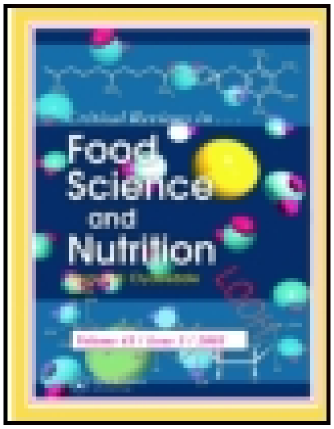

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Effect of dietary fiber on properties and acceptance of meat products: A review

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Effect of dietary fiber on properties and acceptance of meat products: A review

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ABSTARACT

Meat is an important source of all essential nutritional components of our daily diet as it content most of the essential amino acids, fatty acids, vitamins and minerals which are lack in plant based food, but it is devoid of dietary fiber, which is very essential component for normal physiological/biochemical process. During meat products processing its functional values can be improved by supplementation of dietary fiber rich vegetative substances like cereal and pulse flour, vegetable and fruits pulp etc. by this process a significant proportion of required daily allowance of dietary fiber can be fulfilled for the frequent meat consumers. The consumption of meat products fortified with of dietary fiber can lead to the prevention of diseases like coronary heart disease, diabetes, irritable bowel disease, obesity etc. On the other hand the dietary fiber can effectively incorporated in the processed meat products as binders, extender and filler, they can significantly replace the unhealthy fat components from the products; increase acceptability by improving nutritional components, pH, water holding capacity, emulsion stability, shear press value, sensory characters etc. of finished products. Addition of dietary fiber in the meat products can increase the cooking yield therefore the economic gain as well.

Key words: Dietary fiber, physico-chemical properties, sensory properties, health effect, acceptability.

INTRODUCTION

The primary importance of meat as food lies in the fact that it is a good source of high biological value protein along with essential fatty acids, vitamins, minerals etc. It also provides valuable amount of many essential micronutrients. Meat provides one or more target functions in the body beyond normal nutritional effects and helps in improvement of health or well being. In spite of all the positive effects meat has some draw backs as meat is deficient in very essential dietary fiber. Fiber addition in meat products is on the increase nowadays, due to its technological use and benefits to human health (Vendrell-Pascuas et al., 2000). Foods containing higher proportion of dietary fiber are known to reduce the risk of colon cancer, obesity, cardiovascular diseases and several other disorders (National Cancer Institute, 1984). Several dietetic fibers have been used in meat products not only to determine their possible beneficial effects on health but also as potential fat substitutes (Mansour and Khalil 1997).

Meat contains high amount of saturated fatty acids and cholesterol, which have often been linked to health problems (Fernandez-Gines *et al.*, 2005). Besides, processed meat products have high amount of added salt (Terrell and Brown, 1981) and fat (Wirth, 1991) which are additional risk factors for various diseases. Epidemiological research has demonstrated a relationship between energy rich diet and chronic diseases (Kaeferstein and Clugston, 1995) and thus an increase in the level of fiber diet has been recommended (Johnson and Southgate, 1994).

Whole grains contain fiber and a number of beneficial phytochemicals. It is the combined action of these components that effectively protects against disease. Various

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types of fibers have been used for formulation of restructured meat products and meat emulsions (Grigelmo-Miguel *et al.*, 1999). Fiber with high WHC such as pectin, gums and psyllium has been referred as soluble fiber.

Wheat, rye, rice and most other grains are primarily composed of insoluble fiber (Southgate *et al.*, 1978; Englyst *et al.*, 1982). Oat has a greater proportion of soluble fiber than any other grain. Legumes and beans are also good source of soluble and insoluble fiber (Horn, 1997). Effect of various fibers on quality food differs according to quantity and nature of dietary fiber (Thebaudin *et al.*, 1997).

