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Functional Meat Products: A Review

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ABSTRACT

Scientific progress in understanding the relationship between nutrition and health has an increasingly profound impact on consumer's approach to nutrition which has resulted in the development of the concept of functional foods. It is a practical and new approach to achieve optimal health status by promoting the state of well-being and possibly reducing the risk of disease. The term functional foods comprises some bacterial strains and products of plant and animal origin containing health-promoting physiologically active compounds in addition to the traditional nutrients which are beneficial for human health and reducing the risk of chronic diseases. Consumer's increasing interest for maintaining or improving their health by eating these specific food products has led to the development of many new functional foods. Most of these new formulations are dairy products, vegetable based products, specific fats, etc., but so far only few of them are based on meat products. 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. This study reviews and discusses some of the findings published in recent years regarding the functional meat products.

Key words: Functional foods, meat products, functional ingredients, modifications

INTRODUCTION

The term functional food has already been defined several times (Roberfroid, 2002) but so far there is no unitary accepted definition for this group of food (Alzamora *et al.*, 2005). Typically, a food marketed as functional contains added, technologically developed ingredients with a specific health benefit (Niva, 2007). These are food-type products that contain significant levels of biologically active components (Drozen and Harrison, 1998) that influence specific physiological functions in the body, thereby providing benefits to health, well-being or performance, beyond regular nutrition and are marketed and consumed for this value added property. They may improve the general conditions of the body (e.g., pre- and probiotics), decrease the risk of some diseases (e.g., cholesterol-lowering products) and could even be used for curing some illnesses. The term functional food itself was first used in Japan, in the 1980s, for food products fortified with special constituents that possess advantageous physiological effects (Hardy, 2000; Kwak and Jukes, 2001;

Stanton *et al.*, 2005). Consumers more and more believe that foods contribute directly to their health (Mollet and Rowland, 2002; Young, 2000) and are not intended to only satisfy hunger and to provide necessary nutrients but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumers (Menrad, 2003; Roberfroid, 2000b). Thus, there is an increasing demand of functional foods that is very well justified by certain factors like increasing cost of healthcare, the steady increase in life expectancy and the desire of older people for improved quality of their later years (Kotilainen *et al.*, 2006; Roberfroid, 2000a, b). Different demographical studies revealed that the medical service of the aging population is rather expensive (Mark-Herbert, 2004; Menrad, 2003) and as said by Hippocrates Let food be thy medicine and medicine be thy food seems to be an economical way out.

The concept of functional food was first promoted in 1984 by Japanese scientists who studied the relationships between nutrition, sensory satisfaction, fortification and modulation of physiological systems. In 1991, the Ministry of Health introduced rules for approval of a specific health-related food category called FOSHU (Food for Specified Health Uses) which included the establishment of specific health claims for this type of food (Burdock *et al.*, 2006; Kwak and Jukes, 2001; Menrad, 2003; Roberfroid, 2000b). Most people would like to eat a healthier diet without fundamentally changing their eating patterns. The unwillingness of the consumer to change dietary habits suggests that there is a great market potential for foods with altered nutritional characteristics but unchanged sensory attributes (Becker and Kyle, 1998). Thus, form and amount of intake of the functional food should be as it is normally expected for dietary purposes. Therefore, it should take just as normal food form and not be in the form of pill or capsule (Diplock *et al.*, 1999) although, 2001 FOSHU products in Japan can also take the form of capsules and tablets, but a great majority of products are still in more conventional forms (Ohama *et al.*, 2006). Functional foods are meant to be eaten as part of the regular diet. In some cases, one or more additional ingredients are added that impart health benefits above and beyond those of regular food (Stauffer, 1998).

