Review Article

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Meat as a Functional Food: Concepts and Breakthrough

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Abstract

Functional food technology is an impending applied science that claims to boost health or well being by providing account beyond that of fundamental nutrition. Meat and meat products have multifarious disease preventing and health promoting benefits that's make them a viable option to be used as a functional food. However, consumer often associates meat with a contravening health image. The deplorable image of meat is mainly due to content of fat, saturated fatty acid and cholesterol and, the alliance of these with chronic diseases. This review highlights that enrichment of meat with fibres, probiotics, omega-3 fatty acids, CLA, selenium and antioxidants or elimination or reducing components that considered being harmful can embellish its functional properties. This limited explored annex of food science and technology offers a comprehensive scope to meliorate the dietary as well as health promoting properties of meat and meat products. In addition, many regulatory hurdles must be overcome for the commercial production of meat functional food.

Keywords: Functional Meat; Food; Health; Probiotic.

Introduction

Functional foods are foods that have a conceivable positive effect on health beyond basic nutrition. Proponents of functional foods promote optimal health and help reduce the liability of disease. The term functional food was aboriginal introduced in Japan in the mid-1980s and refers to processed foods containing ingredients that aid specific bodily functions in addition to being nutritious. These products include foods with reduced fat, sugar or salt, fortified with minerals, vitamins, phytochemicals, probiotic bacteria or poly unsaturated fatty acids. The term "functional food" has already been defined several times (Roberfroid, 2002). From a market perspective, functional foods are difficult to quantify because different definitions are used. The functional foods market can, however, be seen as part of a broader health-based/driven foods market. This includes natural and organic foods, 'low and lite', weight management and vitamin- and mineral-fortified products as well as functional foods (Weststrate *et al*., 2002).

There are several blueprints for development of functional foods. The most common is incorporation of nutraceuticals or bioactive chemicals which are found as natural components of food of either animal or vegetable origin into the existing traditional food products to gain health benefit. Examples of such functional ingredients are: dietary fiber; oligosaccharides; sugar alcohols; amino acids, peptides and proteins; glycosides; isoprenes and vitamins; choline; lactic acid bacteria; minerals; unsaturated fatty acids and others not included in the former categories, e.g. antioxidants, plant sterols (Chapman & Hall, 1994). Although the vast number of naturally occurring health-enhancing substances are of plant origin, there are a number of physiologically-active components in animal products that deserve attention for their potential role in optimal health. Among the functional foods of animal origin the crucial role play milk products fermented with probiotic bacteria and/or with added probiotic, prebiotic and bioactive substances such as vitamins, minerals and plant extracts; and lactose-reduced milk (Hoffmann *et al*., 2010). Designer eggs with enhanced level of antioxidants: vitamin E, carotenoids, selenium and **ù** -3 fatty acids, such as docosahexaenoic acid, are also a developing group of functional food (Surai & Sparks, 2001). At the same time the meat industry follows the functional trends, however slowly despite the fact that the development in this area could stop the declining tendency of meat consumption caused by combination of socio-economic and health related reasons (Jiménez and Colmenero 2007). Functional compounds, especially peptides, can also be generated from meat and meat products during processing such as fermentation, curing and aging, and enzymatic hydrolysis (Zhang *et al.,* 2010).

The benefits and risks to individuals and populations as a whole must be overseer carefully when considering the widespread use of physiologically active functional foods. The optimal levels of the majority of the biologically active components currently under investigation are yet to be determined.

Meat as a Functional Food

Meat and poultry products are a food category with both positive and negative nutritional attributes. Muscle foods are major sources for many bioactive compounds including iron, zinc, conjugated linoleic acid (mainly ruminants) and B vitamins (Jimenez-Colmenero *et al*., 2001). However, meats and processed meats are also associated with nutrients and nutritional profiles that are often considered negative including high levels of saturated fatty acids, cholesterol, sodium and high fat and caloric contents (Whitney & Rolfes, 2002). Some of these negative nutrients in meats can be minimized by selection of lean meat cuts, removal of adipose fat, dietary manipulation to alter fatty acid composition and proper portion control to decrease fat consumption and caloric intake.