Dietary fiber

The term dietary fiber was apparently coined by Hipsley (1953) to better describe the unavailable carbohydrates contents of plant foods, which were thought to be protective against pregnancy toxemia. Trowell (1972) defined dietary fiber as that part of whole grains, vegetables, fruits and nuts that resists digestion in gastro intestinal tract. It consists of carbohydrates viz. cellulose, hemicelluloses and pectin and non carbohydrate lignin which differ in chemical and morphological structure and in physiological effects. Spiller et al. (1978) used the word plantix for fiber. The word was derived from plant and matrix, because undigested plant compounds form a complex matrix in human gastro intestinal tract. Trowell et al. (1985) defined the term dietary fiber as "the sum of polysaccharides and lignin which are not digested by endogenous secretion of human gastrointestinal tract". The major source of dietary fiber is derived from cell wall materials in most diets. The food sources of dietary fiber are cereals, vegetables, fruits and nuts. In cereal flour, the degree of refinement determines the dietary fiber content. Maximum amount of hemicelluloses in diet is contributed by all bran and husks, cellulose by fruits and vegetables and lignin by leafy vegetables (Van Soest, 1976). Schweizer and Wursch (1979) analyzed nineteen cereal and fruit fibers for dietary fiber content. They reported that soluble fiber accounted for 4-21% of dietary fiber in cereal bran and 19-59% in legumes, vegetables and fruits. Theander and Aman (1979) reported that water soluble dietary fiber (SDF) accounted for 1-4% and water insoluble dietary fiber (IDF) for 8-38% of the dry matter of food stuffs, like wheat bran.

Benefits of fiber in food

Due to numerous functional characteristics including water holding capacity, lubrication, freeze/thaw stability and texture modification, fiber is a valuable extender, binder and fat replacement ingredient in manufacturing various meat products (Gelroth and Ranhotra, 2001). Fiber incorporation in meat products appeals to many health conscious consumers looking for low and reduced fat products. Red meat and pork products can benefit from lubrication, slipperiness and body and mouth feel due to presence of fiber as a fat replacer (Gelroth and Ranhotra, 2001).

Carrageenan is highly recommended for use in meat products due to its cold stability, freeze/ thaw stability and water binding properties (Mauro and Wang, 1997). Other fiber sources such as oat, soy, pea, psyllium, vegetable fiber and cellulose are also suitable for use in meat (Andres, 1986; Przybyla, 1988; Chan and Wypyszyk, 1988; Duxbury, 1993; Mauro and Wang, 1997). Cellulon^{TM}, a bacteria formed cellulose, serves as low cost extender of the expensive surimi protein as well as improves the texture and adds whiteness to the color of the surimi (Kent *et al.*, 1991). In production of meat analogue from plant protein, addition of psyllium mucilloid aids in modifying the texture to impart a meat like chewiness (Chan and Wypyszyk, 1988).

Wheat flour in chicken nuggets (Rao *et al.*, 1997), common bean flour in beef sausages (Dzudie *et al.*, 2002) and soy flour in buffalo meat burgers (Modi *et al.*, 2003) have been used as fillers, binders or extenders. There is great interest in increasing the consumption of oat based products which contain both SDF and IDF (Behall *et al.*, 1997; Steenblock *et al.*, 2001). Addition of oat bran or oat fiber to comminuted meat products has been demonstrated (Keeton, 1994; Serdaroglu and Tomek, 1995; Desmond *et al.*, 1998; Hughes *et al.*, 1998; Yilmaz and Daglioglu, 2003).

Role of dietary fiber in disease prevention

Epidemiological research has demonstrated a relationship between a diet containing an excess of fat and sugar and emergence of a range of chronic diseases, including colon cancer, obesity, cardiovascular diseases and other disorders (Best, 1991; Kaeferstein and Clugston, 1995; Beecher, 1999). Increase in food level of dietary fiber in the daily diet has been recommended to avoid these diseases (Eastwood, 1992; Johnsen and Southgate, 1994) as presence of fiber in foods diminishes their caloric content and is known to reduce the risk of such diseases (Desmedt and Jacobs, 2001; Anon, 2001).

Recent research provides evidence that viscous polysaccharides act in the gastrointestinal tract to reduce blood cholesterol by decreasing absorption of cholesterol or fatty acids and decreasing absorption of biliary cholesterol (Anderson *et al.*, 1984; Marlett *et al.*, 1994). Fiber may also alter serum concentration of hormones or short chain fatty acids that affect lipid metabolism. Beta–glucan, the water soluble fiber prevalent in oat and barley, has been shown in animal models to be active against agents causing altered cholesterol metabolism (Shinnick *et al.*, 1991). The soluble dietary fraction is considered to be chiefly involved in lowering effect on blood cholesterol and glucose intestinal absorption. It has been documented that the hypocholesterolemic effects of dietary fiber are due to increased secretion of bile acid and cholesterol (Bosaeus *et al.*, 1986).

Another type of dietary fiber called resistant starch may also reduce the risk of coronary heart diseases. Resistant starch is a type of starch that resists digestion in small intestine and passes unchanged into the large intestine. Resistant starch is fermented by gut bacteria in large intestine producing short chain fatty acids. These short chain fatty acids may help to reduce the blood cholesterol levels. Some foods rich in resistant starch are whole or partly milled grains and seeds, pulses and corn flakes (Sharma *et al*., 2008).