Most early developments of functional foods were those of fortified with vitamins and/or minerals such as vitamin C, vitamin E, folic acid, zinc, iron and calcium (Sloan, 2000). Subsequently, the focus shifted to foods fortified with various micronutrients such as omega-3 fatty acid, phytosterol and soluble fiber to promote good health or to prevent diseases such as cancers (Sloan, 2002). More recently, food companies have taken further steps to develop food products that offer multiple health benefits in a single food (Sloan, 2004). Functional foods have been developed in virtually all food categories. These products have been mainly launched in the dairy, confectionery, soft-drinks, bakery and baby-food market (Kotilainen *et al.*, 2006; Menrad, 2003) but so far only few of them are based on meat. This article reviews some modifications done in meat and meat products to produce various functional meat products. Numerous functional compounds are present in meat and its derivatives and thus, may also be considered as a functional food. Using food for health purposes rather than for nutrition opens up a whole new field for the meat industry that can explore various possibilities, including the control of the composition of raw and processed materials by reformulation of fatty acid content or by inclusion of dietary fiber, antioxidants or probiotics, etc. (Jimenez-Colmenero *et al.*, 2001; Mendoza *et al.*, 2001; Scollan, 2007).

During last two decades, an increasing amount of attention has been focused on the emergence of a value added food category founded on the specific health and preventive properties provided by certain foods. In addition, in an older population, more people face the health challenge posed by aging. These trends create a receptive climate for the functional foods/nutraceuticals explosion.

The category has been described by a wide and creative variety of nomenclatures, including nutraceuticals, designer foods, nutritional foods, functional foods, medical foods, longevity foods, hypernutritional foods, super foods, pharma foods, prescriptive foods, phyto-foods, therapeutic foods, fitness foods, foodiceuticals and numerous other terms. As interest in healthy eating has developed in recent years, one of the main responses was the removal of ingredients perceived as unhealthy, such as fat, sugar and salt. Low fat, no fat and reduced-calorie foods were responses to consumers' desire to eat healthier. Reducing dietary fat is a major dietary goal for many consumers and there are various aspects of interest relating to product design and fat reducing strategy. These specific considerations regarding nutritional, sensory, technological, safety, appreciation, legal and cost procedures are important to an improved product design (Tokusoglu and Unal, 2003). Although, these characteristics still represent a major factor in a product's appeal, functional foods add yet another alternative for consumers to better their diets (Ohr, 1997).

Foods of animal origin including meat are required to maintain the health of a human body (Nestle, 1999). Meat is specifically valuable as a source of omega-3 fatty acids, vitamin B12, protein and highly bioavailable iron (Bender, 1992). The consumption of meat and other animal products can alleviate nutritional deficiency, which is still widespread in developing countries and secure a better child physical and mental development (Delgado, 2003; Speedy, 2003). Population growth, urbanization, economic growth and flourishing markets all lead to the increasing demand for meat and animal products (Delgado, 2003; Costales *et al*., 2006; Steinfeld *et al*., 2006a, b). Also, changing nutritional needs, driven by growing incomes and demographic transitions, there is an increased need for livestock products including meat on a global scale (Rosegrant *et al*., 1999; Speedy, 2003; Steinfeld *et al*., 2006a, b). Apart from the nutritional status, meat and other animal products play an important social role in the modern society. Until 2020, meat demand is expected to increase highly in developing countries and slightly in developed counties (Rosegrant *et al*., 1999; Delgado, 2003). Both meat and its associated products can be modified by adding ingredients considered beneficial for health or by eliminating or reducing components that are considered harmful. In this way, a series of foods can be obtained which, without altering their base, are considered healthy.

