) has been suggested as a potential way to compensate and/or replace saturated, monounsaturated and ω-6 polyunsaturated fatty acids in foods.

Despite the dietary benefits of consuming ω-3 PUFAs, fish oils are difficult to include in foods. The unsaturated lipids have an increased sensitivity for lipid oxidation and the generated lipid oxidation products results in a rapid development of the characteristic "fishy" flavor of these oils. Upon inclusion in meat products, one can expect this flavor note to propagate to the raw or processed sausage. Many ongoing studies show that when the oils are included in a protein-stabilized emulsion and mixed with the meat batter, the flavor degradation is much reduced, especially after heating of the sausage[10]. It appears that this is due to the presence of antioxidants in the spice mixes that are usually part of any sausage recipe as well as the very high protein content in meat products, which alters the propagation of the lipid oxidation. A further alternative is to use plant oils that while not rich in EPA or DHA contain significant quantities of α- linolenic acid (ALA; C18:3). Examples of such oils are maize, soy, cotton, canola, linseed, grape seed, walnut and others[11].

The content of cholesterol in meat and meat products is influenced by a variety of different factors, such as type of meat, the cut, and the preparation conditions (broiled, pan fried, boiled etc.). Despite these variations, the concentration of cholesterol generally varies between 75 and 95 mg per 100 g of meat with the notable exception of innards such as kidney, heart, and liver that have significantly higher cholesterol contents at 300–375 mg per 100 g of meat.

A completely different approach to reduce cholesterol uptake is by including an interesting new component in meat products, namely conjugated linoleic acid (CLA; octadiendecadienoic acid 18:2). CLA is naturally present in meat and has shown to be able to decrease the accumulation of cholesterol in acetylated LDL induced mouse RAW264.7 macrophage-derived foam cells presumably by enhancing lipid acceptor-dependent cholesterol efflux. To achieve significant reduction in cholesterol levels though, concentrations higher than those naturally present in meat must be consumed. Thus, studies have focused on increasing the concentration of CLA in meats. For example, the CLA content of meat increased with a supplementation of the animal feed by linoleic acid[11].

3. Reduction of salt and sodium

Low-salt products would satisfy the needs of certain populations. Sodium chloride in meat products is an essential ingredient providing simultaneously a number of different functionalities. Firstly, salt is being used as a preservative to prevent the spoilage of perishable foods, of which meat products are characteristic example. The reduction of water activity due to the addition of salt and the presence of ions exerting osmotic pressure effects on the microorganisms increase the shelf life of processed meat. Thus, when the salt content in meat products is reduced below typically used levels:

- The product has a shorter shelf life or may no longer be safe without addition of other preservatives.
- Salt is a critical component to give meat products their characteristic flavor. In this respect, salts have found to enhance typical meat flavor in processed meat.
- Salt plays a key role to create the desired texture of a processed meat product. This is because the level of salt directly influences the solubility of the myofibrillar meat proteins myosin and actin.

Hypertension is one of the main risk factors for cardiovascular disease. The WHO recommends as little as 5 g of salt per day, which is equivalent to 2 g sodium per day (WHO, 2003). The consumption of meat and meat products contributes about 16– 25% to the total daily intake of sodium chloride and thus is second only to bread with respect to salt levels (WHO, 2003). In order to lower the content of salt, there are many potential solutions[12,13].

- Sodium chloride may be replaced by potassium chloride. This method is in fact the most commonly used method to date. However, potassium chloride has a slightly bitter taste and to prevent the product from having unacceptable sensory properties, masking substances have to additionally be added to the products. Newer studies have attempted to use complex mixtures of alternative salts to mediate some of the negative sensory effects.
- Flavor enhancer may be added to the meat product. The flavor enhancers while themselves not having a salty taste may in combination with salt increase the saltiness of the product. For example, carboxymethyl cellulose and carrageen an in combination with sodium citrate have been shown to enhance saltiness in frankfurters [14].

A change in particle size of undissolved salt crystals could lead to a more rapid dissolution behavior in the mouth thereby yielding a more pronounced salty taste of the product. However, to prevent excessive growth of salt crystals, this approach may need to be combined with an additional modification changing the physical state of salt from a crystal to a glass. Angus reported that in this case, particle size of table salt crystals that ranged from 200 to 500 µm could be reduced to 5–10 µm when the salts existed in an amorphous cubic-glass form stabilize the interface of meat fats thereby forming a stable emulsion.

4. Use of nitrite substrate

One of the most important functionalities of nitrite is its ability to inhibit the growth of food pathogens in meat products. The inhibition of bacteria by nitrite has been attributed to a variety of different mechanisms including the inhibition of oxygen uptake, oxidative phosphorylation and proton-dependent transport. Nitrite was also found to inhibit a number of enzymes that are essential to the metabolism of bacteria such as aldolase. Moreover, nitrite generally causes a breakdown of the proton gradient in bacteria needed to generate ATP.

The different effects that addition of nitrite has on the metabolism of food pathogens are the key reason why the compound is so effective. Since nitrite acts on multiple sites simultaneously, it is very difficult for food pathogens or food spoilage organisms to adapt to its presence. Small concentrations of nitrite are sufficient to cause a broad spectrum inhibition of food pathogens. One method to avoid the direct addition of nitrite to meat is to instead add ingredients that have natural high nitrate content. This method is used in the production of organic versions of cured meats.

Organic "uncured" meat products exhibit all typical sensory properties (color, appearance, and shelf life stability) of nitrite-cured meat products. Ingredients that have been used to manufacture "nitrite-free" cured meat products include unrefined sea salt, turbinado sugar (a raw sugar that is produced by first evaporating sugar cane juice followed by the removal of surface molasses by centrifugation), flavors and spices, celery, carrot, beet and spinach juice. While it had been initially suggested that the technological effect of these ingredients may be due to their residual nitrite content, their nitrite level was either extremely low (e.g. 0.3–1.7 ppm for sea salt), or non-existent.

Vegetable and spice matter instead contain high levels of nitrate that during curing can be converted by nitrate-reducing bacteria into nitrite. An alternative to the use of nitrite is to add naturally occurring antimicrobials to meat products. Antimicrobial agents have been defined as "chemical compounds present in or added to foods, food packaging, food contact surfaces, or food processing environments that inhibit the growth of, or inactivate pathogenic or spoilage microorganism".

CONCLUSION

As Swatland *et al.* noted: "introducing new technology into meat industry, at the level of slaughtering, meat cutting, and distribution, is not easy". The world of meat faces a permanent need for new methods of meat quality evaluation. Researchers wanted improved techniques to deepen their understanding of meat features. This review article reviewed advances in the development of ingredients for meats and meat products. Consumer preferences for meat, from a sensory stand point are influenced by appearance, tenderness, flavor, and juiciness. It highlighted that developments are proceeding at an increasing pace. Consumers demand healthier meat products that are low in salt, fat, cholesterol, nitrites and calories in general and contain in addition health-promoting bioactive components such as for example carotenoids, unsaturated fatty acids, sterols, and fibers. On the other hand, consumers expect these novel meat products with altered formulations to taste look and smell the same way as their traditionally formulated and processed counterparts[13,15,16].

Driven by the demand for new products with new formulations, the meat industry is forced to install flexible production lines that can generate large quantities of high quality meat products with nutritional benefits. A review of the literature reveals that new formulation and ingredient systems are often developed without a process in mind and vice versa, processing lines may be developed that are not able to cope with future changes in formulations and ingredient systems.

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