The beneficial effect of soluble fiber in diabetes may be mediated through slow absorption and digestion of carbohydrates that lead to a reduced demand of insulin (Slavin *et al.*, 1999). Insoluble fiber shortens intestinal transit, which therefore allows less time for carbohydrate to be absorbed (Anderson and Bryant, 1986).

Fiber fortification and quality of meat products

Meat contains several important nutrients. Various factors such as species, breed, sex, age, diet, management and processing influence the composition of meat. During processing of meat addition of non meat ingredients as binders, fillers and extenders changes the composition of meat drastically. Bran when added to meat products affect composition of meat products as its composition is entirely different from meat.

Ranhotra *et al*. (1994) reported that moisture, protein, fat, ash, total dietary fiber

(TDF), IDF, SDF and starch content of wheat bran were 7.8, 14.9, 2.7, 6.9, 49.2, 46.8, 2.4 and 18.5% respectively whereas, in oat bran these values have been reported to be 6.9, 18.6, 9.2, 2.4, 15.3, 7.9, 7.4 and 47.3%, respectively (Jaskari *et al.*, 1995).

During thermal processing bran undergoes changes in chemical composition and functional properties like water and oil holding capacity, density, hydration time, swelling etc. (Hwang *et al.*, 1995). They observed that, thermal treatment of wheat bran caused an increase in SDF and decrease in IDF content (2.7% in raw to 5.6% in microwaved-drum dried-extruded bran). An increase of 20-75% was observed in water holding capacity.

Chang and Carpenter (1997) utilized hydrated oat bran in frankfurters and observed that moisture content increased with water level and decreased with increasing oat bran level. Fat content decreased as level of added water and/or oat bran increased. Oat bran functioned as water absorbent, leading to more water retention in frankfurters. Protein content of frankfurter was different among treatments but there were no linear relationship with addition of water and oat bran. They further reported that addition of oat bran increased the carbohydrate level in patties.

Chevon patties containing oat bran at levels of 15, 20, 35 and 50% were formulated by Dawkins *et al.* (1999). Moisture, protein and fat content decreased and ash content increased with increase in fiber content of patties. Mean ash value ranged from 1.34-1.48%. TDF was 6.01, 6.26, 8.64 and 10.81%, respectively. An increase in both SDF and IDF in patties was observed. It was reported that patties prepared with 20% w/w oat bran would provide 1/3 of recommended daily intake (20-30g) of fiber.

Mansour and Khalil (1999) replaced fat in beef burger with hydrated wheat fiber

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(1:1) at 50, 100 and 150g/kg fat. Decrease in fat content and increase in moisture, protein, ash and carbohydrate content was reported in both uncooked and cooked samples. Addition of wheat fiber to beef burger resulted in retention of more moisture during cooking due to their ability to bind water. Dawkins *et al.* (2001) standardized goat and rabbit meat patties with oatrim and oat gum. Moisture content decreased with increased addition of oatrim and oat gum, a phenomenon generally experienced with addition of hydrocolloids to a system containing free water. Fat content showed a slight decrease with increased oatrim and oat gum when compared to the control. Yilmaz and Daglioglu (2003) replaced fat (25%) of meat balls with oat bran at 5, 10, 15 and 20% levels. With increasing amounts of oat bran the moisture and fat content decreased while protein and ash content increased. Chemical composition of meat balls with 5, 10, 15 and 20% of rye bran was assessed by Yilmaz (2004). Moisture and fat content decreased with addition of rye bran. Protein and ash content gradually increased with increasing of rye bran. Cereal bran based meat balls were incorporated with 5, 10, 15 and 20% oat, rye, wheat and corn bran (Yasarlar *et al*., 2007). Moisture and fat content gradually decreased with the rise in added wheat bran and oat bran. An increase in protein, ash and dietary fiber content was observed as the level of replacement with oat and wheat bran increased. Highest value of dietary fiber was observed in 20% corn bran samples followed by wheat, rye and oat bran. Meat balls with added wheat bran at 5, 10, 15 and 20% levels showed lower moisture and fat content with increasing amount of wheat bran. Protein and ash content of products gradually increased (Yilmaz, 2005).