Being a major source of Saturated Fatty Acids (SFA) in the diet, meat has been implicated in diseases associated with modern life, especially in developed countries. The n-6:n-3 ratio of polyunsaturated fatty acids (PUFA) is another risk factor associated with cancers and coronary heart disease. Thus, one of the functional modifications done in meat is change in its fatty acid and cholesterol levels. Wood *et al*. (2003) observed that n-3 PUFA levels in pigs fed on linseed diet produced higher levels of thiobarbituric acid reactive substances (TBARS) without altering the sensory attributes of meat. According to Chizzolini *et al*. (1999), selection of breeds and genetic lines within breeds, changes in animal feeding practices, including some feed additives (like probiotics) and intervention in animal metabolism (like anabolic implants) are the main tools used to achieve a reduction in carcass fat content, although many such practices are not authorized in many countries. Velasco *et al*. (2004) reported that weaning had more profound effect than the type of feed on the fatness and quality characteristics of the meat obtained from lambs. However, a decrease in the intramuscular fat content would decrease sensory attributes of meat, especially juiciness and flavor, which are already impaired in some cases (Chizzolini *et al*., 1999). Variations in fatty acid composition have an important effect on firmness or softness of the fat in meat. The effect of fatty acids on the shelf life meat is explained by the development of rancidity due to the oxidation of unsaturated fatty acids. However, the changes in fatty acid composition have not been directly linked to changes in muscle colour and myoglobin oxidation (Wood *et al.*, 2003). Dal Bosco *et al.* (2004) reported that enrichment of n-3 PUFA did not increase the oxidation level in rabbit meat. The α-linolenic acid-vitamin E diet favored the accumulation of long chain polyunsaturated n-3 in the meat and improved its oxidative stability and consequently its nutritional value. Enser *et al.* (2000) reported that pigs fed on linseed showed an increase in the n-3 PUFA in meat, finding that it may be readily manipulated to increase the concentrations. Hur *et al.* (2004) reported that the concentration of conjugated linoleic acid, having anti-carcinogenic, anti-diabetic, anti-obesity, anti-atherogenic, immunomodulatory and anti-oxidative properties (Khanal and Olson, 2004; Akalln and Tokusoglu, 2003), was significantly increased by the substitution of fat in beef patties and substituted CLA sources improved the color stability possibly by inhibition of lipid oxidation and oxymyoglobin oxidation.

Another functional modification that can be done in meat products is the addition of fiber that produces a diminution in caloric content as studies have proven a relationship between a diet containing an excess of energy-dense foods and the emergence of a range of chronic diseases, including colon cancer, obesity, cardiovascular diseases and several other disorders (Best, 1991; Kaferstein and Clugston, 1995, Beecher, 1999). Sadri and Mahjub (2006) found a positive association between meat consumption and colorectal cancer. Therefore, an increase in the level of dietary fiber in the daily diet has been recommended (Eastwood, 1992; Johnson and Southgate, 1994). Several studies have proved that dietary fibers have the potential to reduce blood low density lipoprotein cholesterol (Brown *et al.*, 1999), risk of diabetes mellitus type 2 (Willet *et al.*, 2002), coronary heart disease (Bazzano *et al.*, 2003), blood pressure (Streppel *et al.*, 2005), obesity (Liu *et al.*, 2003) and colorectal cancer (Schatzkin *et al.*, 2007). Studies have shown that the consumption of fruits and vegetables imparts the dietary fiber and health benefits that are mainly attributed to organic micronutrients such as carotenoids, polyphenolics, tocopherols, vitamin C and others (Scheieber *et al.*, 2001).

Non-meat proteins from a variety of plant sources such as soy proteins (Gujral *et al.*, 2002; Pietrasik and Duda, 2000; Porcella *et al.*, 2001), buck wheat protein (Bejosano and Corke, 1998), samh flour (Elgasim and Al-Wesal, 2000), common bean flour (Dzudie *et al.*, 2002), bengal gram, green gram and black bean (Modi *et al.*, 2003; Bhat and Pathak, 2009) and corn flour (Serdaroglu and Degirmencioglu, 2004) have been used in comminuted meat products. Inclusion of legumes in daily diet has many physiological effects in controlling and preventing various metabolic diseases such as coronary heart disease and colon cancer (Tharanathan and Mahadevamma, 2003). Many non-meat proteins as fiber sources has been used in cooked meat products to increase the cooking yield due to its water-binding and fat-binding properties and to improve texture (Cofrades *et al.*, 2000). Yilmaz (2004) used rye bran as a fat substitute in the production of meat balls that improved their nutritional value and health benefits as the total trans-fatty acid content was lower and the ratio of total unsaturated fatty acids to total saturated fatty acids was higher in the extended samples. Rye consumption has been reported to inhibit breast and colon tumor growth in animal models, to lower glucose response in diabetics and to lower the risk of death from coronary heart disease. Steenblock *et al.* (2001) studied the effects of oat on the quality characteristics of light bologna and fat-free frankfurters indicating that the addition of oat fiber produced greater yields (attributed to its water-absorption capacity), increased hardness and a lighter red color. Oat products have also achieved a very positive consumer image because of the health benefits that have been associated with their consumption. Garcia *et al.* (2002) reported that oat bran and oat fiber provide the flavor, texture and mouth feel of fat in ground beef and pork sausages. Bhat and