Carabeef

Buffalo meat has good functional properties for processing into variety of meat products such as sausages, burgers, kababs, patties (Suman & Sharma, 2003; Nissar *et al*., 2009, 2008). An anti-carcinogenic fatty acid known as conjugated linoleic acid (CLA) was first isolated from grilled beef in 1987 (Ha *et al*., 1987). Beef fat contains 3.1 to 8.5 mg CLA/g fat with the 9-cis and 11-trans isomers contributing 57- 85% of the total CLA (Decker, 1995). CLA is an effective anti-carcinogen in the range of 0.1-1% in the diet, and it is a potent antioxidant and immune-modulator. Beef is also a major source of selenium for human and the concentration of selenium in beef varies dramatically among countries and regions (McNaughton & Marks, 2002). A peptide L-Carnitine is abundantly present in beef which reduces the cholesterol content, producing energy and maintain the stamina of body. Nuckles and Smith (2007) studied on functional properties of beef and beef by product protein fractions in frankfurter batters. Results suggest that the yield and texture of frankfurters might be improved by adjusting the type and quantity of meat in a formulation to achieve minimum quantities of protein and myosin.

Mutton and Chevon

Mutton is an excellent source of protein, 4 oz. of lamb contains 27.5 g of protein, or 55% the recommended daily intake for an adult. Eating 4 oz. of lamb also delivers 48 per cent, 37 per cent and 14 per cent of the daily value for vitamin B_{12}, niacin and riboflavin, respectively. Lamb is also a good source of some minerals and trace elements especially zinc. Zinc supports the immune system; an aid wound healing and maintains healthy testosterone levels. Lamb is also a good source of iron and copper. Unfortunately, lamb is rich in saturated fat and purines which is responsible for heart disease, increased blood cholesterol levels and kidney stones respectively. So, there is lot of scope for improvement of functional property of mutton.

Goat meat may be an excellent resource in the preparation of low-fat diets, since the fat content of lean meat is significantly less (James & Berry, 1997). Red meat muscle has high myoglobin content and provides a high level of bio-available iron (Worthington Roberts & Monsen, 1990), the haem iron being 5-10% more available than nonhaem iron and appears to enhance the absorption of non-haem iron from other foods. Although an essential dietary component, lean meat has a low Ca content which is insufficient to provide the recommended daily allowance (RDA). The trace minerals Cu, Mn and Zn in meat are highly bioavailable since meat does not contain inhibitors present in some vegetables. The vitamins thiamine, riboflavin and niacin in lean goat meat are, reported 4.5mg total folic acid and 2.8mg vitamin B_{12} per 100g (USDA Composition of Foods, 1986).

Pork

Pork meat offers excellent nutritive and dietetic properties. Its proximate composition demonstrates high protein content (19.1- 23.4%) in lean tissue with high levels of essential amino acids. Pork meat offers excellent nutritive and dietetic properties. It is also a good source of Fe and Zn; and Se is an essential trace mineral due to their role in regulating various physiological functions. Fortification of pig diets with Se or Zn increased its content and lipid oxidative stability of pork muscle tissue. Pork meat is also characterized by low Na content (Bonos *et al*., 2007). Pork meat has been used as a valuable protein source for the production of bioactive peptides. Other bioactive peptides with antioxidant, antimicrobial, antithrombotic etc. properties are also developed by porcine muscle as a functional ingredient. Some antioxidative peptides are generated from pork meat protein that can also produce anti-stress and anti-fatigue effects in the human body.

Fish meat

Fish oil derived primary animal sources can also produce some important functional properties like supplementing the products with omega-3 fatty acids which have beneficial effects on the health. Omega-3 fatty acids are involved in gene expression (as second messengers) and cyclic adenosine monophosphate signal transduction pathways to regulate the transcription of specific genes (Clarke & Jump, 1994; Graber *et al*., 1994). Omega-3 fatty acids such as DHA can also contribute to the development of infant brain and liver (Martinez & Ballabriga, 1987) and play important roles in the prevention and treatment of various kinds of diseases. The Dietary supplementation of fish oils reduced blood pressure and inhibited hypertension (Appel *et al*., 1993).

Poultry meat

Poultry meat proteins are the main structural and functional components in many food systems. Functional properties determine the value of a protein and its impact on final product quality. For processed poultry products, water-binding, fat-binding and meat-solubility, viscosity and emulsification are the principal properties of interest in the initial, raw product. Heat-induced gelation, water-binding and fat-binding are some of the more important functional properties in cooked products (Smyth *et al*., 1999). Water makes up 73±76% of raw poultry meat and is an important functional component that largely accounts for the juiciness of cooked meat and technological yield for processed products (Mead, 2004). Poultry meat has low fat and undesirable trans fatty acids. Breast meat contains less than 3g fat/ 100g and about half of the fat of chicken meat is desirable monounsaturated fatty acid. Poultry meat is also highly rich in minerals and vitamins. The recommended dietary intake (RDIs) of niacin can be met with 100 g of chicken meat per day for adults and 50 g for infants.