Effect of dietary fiber on product pH

The pH of muscle is an important parameter which signifies the functional properties and keeping quality of meat on storage. The pH of muscle falls after slaughter due to production of lactic acid to reach an ultimate level of 5.5 to 5.7. This ultimate pH varies in different carcasses and muscles of the same species. Cooking also influences the pH of muscle. Bouton *et al.* (1971) observed an increase in pH during cooking. Above findings were confirmed by Fogg and Harrison (1975), Babu *et al.* (1994) and Nath *et al.* (1996) who reported an increase of 0.3 to 0.4 units in pH on cooking of chicken meat. Babu *et al.* (1994) attributed the increase in pH on cooking to increased salt concentration due to loss of moisture and the change in the net charge of proteins due to denaturation. Addition of fiber also causes change in pH of meat products. Meat balls produced with four different formulations of 5, 10, 15 and 20% oat bran showed difference in pH (Yilmaz and Daglioglu, 2003). The highest pH value was obtained in 10% oat bran added meat balls. Yilmaz (2005) observed that the pH of meat balls with 5, 10, 15 and 20% of wheat bran ranged from 5.91 to 6.11 and increased significantly with the increase in wheat bran. The highest pH value was obtained in meat balls containing 20% wheat bran. In another study, Yilmaz (2004) incorporated rye bran in low fat meat balls at 5 to 20% levels. In case of rye bran also, the pH values of meat balls increased. Grigelmo-Miguel *et al.* (1999) on the other hand observed that the peach fiber, which had acidic pH, when incorporated in frankfurters reduced their pH as the level of incorporation increased.

Fiber and Water holding capacity of products

Water holding capacity (WHC) is the ability of meat to hold fast to its own or added water during processing. Good WHC is essential as it provides desirable characteristics to

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meat products. Fiber is suitable for addition to meat products and has been used previously in cooked meat products to increase the WHC (Cofrades *et al.*, 2000). Chang and Carpenter (1997) incorporated wheat and oat bran with a view to reduce fat in frankfurters. With increased oat bran, more water was retained in frankfurters. Hughes *et al.* (1997) assessed the effect of oat fiber and carrageenan on frankfurters made with different levels of fat. Addition of these two ingredients had significant effect on WHC. The results showed that oat fiber at 2% level increased the WHC as compared to control. Many of the characteristics of oat fiber such as its absorption capacity could potentially benefit products, such as fat free frankfurters and low fat bologna (Fernandez-Gines *et al.*, 2005). It was observed that the frankfurter formulated with 29% dietary fiber suspension retained the water better due to good WHC of dietary fiber.

Inner pea fiber is identified as an ingredient capable of retaining high water in ground beef, and manufactured from the inner cell walls of yellow field peas. It contains approximately 48% fiber. This source was used in dry form to lower fat content in beef patties (Anderson and Berry, 2000). The results showed improved tenderness and cooking yield. Nuts contain dietary fiber (Halsted, 2003; Sadler, 2004). The use of walnut for preparation of restructured beef steak by Jimenez-Colmenero *et al.* (2003) showed that walnut affects cooking properties making the products softer and providing it with better water binding properties.

Fiber and emulsion stability (ES)

There are numerous emulsion based meat products which form the basis of ready to eat meat products. Stability of emulsion is important in development of these products.

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Dietary fiber components are known to affect the ES. Hughes *et al*. (1997) reported that carrageenan and oat fiber improved the ES of low fat frankfurters. Total expressible fluid declined from 9.6 to 7.6% and from 4.8 to 4.3% on addition of oat fiber at 2% level in frankfurters having 5% and 12% targeted fat respectively. Similar observations with regard to improved hydration capacity leading to better ES have earlier been reported (Marquez *et al*., 1989; Huffman *et al*., 1992).

In meat products development, wheat fiber binds water to give a very stable emulsion which remains so throughout the product processing and storage period. This property enables water to be added to emulsion for low fat meat products development (Kodet *et al*., 1999). Incorporation of alginate and/or carrageenan in reduced-fat meat batter, improved the ES possibly due to formation of more stable complex with denatured meat proteins during heating (Lin and Mei, 2000). However oat fiber has also been shown to increase cooking loss from low fat bologna (Claus and Hunt, 1991).

Fiber and product yield

Addition of bran to meat products is known to increase the yield of the products due to uptake of free water by SDF. Dawkins *et al*. (1999) reported that chevon meat patties prepared with 15, 20, 35, and 50% (w/w) of oat bran, showed significant decline in cooking loss. As low as 1% cooking loss was observed in patties with 50% oat bran supplementation. They attributed it to the absorbent nature of oat bran, as β-glucan, a component of oat bran which is hydrophilic and binds water.