Pathak (2009) added green gram and black bean to the chicken seekh kababs and observed a significant increase in cooking yield and emulsion stability without any significant loss of sensory properties.

Caceres *et al.* (2004) studied the effect of short-chain fructooligosaccharides, non-digestible oligosaccharides, on cooked sausages and reported decrease in energy values from 279 kcal/100 g in the conventional control to 187 kcal/100 g in the reduced-fat sausages with 12% added fiber at 12% soluble dietary fiber. Mendoza *et al.* (2001) prepared low-fat, dry-fermented sausages with a fat content close to 50 and 25% of the original amount and supplemented with 7.5 and 12.5% of inulin and reported a softer texture and a tenderness, springiness and adhesiveness very similar to that of conventional sausages. Anderson and Berry (2000) added inner pea fiber to produce lower-fat beef patties (10 and 14%) and reported an improved tenderness and cooking yield without having negative effects on juiciness and flavor. Citrus byproducts (lemon albedo and orange fiber powder) have been added, at different concentrations, to cooked and dry-cured sausages with excellent results (Aleson-Carbonell *et al.*, 2003, 2004; Fernandez-Gines *et al.*, 2003, 2004; Fernandez-Lopez *et al.*, 2003). Lemon albedo was added at different concentration (2.5 to 10%) to cooked sausages (Fernandez-Gines *et al.*, 2004) and dry-cured sausages (Aleson-Carbonell *et al.*, 2003, 2004). The addition of lemon albedo to both sausages had healthy effects due to the presence of active biocompounds, which induced a decrease in residual nitrite levels. Garcia *et al.* (2002) studied the effect of adding cereal (wheat and oat) and fruit fibers (peach, apple and orange) on the sensory properties of reduced-fat, dry-fermented sausages and reported an improvement in their nutritional properties and an acceptable sensory profile. However, the higher amounts of fiber (3%) increased the hardness.

Vegetable origin protein derivatives have been used in meat products to reduce formulation costs and for their nutritional value (Jimenez-Colmenero *et al.*, 2001). Wheat protein as a meat analogue is a relatively recent development and is essentially made from gluten that has been processed and extruded to resemble the texture of meat (Sadler 2004). Modi *et al.* (2003) studied the effect of different decorticated legume flours on buffalo meat burgers and observed lower thiobarbituric acid values. Nuts contain dietary fiber and various bioactive compounds such as plant sterols, which have cholesterol lowering properties (Halsted, 2003; Sadler, 2004) and decrease the risk of cardiovascular diseases. Jimenez-Colmenero *et al.* (2003) studied the addition of walnuts to restructured beef steak and reported that the addition of walnuts affects the cooking properties, color, texture and sensory attributes, making the product softer and providing it with better water-binding properties.

