Functional meat foods and edible packaging: An emerging trend and future prospective of food technology

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Introduction

The conception of "functional food" was introduced long back to the world. With no globally accepted definition as yet, FSSA 2006 definition is relevant in the Indian context. The Food Safety and Standards Act, 2006 (FSSAI) defines functional foods as "foods which are specially processed or formulated to satisfy particular dietary requirements which exist because of a specific physical or physiological ailment, wherein the composition of these foodstuffs must differ significantly from the composition of ordinary foods of comparable. Utilization of meat and non-meat ingredients in the right proportions can enhance health benefits (Bharti *et al*., 2015) and hence can be converted into functional meat foods. The demand for such meat products is poised to increase in coming years due to their nutritional value as excellent protein.

Modern consumers desire healthier meat food products with low salt, cholesterol, fat, nitrites and calories in general and must contain health-promoting bioactive components for instance carotenoids, unsaturated fatty acids, sterols, fibers and bioactive compounds (Bharti *et al*., 2015b). Instead, consumers expect these innovative meat products with altered formulations to taste, look and smell the same way as the traditionally formulated products are prepared (Anita *et al*., 2015; Weiss *et al*., 2010 and Bharti *et al*., 2019). The FSSAI definition is a broad spectrum definition that clubs the foods for special dietary uses, functional foods, nutraceuticals and health supplements together. Besides the various health benefits, functional foods also accomplished economic benefits as they can give higher profitability over conventional or traditional meat food products. Developing countries have started to emerge as exporters to cater to the increasing demand in developed countries. Moreover, demand for functional foods within developing countries is growing, presenting a lucrative opportunity to develop domestic markets (Sharma *et al*., 2016).

In recent years, much consideration has been engrossed in extracts from herbs and spices, which have been used for centuries to improve the sensory characteristics and shelf-life of food (Bharti *et al*., 2012 and Fernandez *et al.*, 2005). Reduction of the use of chemical additives in the food industry, growing interest has risen recently in the use of natural food additives with antimicrobial and antioxidant properties that do not have any negative effects on human health (Alves-Silva *et al*., 2013).

Progressions for the development of functional meat foods

The functionality enhancement of various foodstuffs can be aided by introducing probiotics, dietary fibers, Poly Unsaturated Fatty Acid (PUFA) and specifically omega 6 and omega 3 fatty acids reducing the salt and saturated fat content in the formulation. Functional ingredients are responsible for making the food functional and consumer acceptance is the key to the success of functional foods in the market. Products that contain dietary fibers are excellent substitutes due to their inherent functional and nutritional effects and Fiber usually used in food products, should not only supply fiber but also provide enhanced functional properties. (Biswas *et al*, 2014). Functionality enhancement also includes processes like modification of fatty acids, fermentation and generation of bioactive peptides and use of natural antimicrobials. Functional food products can be developed by using the following techniques:

1. Fermented products
2. Dietary fibre enrichment
3. Fat reduction
4. Salt reduction
5. Modification of fatty acid profile
6. Antioxidants and antimicrobials with natural resources

Fermented meat products

Fermented meat food products represent an imperative component of the functional food industry. Intense research efforts are underway to develop meat products into which probiotic organisms are incorporated to make them more valuable meat products. The products contain a diversity of flavors, textures, and appearances, which are directly dependent on the type of microorganism used. The microbial enzymes and metabolites compulsory to produce these products are provided by a diverse set of microorganisms, including molds, yeasts, and bacteria. Of these organisms, homofermentative lactic acid bacteria are of the utmost importance, Generation of bioactive peptides in fermented meat food products is another possible direction for introducing physiological functions to increase functionality.

Developing functional fermented meat products could be an alternative process in the meat industry as it is known to destroy undesirable components producing a safer product and also improving the shelf life, texture, taste and aroma of the product. The presence of aromas makes fermented meat-based products more appetizing. Fermentation may also result in the synthesis of certain amino acids and improve the availability of B group vitamins. The use of starter cultures mainly (Lactic Acid Bacteria) LAB as functional starter cultures have been suggested in order to address these safety issues. The main antimicrobial activity displayed by LAB strains are due to acidification of raw meat as well as bacteriocin production may be used to combat microbial contamination and also substantiate to be a better alternative for preservation instead of chemical food preservative. Meat products containing functional starter cultures significantly enhance microbial safety and contribute more toward organoleptic, technological, nutritional, or health-promoting properties.