Cooking yield significantly improved by fiber type and levels in beef burger (Mansour and Khalil, 1999). This improvement was attributed to increase in moisture binding by the added wheat fiber. High fat beef burger (control) had lowest cooking yield (72.7%) whereas burgers with wheat bran at 150g/kg fat replacement level had significantly higher (78.4%) yield. The high cooking loss in control was reported to be due to excessive fat separation and water released during cooking. Grigelmo-Miguel *et al.* (1999) reported that the weight loss during heating of low fat high peach dietary fiber frankfurters was similar to those of control having 20% fat, as the high WHC of peach dietary fiber retained the excess of water in frankfurter. Rye bran was used as a source of fiber in meat balls (Yilmaz, 2004). The cooking loss of meat balls made with 5 to 20% levels of rye bran was lower than control. The lowest weight loss (7.69%) was reported at a level of 20%. In another study, Yilmaz (2005) observed that weight loss in high fat meat balls was the highest, which declined significantly when wheat bran was added at 5 to 20% levels. The lowest weight loss was found in 20% wheat bran added sample. Significant decline in the weight loss of meat balls having 5, 10, 15 and 20% of cereal bran was observed by Yasarlar *et al.* (2007). The lowest weight loss (7.33%) was obtained in 20% wheat bran meat balls. The highest weight loss in control meat balls was reported due to high loss of fat and moisture during cooking.

Fiber and tenderness

Tenderness of meat products is an important sensory trait which determines the acceptance of the products by consumers. Warner-Bratzler shear press has been successfully used for measurement of tenderness of meat products. Addition of binders, fillers, extenders etc. substantially affect the shear press value of meat products.

Chang and Carpenter (1997) incorporated wheat and oat bran in reduced fat

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frankfurters. Results showed that the frankfurters with higher levels of oat bran required high shear press to break them. Shear press value decreased with addition of water.

Shear press value of beef burger containing wheat fiber was significantly higher in wheat bran added burger than that of control (Mansour and Khalil, 1999). It has been suggested that shear press value of bran beef burger might improve on increasing the extent of hydration to more than 2:1 (water: fiber). On the other hand, Dawkins *et al*. (1999) reported that shear press value decreased with increased fiber in chevon patties having 15 to 50% oat bran. They attributed the fall to decreased binding within meat matrix due to lower protein in bran patties as protein in general tend to exhibit good binding capacity. Dawkins *et al.* (2001) also observed that the shear press value tends to decrease with higher levels of oatrim and oat gum.

Fiber and organoleptic properties

Palatability of meat products depends upon the qualities like aroma and flavor, color, appearance, tenderness and juiciness. Studies on the acceptance of meat and meat products by consumers have shown that texture and tenderness have much importance among all the attributes of eating quality (Newbold and Harris, 1972). With the rapid development of fast foods, especially ready to eat meat products meant for short term storage under refrigeration temperature, flavor as sensory attribute has gained much importance because of oxidative rancidity of meat products.

Effect of added water and oat bran on hardness, juiciness and graininess of frankfurters were assessed by Chang and Carpenter (1997). Frankfurters with oat bran were perceived as having more hardness than those without oat bran. More grainy and less

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juicy texture was observed in frankfurter with higher oat bran. The visual density and the brightness value of cooked beef burger were not influenced by the addition of hydrated wheat fiber (Mansour and Khalil, 1999). The sensory panel showed no significant difference for tenderness, juiciness, beef flavor intensity and overall palatability at the different added fiber levels. Juiciness of oat gum and oatrim based meat patties was slightly higher than that of control patties (Dawkins *et al.*, 2001). Tenderness was slightly higher for oat gum than oatrim patties, regardless of meat used. Flavor scores were not affected by oat gum or oatrim addition. Yilmaz and Daglioglu (2003) observed that lightness of meat balls prepared with oat bran, as measured by Hunter-L value, increased with oat bran addition. The highest L value (lightness) was obtained for 20% oat bran meat balls among 5, 10, 15, and 20% levels. The redness of meat ball decreased from 10.08 in control to 8.04 in 20% oat bran meat balls. The yellowness and firmness gradually increased with addition of bran. Meat balls with 5, 10, 15, and 20% rye bran showed higher lightness values. Highest L value was obtained for 20% rye bran added meat balls. The firmness increased with rye bran addition. The control meat balls had the lowest firmness whereas meat balls with 20% added rye bran had the highest values (Yilmaz, 2004). Increase in lightness and decrease in redness of meat balls when incorporated with increasing levels of wheat bran, has also been reported by Yilmaz (2005). Yasarlar *et al.* (2007) reported that there was a significant decrease among sensory properties of meat balls prepared with wheat, rye, oat and corn bran. Redness of meat balls gradually decreased and lightness increased as the level of oat bran increased from 5 to 20%. The firmness increased and meat ball with 20% oat bran had highest firmness value.