Plant-derived proteins from soybeans have been used in traditional comminuted meat products (30% fat) as meat replacements. Soy proteins (flours, concentrates and isolates) are more commonly used in processed meat products for their functional properties and relatively low cost compared with lean meat (Chin *et al.*, 1999). Soy proteins have been incorporated in these products for their water-binding and fat-binding ability, enhancement of emulsion stability and increased yields (Chin *et al.*, 2000). Soy oil also contains approximately 0.2 g plant sterols per 100 g that are associated with lowering plasma LDL cholesterol at intakes of 2 to 3 g d^{-1} (Ferrari and Torres, 2003; Sadler, 2004). Soy proteins' benefits relate to the reduction of cholesterol levels and menopause symptoms and the reduction of the risk for several chronic diseases, i.e., cancer, heart disease and osteoporosis (Jimenez-Colmenero *et al.*, 2001; Halsted, 2003). Many studies have found that adding soy protein to the diet or replacing animal protein in the diet with soy lowers blood cholesterol (Carroll, 1991; Sirtori *et al.*, 1993). The cholesterol-lowering effect of soy has been attributed to isoflavones, a class of phytochemicals found in soybeans (Potter, 1998). Soy-protein drinks that contain naturally occurring high levels of isoflavones reduce total cholesterol and LDL cholesterol, the so-called bad cholesterol, in patients who had high cholesterol levels despite consuming a low-fat, heart-healthy diet. Lee *et al.* (1991) point to an important link between soy consumption and a reduced risk of certain types of cancer. It is well known that Asian women, who typically eat a soy-based diet, have a much lower incidence of breast cancer than Western women. Daidzein and genistein are the two primary isoflavones found in soybeans. These compounds may reduce the risk of a number of cancers, including those of the breast, lung, colon, rectum, stomach and prostate. Studies indicate that consuming soy isoflavones may reduce the frequency and intensity of hot flashes in menopausal women. The improvements in menopausal symptoms are attributed to phytoestrogenic factors in soybeans. In addition, Cassidy *et al.* (1994) found significant changes in the menstrual cycle of women who were fed a soy diet. Specifically, their hormones levels were altered and the menstrual cycle was lengthened. Soy foods may help prevent and treat osteoporosis and may play other roles in protecting bone health (Anderson and Garner, 1997). The isoflavones daidzein and genistein, found in significant amounts only in soybean and soyfoods, may directly inhibit bone resorption (Brandi, 1992; Anderson *et al.*, 1995). Soy protein binds, emulsifies and hydrates meat products. It makes meat products juicer, which improves flavor, color, texture, shelf life, sliceability and yield. It can be used to lower the percentage of fat in ham, sausage, luncheon meats and hot dogs. Up to 30% hydrated soy protein is permitted in commercially made hamburger patties provided the final product meets specified water-to-protein requirements (Lusas and Riaz, 1995). Soy concentrates have the ability to bind and hold natural flavors and moisture, resulting in products that stay moist and flavorful even after reconstitution in conventional or microwave ovens. Soy protein concentrates can withstand stresses caused by multiple cooking, microwave heating, retort cooking and extended storage or handling time. Their retention of functionality in the presence of salt during reheating and in the freeze/thaw cycle makes them a good choice for use in meat systems. In coarsely ground meat, such as pizza topping, beef patties and Mexican fillings, the concentrate helps retain fat and prevent grease pooling, as well as retain moisture through freeze/thaw and second cooking. The addition of soy concentrates in meat applications does not change current manufacturing processes and soy concentrates can be used in virtually any meat system. A traditional application for soy protein concentrates in the meat industry is in cooked-sausage manufacturing. Soy concentrates can be added in ground meat, whole muscle meats and poultry emulsion meats, dry sausages, seafood and vegetarian foods (McCue, 1994). Some of the approved products are sausage, meat balls and hamburger patties containing soy protein isolate, which may carry the claim that these meat products lower serum cholesterol (Burke, 1998). The textured concentrates impart a meaty texture and also perform well in both raw and precooked meat patties. Textured soy-protein concentrates have high natural-protein content, neutral taste and structure-forming characteristics, which contribute to an improvement in the nutritional profile of standard food products and offer food manufactures new alternatives in product development. The nutritional properties of soy protein products, especially soy protein concentrates (absence of cholesterol, reduced content of fat and calories) and their physicochemical attributes (water absorption, emulsifying capacity) are important advantages for their use in many food applications. Textured soy protein ingredients have been advocated as seafood extenders. Many processors of seafood items, including surimi products, have become interested in soy concentrates because of their water-binding and holding capacity.