Incorporation of functional ingredients in animal diets

Value improvement can be realized by adding functional compounds including ù-3 fatty acid, conjugated linoneleic acid, vitamin E, fatty acids and selenium in animal diets to improve animal production, carcass composition and fresh meat quality

Omega-3 (ω3) fatty acids

This group of fatty acids includes eicosapentaenoic acid (EPA, 20:5), docosapentaenoic acid (DPA, 22:5) and docosahexaenoic acid (DHA, 22:6). Omega-3 fatty acids play important roles in the prevention and treatment of various kinds of diseases. Reports have consistently shown that ω3 fatty acids may delay tumour appearance, inhibit the rate of growth and decrease the size and number of tumours (Kim *et al*., 2009). Coates *et al*. (2009) reported that regular consumption of ω3 fatty acid-enriched pork could decrease the content of serum triglycerides and increase the production of serum thromboxane, and thus can reduce cardiovascular diseases.

The primary source for long chain ω3 PUFA is fish and other seafood. Dietary supplementation of fat and oils is an efficient method to increase the content of ω3 PUFA in animal muscles. Dietary supplementation with vegetable oils including linseed oil and rapeseed oil could also increase ω3 fatty acid content in the form of linolenic acid, which could be used to synthesize long chain ω3 PUFA (Lopez-Ferrer *et al*., 2001). Beti *et al*. (2009) reported that the functional properties of poultry meat are increased by consuming the diet enriched with polyunsaturated fatty acids by using flaxseed in the diet of poultry for increasing the ω-3 PUFA in meat.

Conjugated linoleic acid (CLA)

Various physiological and biological properties have been attributed to CLA including antioxidant and anti-obesity, anti-atherosclerotic, anti-diabetogenic, protection of immune system, anti-carcinogenic (Munday *et al*., 1999) and contribution to bone formation (Roy & Antolic, 2009) and body composition (Smedman & Vessby, 2001). French *et al*. (2000) reported that longissimus muscle from grass-fed beef contained 10.8 mg/g lipid compared to 3.7 mg CLA/g lipid in concentrate-supplemented beef. In semi-membranosus muscle, the total CLA was increased from 5.2 mg total CLA/g in corn supplemented grass fed to 7.7 mg/g lipid in grass-fed beef (Shantha *et al*., 1997). The cis 9, trans 11 isomer of CLA could be incorporated by 46.4% in subcutaneous adipose tissue and the cis 11 and trans 13 was incorporated by 0.74% in intramuscular fat (Gatlin *et al*., 2002). The dietary incorporation of polyunsaturated fatty acids rich ingredients (like safflower oil) in the diet is also a good source of CLA. The dietary incorporation of CLA can also improve the functional qualities in case of broilers by decreasing the fat content of the meat. Dietary CLA not only reduced fat deposition but also altered the fatty acid composition of tissue lipids. The proportion of saturated fatty acids such as palmitic and stearic acids increased significantly, while that of monounsaturated and polyunsaturated fatty acids including plamitoleic, oleic, linoleic and arachidonic acid in broiler chickens decreased significantly (Szymczyk *et al*., 2001).

Vitamin E

Vitamin E supplementation in animal diet and meat products can improve the quality of fresh meat and meat products by limiting protein and lipid oxidation and can improve meat color and reduce lipid oxidation in pork, beef and lamb (Guidera *et al*., 1997). The effects of dietary vitamin E on drip loss were inconsistent: in poultry. Dietary vitamin E inhibited the development of PSE conditions induced by heat stress resulting in improved meat quality (Olivo *et al*., 2001). Diplock *et al*. (1977) also suggested that vitamin E stabilized the membrane of sarcoplasmic reticulum and inhibited the activity of phospholipase A_2 present in skeletal muscle, erythrocyte and other tissues. Diet supplementing with vitamin E in poultry, pigs and cattle prolongs the shelf life of the products. Vitamin E enriched diet or fortification of diet with Vitamin E enhanced the Vitamin E content in the body. Zduñczyk *et al*. (2011) observed that chicken diets fortified with selenium and vitamin E increased the concentrations of both antioxidants in breast muscles without affecting their fatty acid composition

Selenium (Se)

Selenium deficiency is associated with decreased immune function resulting in increased susceptibility to cancer (Gramadzinska *et al*., 2008 and Papp *et al*., 2007), cardiovascular diseases, muscular dystrophy, diabetes, arthritis, cataracts, stroke (Virtamo *et al*., 1985), mascular degeneration (Bird, 1996) and other diseases. Beef is a major source of dietary selenium for human and the concentration of selenium in beef varies dramatically among countries and regions.