Overall acceptability decreased as bran content increased.

Effect of fiber on fatty acid profile of the products

Fatty acid composition of animal fat varies with fatty acid composition of their ration (Ajuyah *et al.*, 1992). Total unsaturation in fatty acids was 70% and saturation 29.8%. Janicki and Appledorf (1974) noted significant changes in C16, C18 and C18:2 fatty acids in beef patties during cooking. C16 underwent the maximum loss during cooking. C18:1 and C18:2 fatty acids per cent increased following cooking treatment. They suggested that C18:1 and C18:2 fatty acids were probably more intimately involved with structural components and phospholipids and less likely to be lost in drip. Ratio of unsaturated to saturated fatty acids increased during cooking.

Addition of fillers, binders etc. changes the fatty acid composition of meat products depending upon their fatty acid composition. Dawkins *et al*. (1999) added oat bran to chevon meat patties in levels from 15-50%. Major fatty acids reported were oleic, palmitic, stearic and linoleic acid and their values at different levels ranged from 22.5 to 34.1, 20.0 to 24.1, 12.3 to 44.2 and 9.2 to19.3%, respectively. Other fatty acids in the concentration of around 2% were myristic, palmitoleic and elaidic acid (trans fatty acid) whereas capric, lauric and linoleic acid (ω-3) were less than 1%. Chevon meat patties formulated with oat bran produced a higher percentage of USFA and lower percentage of SFA. Higher levels of oleic and linoleic acids have been reported to have hypocholesterolemic properties (Mahan and Escott-Stump, 1996).

Yilmaz and Daglioglu (2003) indicated that major fatty acids of oat bran oil were linoleic acid (34.8%) and oleic acid (44.3%). Oat bran added meat balls showed higher

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content of oleic and linoleic acid. Total USFA increased and SFA decreased significantly as the level of oat bran in meat balls increased. Yilmaz (2004) observed that the ratio of total USFA to SFA varied between 1.01 and 1.07 in the rye bran added (5-20% levels) samples. There was significant increase in total polyunsaturated fatty acids in rye bran added meat balls. Low fat meat balls prepared with 5, 10, 15 and 20% wheat bran (Yilmaz, 2005) had USFA to total SFA ratio of 1.02, 1.02, 1.06 and 1.06 respectively while it was 0.99 in the control meat balls (10% fat). There was a significant increase in polyunsaturated fatty acids on addition of wheat bran.

Cholesterol controlling effect of fiber

Presence of cholesterol in animal fat is an important consideration in the development of cardiovascular diseases. Recent research is oriented towards reduction in cholesterol content of meat by producing low fat meat products and supplementation with plant fractions in the form of cereal flour and bran. Cholesterol content of chevon patties standardized with 15-50% of oat bran was assessed by Dawkins *et al*. (1999). It was observed that the cholesterol content of patties with oat bran was lower than the control patties. The cholesterol content gradually decreased with the increase of oat bran. Cholesterol content of uncooked and cooked beef burger having wheat bran, decreased asthe level of fiber increased and fat level decreased. Decrease in the cholesterol content was proportional to the increase in the level of wheat fiber (Talukder and Sharma, 2010).

Conclusion

The functionally significant dietary fiber can easily improve the health beneficiary characters and the consumer acceptance of meat products added with it. The cholesterol reducing property of dietary fiber is being utilized by the meat processors to attract the health conscious consumers worldwide. Various sensory attributes of processed meat products such as texture, juiciness, color are variably influenced by the dietary fiber addition. The overall acceptance of the dietary fiber added meat products has increased positively in resent time. The ways of increasing economic gain by incorporating dietary fiber in the processed meat products is to excavate yet. Further research related dietary fiber might show some newer overall aspect of its beneficiary effect.

Reference

Ajuyah, A.O., Hardin, R.T., Cheung, K. and Sim, J.S. (1992). Yield, lipid, cholesterol and fatty acid composition of spent hens fed full fat oil seed and fish meal diets. *J. Food. Sci***.** **57**(2): 338-341.

Anderson, E.T. and Berry, B.W. (2000). Sensory, shear and cooking properties of low fat beef patties made with inner pea fiber. *J. Food Sci.* **65**: 805-810.

Anderson, J.W. and Bryant, C.A. (1986). Dietary fibre: diabetes and obesity. *Am. J. Gastroenterol*. **81:** 898-906.