Porcella *et al.* (2001) studied the addition of Soy Protein Isolates (SPI) (2.5%) to chorizo raw sausage and reported that it prevented drip loss of vacuum-packaged chorizos during refrigerated storage. Chin *et al.* (2000) studied effect of soy protein isolate on low-fat bologna and concluded that SPI (2%) can be incorporated as fat replacer without any detrimental physicochemical and textural characteristics, except for color values. Chin *et al.* (1999) concluded that 4.4% SPI gives a softer texture to low-fat bologna without altering other chemical parameters. Feng *et al.* (2002) studied the effect of thermally/enzymatically obtained soy protein isolates (2%) on pork frankfurters and observed that heat obtained soy protein improved hardness whereas enzyme-hydrolyzed soy proteins reduced hardness, cohesiveness and breaking strength. Muguerza *et al.* (2003a) studied the replacement of pork backfat with soy oil and reported that the addition of soy oil did not modify the percentage of water or protein and the pH in fermented sausages.

Another important functional modification is addition of natural extracts with antioxidant properties as lipid oxidation is one of the causes for the deterioration of meat and derivatives causing undesirable changes in flavor, texture and nutritional value (Gil *et al.*, 2001). Lipid oxidation can be effectively retarded by the use of synthetic antioxidants which were widely used in the meat industry but concerns over safety and toxicity pressed the food industry to find natural antioxidants (Coronado *et al.*, 2002) extracted from plants such as rosemary, sage, tea, soybean, citrus peel, sesame seed etc as alternatives to the synthetic antioxidants because of their equivalent or greater efficiency (Tang *et al.*, 2001). Tang *et al.* (2001) studied addition of tea catechins to cooked red meat and poultry and observed a significantly controlled lipid oxidation in cooked muscle patties. Jo *et al.* (2003) studied the functional properties of raw and cooked pork patties with added irradiated green tea leaf extract and reported to have beneficial biochemical properties. Coronado *et al.* (2002) prepared wiener sausages with rosemary extract, whose leaves contain a large number of phenolic compounds with antioxidant activities (Gil *et al.*, 2001; Fernandez-Lopez *et al.*, 2003) and observed no lipid oxidation in the product during long-term frozen storage.

A significant sector of the population in Western societies is suffering of cardiovascular diseases being hypertension the most extended. Part of them experience an increase in blood pressure when sodium is present in the diet. As such public health and regulatory authorities have recommended a reduced dietary intake of sodium choride but the intake still exceeds the nutritional recommendations in many countries (Ruusunen *et al.*, 2003a). Hypertension has become an important health concern because it may increase the incidence of symptoms associated with coronary heart disease and stroke. The concern of reducing sodium in the food supply is important to the processed meat industry. Sodium chloride is a principal ingredient in producing processed meats due to its flavour, preservation and protein solubilizing properties. Merely reducing the amount of sodium chloride in the formulation will affect the water holding capacity and emulsifying properties of meat protein (Wierbicki *et al.*, 1957; Hamm, 1960; Schut, 1975). These effects will result in unstable emulsions.

Studies indicate that salt reduction has an adverse effect on water and fat binding in meat products with increasing cooking loss and weakening the texture (Ruusunen *et al.*, 2003a, b). Jimenez-Colmenero *et al.* (2001) reported that approximately 20 to 30% of common salt intake comes from meat and meat derivatives, taking eating habits into account. Ruusunen *et al.* (2003a) studied the preparation of low-salt phosphate-free frankfurters and observed that below 1.5% salt content, phosphate-free frankfurters require additional non-meat ingredients. Ruusunen *et al.* (2003b) studied the quality characteristics of low-salt bologna-type sausage prepared with sodium citrate, carboxymethyl cellulose and carrageenan and with less than 1.4% NaCl, the use of these ingredients decreased frying loss and increased saltiness. Gimeno *et al.* (2001) prepared dry-fermented sausages using calcium ascorbate as a partial substitute for NaCl and seems to be a viable way of decreasing sodium in dry-fermented sausages although, substitution caused higher acidification.

