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Replacement of Saturated Animal Fats in Meat Products: A Review

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Meat is still the most valuable food in the world. The quality aspect of meat is decided by the nutritional and sensory values. Consumers' awareness on diet and health increased the demand for healthy food, specially, meat. Meat is high in saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA). SFA are found to elevate cholesterol which is associated with cardiovascular diseases and other chronic diseases. Replacing or reducing animal fat in meat products could create a better image for the industry, but, sensory quality as well as product stability could be affected. Animal fat can be replaced or reduced by adding more water in the product or by substituting with vegetable fats and/or oils, or by adding hydrocolloids like dextrins, starches, fibers, gums in the product. Marine oils and vegetable oils are used to replace animal fat in meat product but the technological procedures have to be adjusted to produce the similar product due to their different chemical characteristics from animal fats.

Keywords: Animal fat, Saturated fat, PUFA, Fat replacers, Quality

Introduction

Meat is still the most valuable food in the world that comprises around 10-25 % of total energy intake in most of the meat eating countries (FAO, 2002; Valsta *et al*., 2005). The quality aspect of meat is associated with nutritional and sensory values. Moreover, quality of meat is also influenced by socio-demographic conditions of the consumer (Webb and O'Neil, 2008). Nowadays consumers' awareness and consciousness about their diet and health are increasing, and so the demand for healthy food is also rising. On the other hand, foods that are tagged as unhealthy are certain to dwindle away from the market (Colmenero, 2000). Taste and nutritional value of meat are two important quality attributes for the consumers. The amount and type of fat is highly responsible for palatability and eating quality particularly flavour, mouth feel, juiciness, bite, tenderness in meat (Jeremiah *et al*., 2003; Webb, 2006). Thus, meat producers are facing dual problem of reducing fat in meat, and also taking challenge for upholding sensory quality of meat.

The fat content and fat composition in meat and meat products vary significantly depending on the species, age of the animal, and part of the carcass used for meat. Moreover, sex and plane of nutrition also affect meat fatty acid composition, thus affecting texture and flavour of meat (Mottram, 1998; Bolte *et al*., 2002; Wood *et al*., 2003).

The purpose of this article is to review meat fat content in the human diet and its adverse health impact, and to discuss on the widespread areas for replacing saturated animal fat with vegetable oils in processed meat products so as to produce healthy meat products.

Quality attributes and health impact of meat fat

Fats and oils (chemically known as triacyglycerols or triglycerides) are neutral lipids consisting of glycerol molecule attached with three fatty acids that vary in physical and chemical properties (IUPAC, 1978).

There is around 3-35 % fat content in meat and meat products, chicken skin having an even higher value (around 48 %.). Sausages and beef patties contain around 15-25 % fat, whereas salami have twice as high fat (up to 45 %) and nuggets have 20-25 % of fat (Livsmedelsverket, 2004). Fat present in meat mostly contains saturated fatty acids (SFAs) and monounsaturated fatty acids (Figure 1).

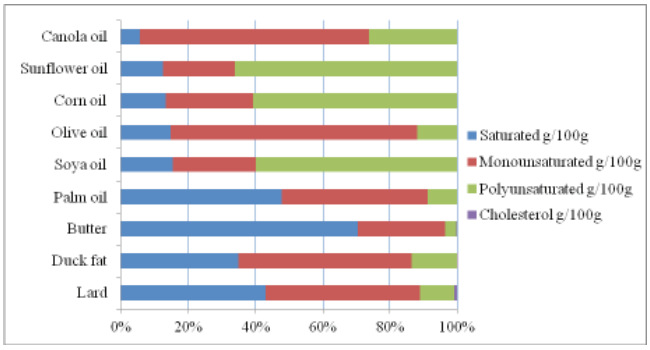

Figure 1. The average fatty acid and cholesterol composition of some common dietary fats.

Pork and poultry meat contains somewhat more unsaturated fatty acids compared to beef and lamb. Cholesterol content varies from 30-120mg/100g of meat, being higher in offal's (NPH, 2001).