Anderson, J.W., Story, L., Sieiing, B., Chen, W.J., Petro, M.S. and Story, J. (1984). Hypocholesterolemic effects of oat bran or bean intake for hypocholesterolemic men. *Am. J. Clin. Nutr*. **40**: 1146-1155.

Anderson J.W. Health benefits of dietary fiber (2009).*Nutrition Reviews* 67(4):188–20.

Andres, C. (1986). Multifunctional fiber provides nutrition, texture and increased functionality. *Food Processing* **47**(13): 39-40.

Anon, (2001). Dietary fibre. *Food Sci*. *Technol*. **15**: 34-37.

Babu, N.P., Kowale, B.N., Rao, V.K. and Bisht, G.S. (1994). Effect of cooking and storage on lipid oxidation and development of cholesterol oxides in chicken meat. *Indian J. Poult. Sci*. **29**: 254-257.

Beecher, G.R. (1999). Phytonutrients role in metabolism: effects on resistance to degradative process. *Nutr*. *Review* **57**: 3-6.

Behall, K.M., Scholfield, D.J. and Hallfrisch, J.(1997). Effect of beta glucan level in oat fiber extracts on blood in men and women. *J. Am. Coll. Nutr.* **16**: 46-51.

Best, D. (1991). Whatever happened to fiber. *Prepared Foods* **160:** 54-56.

Bosaeus, I., Carlsson, N.G., Sandberg, A.S. and Andersson, H. (1986). Effect of wheat bran and pectin on bile acid and cholesterol excretion in ileostomy patients. *Human Nutr. Clin. Nutr.* **40**: 429-440.

Bouton, P.E., Harris, P.V. and Shorthorn, W.R. (1971). Effect of ultimate pH upon the water holding capacity and tenderness of mutton. *J. Food Sci.* **36**(3): 435-439.

Chan, J.K. and Wypyszyk, V. (1988). A forgotten natural dietary fiber: psyllium mucilloid. *Cereal Foods World* **33**: 919-922.

Chang, H.C. and Carpenter, J.A. (1997). Optimizing quality of frankfurters containing oat bran and added water. *J. Food Sci.* **62**(1): 194-197, 202.

Claus, J.R. and Hunt, M.C. (1991). Low-fat, high added water bologna formulated with texture-modifying ingredients. *J. Food Sci.* **56**(3): 643-647, 652.

Cofrades, S., Guerra, M.A., Carballo, J., Fernandez-Martin, F. and Jimenez-Colmenero, F. (2000). Plasma protein and soy fiber content effect on bologna sausage properties as influenced by fat level. *J. Food Sci.* **65:** 281-287.

Dawkins, N.L., Gager, J., Cornillon, J.P., Kim, Y., Howard, H. and Phelps, O. (2001). Comparative studies on the physicochemical properties and hydration behavior of oat gum and oatrim in meat-based patties. *J. Food Sci.* **66**(9): 1276-1282.

ACCEPTED MANUSCRIPT

Dawkins, N.L., Phelps, O., Mcmillan, K.W. and Forrester, I.T. (1999). Composition and physicochemical properties of chevon meat patties containing oat bran. *J. Food Sci*. **64**(4): 597-600.

Desmedt, A. and Jacobs, H. (2001). Soluble fibre, In “Guide to functional foods”, Young, J. (Ed.), Leatherhead Publishing, Leatherhead, UK, pp. 112-132.

Desmond, E.M., Trou, D.J., and Buckley, D.J. (1998). The effect of tapioca starch, oat fibre and whey protein on the physical and sensory properties of low fat beef burgers. *Lebensmittel Wiss. u-Technol*. **31:** 653-657.

Duxbury, D.D. (1993). Fiber: Form follows function. *Food Processing* **54**(3): 44-54.

Dzudie, T., Scher, J. and Hardy, J. (2002). Common bean flour as an extender in beef sausages. *J. Food Eng*. **52**: 143-147.

Eastwood, M.A. (1992). The physiological effect of dietary fiber: an update. *Ann. Rev. Nutr*. **12**: 19-35.

Englyst, H., Wiggins, H.S. and Cummings, J.H. (1982). Determination of the non starch polysaccharides in plant foods by gas-liquid chromatography of constituent sugars as alditol acetate. *Analyst* **107**: 307-318.

Fernandez-Gines, J.M., Fernandez-Lopez, J., Sayas-Barbera, E. and Perez-Alvarez, J.A. (2005). Meat products as functional food: A review. *J. Food Sci*. **70**: R37-R43.