Another functional modification is the addition of oils to meat products. Consumption of olive oil is related to a decreased risk of heart disease and breast cancer (Pappa *et al.*, 2000). Studies on the preparation of low-fat frankfurters using olive oil to replace (0 to 100%) pork backfat showed that the higher levels of olive oil had the lowest overall acceptability (Pappa *et al.*, 2000). Vegetable oils have also been used as partial substitutes of pork backfat in low-fat frankfurters and other types of cooked product giving rise to products with more adequate fatty acid profiles and cholesterol levels than traditional ones (Muguerza *et al.*, 2001). Muguerza *et al.* (2001) studied the effect of replacement of pork backfat by olive oil in traditional Spanish sausage and observed an increase in oleic and linoleic acid levels whereas cholesterol content was reduced without affecting the sensorial attributes. Ansorena and Astiasaran (2004) reported an increase in the monounsaturated fatty acids fraction (MUFA) on addition of olive oil to sausages and reported it to be more effective than vacuum-storing methods in avoiding lipid oxidation during storage. Muguerza *et al.* (2003b) also found a significantly increased MUFA content and decrease in the oxidation process with 20% pork backfat replacement by olive oil in reduced fat Greek sausages. Severini *et al.* (2003) studied the salami products and found that the partial substitution of pork backfat by extra virgin olive oil substantially affected the water activity and firmness whereas the addition of the extra virgin olive oil does not reduce the shelf life in terms of lipid oxidation. Interesterified vegetable oils are another option that can be used as a fat replacer to modify the fatty acid composition of meat products without any detrimental changes in their sensory characteristics. Yilmaz *et al.* (2002) studied the effect of sunflower oil on low-fat frankfurters and found a higher content of unsaturated and essential fatty acids, without any negative sensory characteristics.

Studies have proven the protective effect of n-3 polyunsaturated fatty acids against some common cancers such as breast and colon cancer, rheumatoid arthritis, inflammatory bowel diseases and cardiovascular diseases (Hoz *et al.*, 2004). Oils in the form of n-3 polyunsaturated fatty acids occur mainly in cold water fish and dietary fish oil significantly influence the n-3 fatty acid and cholesterol content of meat lipids (Jeun-Horng *et al.*, 2002). Jeun-Horng *et al.* (2002) studied the addition of fish oil (2 to 4%) to the diet of chickens used to make chicken frankfurters and reported non-significant influence on various physicochemical, proximate and sensory parameters with higher contents of eicosapentaenoic acid (EPA) and docosahexanoic acid (DHA), but a lower content of n-6 fatty acids. Chekani-Azar *et al.* (2008) studied the effect of replacing poultry fat with fish oil in broiler diets on fatty acid composition and sensory quality of broiler meat. Total saturated as well as total monounsaturated fatty acids decreased significantly whereas the amounts of total polyunsaturated fatty acids were significantly increased. Linolenic and long-chain n-3 PUFA in the breast tissue also increased thereby decreasing the n-6: n-3 ratio. Sensory parameters were not altered at 1% replacement level.

CONCLUSIONS

Consumers have become better informed about nutrition and want to learn more about the medical benefits of food. Food manufacturers face the challenge of providing nutritious food, while at the same time, ensuring that the product has an appealing taste, texture and appearance. Thus, producers of meat products have modified their formulas/recipes to meet the changing demands of the marketplace by addition of certain components that add functional properties to meat products or by reduction of certain ingredients that are not considered beneficial to health. Further research is needed to understand their interactions with meat products constituents and thus to improve their safety in potential industrial applications.

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