Rozbicka-Wieczorek *et al*. (2012) reported, however, that supplementation of broiler chicken diet with lycopene and Se increased the value of the PUFA/SFA ratio in the muscles of pullets and, especially, cockrels. The role of sodium chloride replacement for improving the functionality of mechanically deboned turkey frankfurter was studied by Hand *et al*. (1982) and the results indicated that frankfurters prepared using 100% potassium chloride had more processing and consumer shrinkage than controls

Incorporation of functional ingredients during processing

During past few decades, non-meat additives have been widely utilized in meat products to reduce product's costs and improve the functionality of the products. These additives include vegetable proteins, dietary fibers, herbs and spices, and probiotics, and they can increase the nutritional value and provide benefits to human health.

Fibers

Dietary fibers isolated from various plants have diverse functional properties namely solubility, viscosity, gel forming ability, water-binding capacity, oil adsorption capacity, and mineral and organic molecule binding capacity, which affect product quality and characteristics (Tungland & Meyer, 2002). Dehydrated fruit, vegetable and cereal fiber can be used in the food industry as functional ingredient with excellent results (Viuda-Martos *et al*., 2010). Dietary fibers from oat, sugar beet, soy, pea, apple, and wheat have been included in the formulations of several meat products such as patties, sausages and bologna (Backers & Noll, 2001). Addition of dietary fiber obtained from inner pea and chicory root improved gel strength and hardness of low-fat fish sausages without influencing textural and color parameters of the sausages (Cardoso *et al*., 2008). Lee *et al*. (2008) reported that doughnut containing soybean hulls flour had lower fat contents, but increased hardness and crispiness without affecting any sensory quality parameters. Eim *et al*. (2008) reported carrot can be effectively added to sobrassada to improve the textural and sensory characteristics of the developed products. But the result suggested that the addition of carrot in Sobrassada modifies the organoleptic properties, depending on the concentration. All sensory attributes were declined when level of added DF was greater than 3%. Soy hulls have been incorporated for the preparation of high fibre camel meat patties (Al-Khalifa & Atia, 1997). Grigelmo-Miguel *et al*. (1999) used two different peach dietary fibre suspensions (17 and 29%) to obtain low fat high dietary fibre frankfurters.

Fat replacers

Fat is a very important component of cookies contributing to the texture, mouth feel, flavor and overall perception of them (Zoulias *et al.,* 2002). However, an excess of energy intake and the consequent high amount of fat (especially saturated fat) is associated with health disorders such as obesity, cancer, high blood cholesterol and coronary heart disease (Akoh, 1998). Replacing fat without affecting product quality characteristics is a challenging task (Röble *et al.,* 2011). "Fat replacers" are substances of carbohydrate or protein nature which can imitate the functional and sensory properties of fat (Lindsay, 2000). Brewer (2012) reported that flavor intensity, juiciness, and tenderness of meat products were directly correlated with fat content and that reducing fat content reduced overall acceptability. Reducing the fat content of ground beef to 10% often results in a cooked product that is blend and dry with a hard, rubbery texture (Keeton *et al*., 1994).

Herbs and spices

Lipid oxidation is the major reaction that deteriorates flavor, color, texture, and nutritional value of foods (Kanner, 1994). Some natural ingredients including herbs and spices have been studied especially in Asian countries as potential antioxidants in meat and meat products (McCarthy *et al.,* 2001). Herbs and spices are widely used in many forms of cooking for their strong flavor, which are considered to enhance many other flavors. Turmeric has also been used in traditional medicine for the treatment of various external or internal inflammatory conditions such as arthritis, colitis and hepatitis. (Bengmark, 2005). Ankari *et al.* (1999) described a lot of spices and condiments (particularly clove *(Eugenia caryophyllus)*, ginger *(Gingiber officinale)* and garlic *(Allium sativum)* used in Indian diet and medicine) having antibacterial properties and used in Ayurveda for the treatment of various bacterial diseases. Uhart *et al.* (2006) evaluated the effect of garlic, ginger and turmeric against *Salmonella typhi* DT 104 inoculated in spice paste or in buffered peptone water or in heat treated ground beef stored at 4^0C and 8^0C for 10 days and reported that in a complex food system such as ground beef, the inhibitory activity of these spices decreased considerably. Addition of 1% and 3% of garlic juice could lead to decreased peroxide value, TBARS, residual nitrite and total microbiological counts than those of control in emulsified sausage during cold storage (Park & Kim, 2009). Catechins is a predominant group of polyphenols present in green tea leaves composed of four compounds epicatechin, epicatechin gallate, epigallocatechin, and epigallocatechin gallate (Zhong *et al.,* 2009). Sage extract alone or in combination with sodium isoascorbate resulted in decreased water activity and pH, reduced mesophilic bacteria and coliforms counts in raw vacuum-packaged turkey meatballs, but had better taste in cooked meatballs (Karpinska-Tymoszczyk, 2007).