Human and other mono gastric mammals cannot synthesize n-3 and n-6 polyunsaturated fatty acids; hence they are essentially required in our daily diet. Fish oil, comparatively, contains high amount of higher PUFAs (polyunsaturated fatty acids) like arachidonic acid, eicosapentaenoic acid and docosahexaenoic acid, than red meat (Smith, 2007).

Saturated fatty acids content in food are directly related to elevated low density lipoprotein (LDL) cholesterol mainly due to the presence of myristic and palmitic acids contributing

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in about 30-40 % of total fatty acids. It has been found that higher intake of meat and meat products are associated with higher amount of saturated fat and cholesterol in the diet that are dubbed as bad fats (Livsmedelsverket, 2004; Ozvural and Vural, 2008). Lin *et al*., (2004) theorized that an increase in the risk of colorectal cancer is associated with dietary saturated fat. People are reluctant to increase sausage consumption because of SFA content in it and these fatty acids are associated with increased risk of coronary heart diseases (Gines *et al*., 2005).

The recommended guidelines for balanced diet published by WHO/FAO are based on the preventive effect on chronic diseases like obesity, cardiovascular diseases (CVD), diabetes type 2, and cancer. These recommendations include the target of 20-35 % of total calorie to be supplied from total dietary fat intake. Similarly, intake of SFA should not exceed 10 % of total energy intake; PUFA should be 6-11% (n-6 and n-3 PUFA to be 5-8 % and 1-2 % respectively), and cholesterol has to be less than 300 mg in our daily diet (FAO/WHO, 2010).

Earlier, medical recommendations were made to reduce total fat intake in order to avoid negative health effect of obesity, CVD, and other health conditions predisposed by the consumption of high amount of fat. Nowadays, these recommendations are clearly shifted towards the quality rather than quantity as such. Diets high in PUFAs (importantly n-3, n-6 PUFA and Conjugated linoleic acid) are now highly emphasized to prevent above mentioned adverse health conditions (Wood *et al*., 2003; Laaksonen *et al*., 2005). Studies have revealed that the intake of more PUFA and less saturated fat in the diet, starting from childhood, reduced total cholesterol and LDL cholesterol in adults (Öhlund *et al*., 2007). Several animal studies have also shown that conjugated linoleic acid helped to reduce the risk of cancer, atherosclerosis and diabetes (Rainer and Heiss, 2004). Alternatively, vegetable oils are cholesterol free and have high ratio of unsaturated fatty acids as compared to animal fat (Liu *et al*., 1991). Introducing those fats/oils in meat products could create a better image for the industry. However, the use of vegetable oils may negatively affect the overall quality of the product, which is undesirable for the consumer. Therefore, research in advance is necessary to produce healthy and tasteful meat products.

Sensory and keeping quality of meat and meat products are highly influenced by physical and chemical properties of fat and fatty acids. Sensory quality can be adversely affected by lowering the fat content in meat. Meat containing higher ratio of saturated fat with long chain fatty acids tends to solidify readily upon cooling, thus, influencing flavour and overall palatability. On the other hand, unsaturated fat with double bonds gets readily oxidized, adversely affecting the flavour and stability of the product (Kempster *et al*., 1982).

Technological aspects of replacing meat fat

Technological factors have to be considered while replacing animal fat in meat. Figure 2, reflects the principal factors that have to be considered while replacing animal fat in the product (Colmenero, 2000).