Bioactive components from meat

Bioactive compound are generated during the microbial fermentation of meat: whereas some do occur naturally in meat some of these can be isolated via enzymatic hydrolysis of meat Bioactive compounds may be defined as any substance that may be considered a food or part of a food that provides medical or health benefits including the prevention and treatment of a disease. Bioactive compounds have been shown to exhibit physiological benefits upon ingestion. Most bio-actives are naturally occurring compounds that can be extracted from plant or animal sources. A pre-requisite for the physiological action of many bio-actives is that (a) sufficient quantities of components are present in the food system (b) compounds remain physically and chemically active during production, storage and consumption (c) upon consumption pass through the human digestive system in the form that allows the compounds to be optimally absorbed in the intestinal tract.

Angiotensin I-converting enzyme (ACE) inhibitory Peptide

ACE inhibitory activity has been identified from the proteolytic degradation products of native proteins from meat, dairy, fish, eggs etc. Bioactive peptides recovered from the hydrolysis of skeletal muscle proteins including myosin, tropomyosin, troponin, actin and collagen have been shown to vary in size and ACE inhibitory activity. These fractions could be generated using enzyme technology, concentrated and incorporated into functional meat products at an acceptable level. Preformed bioactive peptides would be promising ingredients in emulsion-based meat products, where they can remain active in the lipophilic matrix. Upon digestion of lipid in the intestine, the peptides would be absorbed into the blood and reduce blood pressure (Ryan *et al*., 2011).

Conjugated linoleic acid (CLA)

CLA may be defined as a group of positional and geometric isomers of octadecadienoic acid. It is most abundant in fat and muscle of ruminant animals because rumen bacteria convert lenoleic acid to CLA by their isomerase. CLA plays a role in the prevention / control of obesity, diabetes and modulation of bone metabolism. It also shows anticarcinogenic, antioxidative and immunomodulative properties. It has been also reported to promote several biological reactions resulting in improved wound healing, reduce cell damage in Alzheimer's disease patients, slow ageing and increase muscle strength and endurance technologies for industrial-scale production of such peptides have recently been developed and already there are a few products supplemented with peptides with specific bioactivities on international markets (Korhonen, 2009).

Dietary fiber incorporation

Dietary fibers are the significant component that are naturally present in various sources of plants such as cereals, legumes, fruits and vegetables which plays a physiological role in human health, for instance, improving blood glucose control in diabetes, lowering cholesterol and blood pressure, reducing cancer risk and helping with weight loss management. Furthermore, dietary fibers have been added as a functional food ingredient to meat food products for significant improvement in water-holding capacity, viscosity, gel-forming ability, and fat-binding capacity (Kim *et al*. 2012). Apart from the nutritional

properties, dietary fiber is also used for technological up gradation like improvement in cooking yield, rheological properties, enhancing the texture and reducing formulation costs and in meat products (Bharti *et al*., 2017). The addition of functional ingredients helps to modify the overall technological and sensorial characteristics of a meat system such as water holding capacity (WHC), fat holding capacity and texture properties In meat products, fiber is now being used as the most common functional ingredients as fat replacer, volume enhancer, binder and stabilizer (Viuda-Martos *et al*., 2008 and Patel *et al*., 2021).

Reduction of fat

Fat is a very important ingredient contributing to the texture, flavor and overall perception of meat products (Arya *et al*., 2017). Fat can trap air during mixing, producing the meat batter that consists of masses of tiny air bubbles trapped within droplets of fat. Fat also imparts richness and tenderness, improving flavor and mouth feel of processed meat products (Bharti *et al*., 2011). Excess intake of fat (especially saturated fat) is associated with many health conditions such as obesity, high blood cholesterol, coronary heart disease and cancer, (Akoh, 1998). The total fat content should not be higher than 30 percent of the daily energy intake. Yilmaz (2005) reported that meat balls containing wheat bran had lower concentrations of total fat and total trans fatty acids than the control samples. Meat balls made with the addition of 20% wheat bran had the highest ash, protein contents, Gok *et al*. (2011) used ground poppy seeds as fat replacer for the development of meat burgers and reported that 20% ground poppy seed had significantly better texture and juiciness score.

Modification of Fatty acid

Meat fat contains a portion of saturated fatty acids and an upright amount of cholesterol. So instead of using animal fat in meat products, a shift should be made to use vegetable oils such as sunflower oil, soy bean oil, safflower oil, linseed oil, olive oil, canola oil etc. These oils are high in mono and polyunsaturated fatty acids and free from cholesterol. Sunflower oil and soybean oil are rich in health promoting omega-6 fatty acids, whereas linseed oil is rich in omega-3 fatty acids. Fatty acid composition has a considerable effect on health since each fatty acid affects the circulation of lipids differently (Lovejoy *et al*., 2002). The functionality of MUFA and PUFA in the diet reduces the level of plasma low density lipoproteins-cholesterol. Hur *et al*., (2004) substituted conjugated linoleic acid (CLA) sources for fat and improved color stability possibly by inhibition of lipid oxidation and oxymyoglobin oxidation was observed. Vegetable/ fish oils contain high amount of MUFAs and PUFAs with negligible cholesterol. Thus, to improve the functionality, various meat products have been made using oils from olive, high-oleic acid sunflower, linseed, peanut, palm, soybean (Jiménez-Colmenero, 2007).