Probiotics and prebiotics

Probiotics are live organisms which confer health benefits on the host by improving the intestinal microbial balance, whereas prebiotics are selectively fermented ingredients that allow specific changes, both in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well being and health. They should be recruited as generally regarded as safe (GRAS) in foods. There is no official recommended safe dosage for probiotics, but most sources advocate a daily 3 to 5 billion colonizing- forming units (CFUs), however they should provide 20 million to 70 billion CFUs per daily dose. Symbiotics is the condition of combination of Probiotics and Prebiotics that beneficially affects the host by improving the survival and implantation of live microbial dietary supplements in the GI tract, by selectively stimulating the growth and/or by activating the metabolism of one or a limited number of health promoting bacteria, and thus improving host welfare. The best example of symbiotic of pro–prebiotic is Bifidobacterium+Frutooligosaccharide.

Fermentation

The microbial ecology of meat fermentation is a complex process in which LAB play a major role

(Fadda *et al.* 2001). Vignolo *et al. (*1993) found that nine strains of *Lactobacilus casei* and three strains of *L. plantarum* isolated from dry fermented sausages had an antagonistic activity against the indicator species tested. Bacteriocins are the peptides with antibacterial properties produced by LAB. These peptides can reduce or inhibit the growth of other Gram-positive bacteria and thus they can be used to control the growth of food borne pathogens (Diep & Nes, 2002). The bacteriocin produced by *L. casei* and showed antibacterial effects against *L. plantarum, L. monocytogenes, S. aureus* and a wide range of Gram-negative bacteria.

The microorganism species most commonly used as starter cultures to fermented meat products

Microorganism	Genus and Species
Lactic acid bacteria	*Lactobacillus acidophilus a, L. alimentarius b, L. brevis, L. casei a, L. curvatus, L. fermentum, L. plantarum, L. pentosus, L. sakei, Lactococcus lactis, Pediococcus acidilactici, P. Pentosaceus*
Actinobacterium	*Kocuria varians* c. *Streptomyces griséus. Bifidobacterium sp.* A
Staphylococcus	*S. xylosus, S. carnosus subsp. carnosus, S. carnosus subsp. utilis,S. equorum* b
Halomanadaceae	*Halomonas elongata b* (tested in dry cured ham)
Enterobacter	*Aeromonas sp.*
Mold	*Penicillium nalgiovense, P. chrysogeum, P. Camemberti*
Yeast	*Debaryomyces hansenii, Candida famata*

Source: Ruiz-Moyano *et al.* (2008)

Conclusion

Functional foods offer considerable budding potential to refine health or guide to avert certain diseases when taken as a part of a balanced diet and healthy lifestyle. In terms of where we see functional foods going in the future, it seems that the products that bundle claims and benefits together are the ones that stand the best chance of long-term survival. Meat is considered to be essential part of diversified diet that ensures adequate intake of essential component in the form of macro and micronutrients. Meat is also a good source of physiological bioactive compounds. Full emphasis must be given to these facts during manufacturing to improve the additional heath beneficial functions of meat products that formulate a superior opportunity to improve image of meat sector and better fulfillment of needs of consumer. The meat functional food market holds numerous possibilities, but also a number of challenges like consumer satisfaction and price sensitivity. Only a stringent scientific access that provides extremely significant result will guarantee the triumph of this new concept of food and nutrition. Health conscious consumers are increasingly seeking functional foods in an effort to control their own health and well being. Also more information and evidences must be available to assist consumer for correctly choosing and using the functional foods and to achieve the promised health benefits. Finally, those foods whose health benefits are supported by plentiful scientific substantiation have the potential to be a meaningful element of a healthy conduct and bestowal to the consumer and the food industry.

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