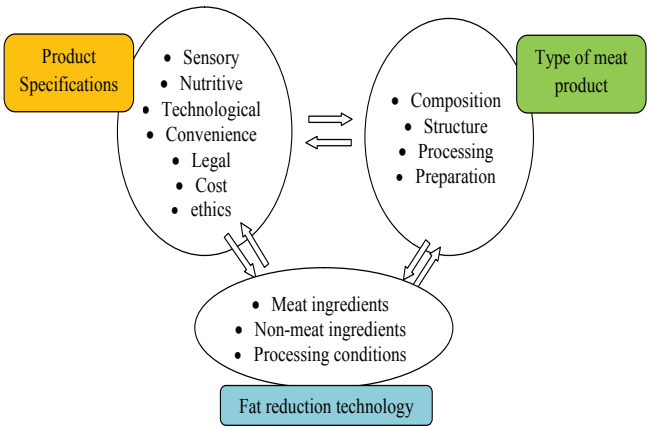

Figure 2. Factors affecting the development of low fat meat products

Byers *et al*., (1993) have raised the question about what should be the minimum amount of fat that is necessary for producing good quality meat product. Challenges for reducing or replacing fat vary according to the type of product and its fat content in it. Use of less saturated fats or oils may bring about changes in processing conditions, change in physic-chemical quality and stability like melting point, flavour, colour, texture etc.

The major problem in replacing and reducing animal fat is flavour, which decreases proportionally with the amount. Animal fat can be partially reduced or fully replaced by adding more water in the product or by substituting animal fat with vegetable fats and/or oils, or by adding ingredients like dextrins, starches, fibers, gums in the product (Ospina *et al*., 2010).

Marine fish oils extracted from salmon, herring, mackerel, and sardines can be used to increase n-3 PUFA in meat product. However, lipid oxidation develops fishy flavor in the end product. When fish oils are added in the form of protein-stabilized emulsion and mixed with the meat batter, fishy flavour is reduced especially after heating. In addition, fishy flavor can be counter acted by deodorizing or refining the oil, using chelators and antioxidants. Natural and synthetic antioxidants (e.g. BHT or BHA) can be used to prevent PUFAs from rapid oxidation.

Since plant and marine oils have chemical characteristics which are different from animal fats, the meat processing procedures have to be adjusted to produce the similar quality in reformulated product. These procedures include direct addition of oil, solid fat, encapsulated oil or pre-emulsified oil (Francisco, 2007).

Incorporation as liquid oil- Liquid oil can be either be added by micro-injection in the meat product with intact muscle tissue or added directly to products. Bloukas and his colleagues (1997) found that when olive oil was added directly in fermented sausage, an unacceptable flavour developed and the texture of the product was very soft.

Incorporation as pre-emulsified oils- Pre-emulsion technology is applied when fats are difficult to stabilize where a protein of non-meat origin is used as an emulsifier. The end product was physically and oxidative stable (Djordjevic *et al*., 2004). Examples of pre-emulsions include olive, linseed, deodorized fish or canola oils.

Incorporation as encapsulated oil- Use of microencapsulated oils was found to delay/inhibit oxidation, prevent undesirable odour and flavour. However, the level of incorporation as encapsulated oil are very low and the amount of n-3 PUFAs required to meet recommendation is too high (Garg *et al*., 2006). Its usage in meat products is very limited.

Incorporation as solid fat- Vegetable fats like palm is stable and can be blended into various level of plasticity through different proportion of stearin and olein. Various meat processing conditions are required. For example, if solid fats are added into meat dough during chopping, higher energy is needed to cut the fat and the heat can cause less stable meat emulsion. Fat can be melted before adding into the meat batter to prevent this problem (Tan *et al*., 2006). However, high melted fat brings waxy taste (Babji *et al*., 2001). Partial hydrogenation is one of the methods to produce solid fat with high melting-point.

Cost is another important factor that has to be taken into account. Occasionally, use of nonmeat ingredients may lead to rise in total cost of production, handling and storage (Mandigo and Eilert, 1994), but this drawback may be offset by the fact that growing numbers of consumers are interested in consuming healthy meat and perceive as better value for money (Colmenero, 2000).

Replacing and reducing saturated animal fats

Various studies has been carried out to replace animal (saturated) fat with vegetable oils in meat products like sausages and patties, but the balance between consumers' acceptability and quality have to be made because vegetable fats differ from animal fats regarding physic-chemical properties and stability (Paneras and Bloukas, 1994).