Reduction and replacement of salt

Sodium chloride in meat products is an essential ingredient providing simultaneously a number of different functionalities. Salt is being used as a preservative, lowering the water activity, creating the desired texture, producing characteristic flavor and helping in the shelf life extension of processed meat. Although salt has various unique functions in the human body as well as in food processing, high amounts of sodium consumption is a rising social problem because it increases the risk of heart attack and high blood pressure. International health organizations recommend that sodium intake be significantly decreased because the high

levels of dietary sodium are associated with high prevalence of hypertension, prehypertension (Doyle *et al.*, 2010). Various attempts have been made to use complex mixtures of alternative salts to mediate some of the negative effects. Meat as such is relatively poor in sodium, containing only 50-90mg of sodium per 100g. However, the sodium in meat products is much higher because of table salt content, which can be 2% in emulsion based or ground meat products to as much as 4-6% in cured meat products. Hence, it is desired that ways and means should be devised to reduce the sodium chloride content of these products to make them healthier without much effect on the sensory acceptability of these products. Verma *et al*., (2010) prepared fiber-fortified chicken nuggets with salt substitution and incorporation of apple pulp as a fiber source at different levels and reported that low fat and high fiber functional chicken nuggets can be developed with very good sensory rating (6.9–7.4) by replacing 40% common salt and incorporation of apple pulp.

Natural antimicrobials and antioxidants incorporation

Lipid oxidation is one of the foremost reasons of chemical deterioration in meat food. The food oxidation process produces a rancid flavor and decreases the sensory and nutritional quality of the products making them unacceptable to consumers (Bharti *et al*., 2012). Many synthetic preservatives, such as butylatedhydroxylanisole (BHA), butylatedhydroxyltoluene (BHT) and tertiary butylhydroquinone (THBQ), are currently being used as hurdle to reduce microbial growth and thereby extend the shelf-life of meat (Arya *et al*., 2018 and Bharti *et al*., 2017). Because of the increasing consumer demand for "healthier" meals (free of conventional chemical preservatives), the use of natural preservatives and environmentally friendly technologies have been suggested (Atarés, and Chiralt, 2016). Unlike synthetic compounds, natural preservatives obtained from spices are rich in phenolic compounds and can enhance the overall quality of food by decreasing lipid oxidation and microbial growth (Zhang *et al*., 2016). The extracts and essential oil from certain plants have been found to possess great antioxidant and antimicrobial activity (Arya *et al*., 2019 and Kong *et al*., 2010).

Edible packaging in meat food

Meat and meat products are highly perishable food commodities providing an almost perfect medium for the growth of both spoilage and pathogenic microorganisms (Rashmi *et al*., 2017). However, difficulties associated with the storage of these meat products are lipid per-oxidation and microbial spoilage, which are considered to be the most influential quality defects of such meat products during storage (Bharti *et al*., 2017b). To extend the period of refrigerated storage, packaging is the most common method used for preserving fresh meat and meat products. Packaging plays a crucial role in meat and meat products preservation as meat products deteriorate much faster and posses a higher potential for contamination as compared to other foods. Practically, the films used for meat and meat products packaging's are derived from synthetic "plastic" materials (Bharti *et al*., 2020). However, these synthetic packagings have been alleged for wellbeing, non-biodegradability and environmental devaluation. Therefore, realizing the need for alternative packaging techniques and enhancement of food safety using natural sources, led the researcher's attention toward natural polymer rather than synthetic packaging material. Starch is a biopolymer that is becoming widely used in technical applications and has recently gained interest as a renewable and biodegradable

plastic (Bharti *et al*., 2021). The application of certain antimicrobials in the edible and biodegradable film prevents microbial contamination. Bharti *et al*. (2022a) and Bharti *et al*. (2022b) developed active edible film with the incorporation of anise caraway essential oil respectively. Certain meat products like chicken nuggets (Bharti *et al*., 2020b) can be preserved for a longer duration with minimal alteration in sensory attributes using active edible packaging.

Conclusion

Meat and meat products can be modified by adding ingredients considered beneficial for health or by eliminating or reducing components that are considered harmful. The use of these ingredients in meat products offers processors the opportunity to improve the nutritional and health qualities of their products. Numerous ingredients can be used in meat food to have functional properties, therefore validation studies need to be conducted to interpret the actual functionality. Edible packaging in the meat food sector is a promising industry that can reduce the plastic burden with the efficient use of natural resources. Both the functionality improvement and protection of nature is the pressing priority for food industry sustenance.

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