Rice bran oil is used for its antioxidant characteristics and ability to stabilize vitamin E (Kim *et al*., 2000). Palm oil is also commonly used because of its high smoking point and anti-oxidation function but its high content of saturated palmitic acid is one of the risk factor for cardiovascular disease (Francisco, 2007).

Marine oil is also used to enrich the meat products with n-3 PUFAs but they are susceptible to lipid oxidation and produce fishy aroma. This problem can be reduced by refining and deodorizing the oil as well as adding antioxidant (Garg *et al*., 2006).

Olive oil is one of the most commonly used vegetable oil in replacing the animal fat due to its high MUFA contents which is beneficial in the prevention of heart disease and cancer. Partial substitution of pork back-fat with olive oil has been tried in cooked, cured and fermented meat products to increase the content of MUFA (Francisco, 2007).

Water binding capacity of meat products with replaced fat is often poor. A few hydrocolloid systems are used to replace fat due to their high water binding capacity which promote the formation of gel, for example, alginate, carrageenan, xanthan gum, cellulose derivates, starches and pectins has been tried (Garcia and Totosaus, 2008). Combination of carageenan and locust bean gum was found to improve the texture and water retention which has minimal impact on the color of sausage. The sensory scores of this mixture were better than using the starch granules as fat replacers. Besides this, carageenan and locus bean are insoluble fiber which plays important roles in reducing the risks of colon cancer, cardiovascular diseases, obesity and other chronic diseases (Caceres *et al*., 2004; Pinero *et al*., 2008).

A research carried out to study the effect of vegetable oils (olive, corn, soybean, canola oil) and rice bran fiber on the composition and rheological properties of meat batters revealed that cohesiveness, gumminess, chewiness and viscosity of the batter prepared from vegetable oil and rice bran fiber were higher, than the batter prepared from pork fat. In addition, batter prepared from vegetable oil and rice bran fiber had lower cooking loss and better emulsion stability (Choi *et al*., 2009). Similar studies were carried out by Liu *et al*., (1991). They found that beef patties containing hydrogenated corn or palm oil were comparable in cooking loss and overall acceptability with the beef patties containing animal fat, thus, lowering the cholesterol content in meat products without adversely affecting the sensory quality of the product.

Turkish fermented sausages (Sucuk) prepared by partially replacing beef fat with hazelnut oil pre emulsified with whey protein powder resulted in softer texture and decreased slicing characteristics, but significantly decreased cholesterol content and increased MUFA and PUFA values (Turp and Serdaroglu, 2008).

Low fat frankfurter prepared by adding seaweed improved water and fat binding property, and it also increased hardness and chewiness quality with enriched n-3 PUFA, but less acceptable flavour due to the presence of seaweed (Lopez *et al.,* 2009).

Strategy for fat reduction in dry sausages is rather challenging job. Products with finely granulated small sized fats are more suitable for reducing animal fat compared to bigger sized coarsely granulated fat particles in dry sausages (Wirth, 1991).

Regarding product safety and stability, low fat sausages prepared by adding extra water may result in shorter shelf life unless sausages are cooked at higher temperature for longer time (Claus, 1991). Frankfurters prepared by replacing animal fat with olive oil had shorter shelf life compared to the controlled samples due to high amount of unsaturated fatty acids that are readily oxidized (Bloukas *et al*., 1997).

Conclusions

Meat is still regarded as valuable protein source food in the world. However, consumers' preference on healthy meat product is also increasing due to various chronic diseases like CVD, cancer and diabetics. Reducing or replacing saturated animal fat could be the solution for producing nutritious product but there are challenges for preparing a healthy product and maintaining its sensory quality for the consumers. There are so many types of technological advancement has been developed to reduce or replace the animal fat, for example, incorporating vegetable fats/oils, use of hydrocolloids like gums, starches, fibers etc. in the products.

Incorporation of vegetable fats/oils could be health beneficial, but, it may negatively affect the overall quality of the product. Therefore, research in advance is necessary to produce healthy and tasteful meat products. Meat content needs to be increased to compensate the reduction of fat in the meat products, and this will cause the increased redness, and firmness.

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