 ACCEPTED MANUSCRIPT

Fogg, N.E. and Harrison, D.L. (1975). Relationship of electrophoretic pattern and selected characteristics of bovine skeletal muscle and internal temperature. *J. Food Sci*. **40**(1)**:** 28-34.

Gelroth, J. and Ranhotra, G.S. (2001). Food uses of fibre. In "Hand Book of Dietary Fibres". Sussan-Sungsoo, C. and Dreher, M.L. (Eds.), Marcel Dekker-Inc., New York, pp. 435-451.

Grigelmo-Miguel, N., Abadias-Seros, M.I. and Martin-Belloso, O. (1999). Characterisation of low- fat high dietary fiber frankfurters. *Meat Sci*. **52:** 247-256.

Halsted, C.H. (2003). Dietary supplements and functional foods: 2 sides of a coin? *Am. J. Clin. Nutr*. **77**: 1001-1007.

Hipsley, E.H. (1953). Dietary fiber and pregnancy toxemia. *Br. Med. J.* **2:** 420-422.

Horn, L.V. (1997). Fiber, Lipids, and coronary heart disease: A statement for healthcare professionals from the Nutrition Committee, American Heart Association. *Circulation* **95**: 2701-2704.

Huffman, D.L., Mikel, W.B., Egbert, W.R., Chen, C. and Smith, K.L. (1992). Development of lean pork sausage products. *Cereal Foods World* **37**: 439-442.

Hughes, E., Cofrades, S. and Troy, D.J. (1997). Effect of fat level, oat fiber and carrageenan on frankfurters formulated with 5, 12 and 30% fat. *Meat Sci*. **45**(3): 273-281.

Hughes, E., Mullen, A.M. and Troy, D.J. (1998). Effect of fat level, tapioca starch and whey protein on frankfurters formed with 5% and 12% fat. *Meat Sci*. **48:** 169-180.

Hwang, J.K., Kim, C.T., Cho, S.J., and Kim, C.J. (1995). Effect of various thermal treatments on physicochemical properties of wheat bran. *Kor. J. Food Sci. Technol*. **27** (3): 394-403.

Janicki, L.J. and Appledorf, H. (1974). Effect of broiling, grill frying and microwave cooking on moisture, some lipid components and total fatty acids of ground beef. *J. Food Sci*. **39**(4): 715-717.

Jaskari, J., Henriksson, K., Nieminen, A., Suortti, T., Salovaara, H. and Poutanen, K. (1995). Effect of hydrothermal and enzymatic treatments on the viscous behavior of dry and wet-milled oat bran. *Cereal Chem.* **72** (6): 625-631.

Jimenez-Colmenero, F., Serrano, A., Ayo, J., Solas, M.T., Cofrades, S. and Carballo, J. (2003). Physicochemical and sensory characteristics of restructured beef steak with added walnuts. *Meat Sci*. **65:** 1391-1397.

Johnson, I.T. and Southgate, D.A.T. (1994). Dietary fiber and related substances. In “Food safety science”. Edelman, J. and Miller, S. (Eds.), Champman and Hill. London, pp. 39-65.

Kaeferstein, F.K. and Clugston, G.A. (1995). Human health problems related to meat production and consumption. *Fleischwirtschaft Technol*. **75**: 889-892.

Keeton, J.T. (1994). Low-Fat meat products, technological problems with processing. *Meat Sci*. **36**: 261-276.

ACCEPTED MANUSCRIPT

Kent, R.A., Stephens, R.S. and Westland J.A. (1991). Bacterial cellulose fiber provides an alternative for thickening and coating. *Food Technol*. **45**(6): 108-111.

Kodet, J., Jelinek, P. and Nejezchleb, J. (1999). Testing a new type of plant fiber. *Meso*. **1:** 76-78.

Lin, K.W. and Mei, M.Y. (2000). Influences of gums, soy protein isolate and heating temperatures on reduced-fat meat batters in a model system. *J. Food Sci*. **65**(1): 48-52.

Mahan, L.K. and Escott-Stump, S. (1996). Delivery type: physical. In "Krause's Food, Nutrition and Diet Therapy". Mahan, L.K. and Escott-Stump, S. (Eds.), W.B. Saunders Co., Philadelphia, PA. pp. 49-61

Mansour, E. H. and Khalil, A. H. (1997). Characteristics of low fat beefburgers as influenced by various types of wheat fibers. Food Research International, **30**(3), 199–205.

Mansour, E.H. and Khalil, A.H. (1999). Characteristics of low fat beef burgers as influenced by various types of wheat fibers. *J. Sci. Food Agri*. **79:** 493-498.

Marlett, J.A., Hosing, K.B., Vellendorf, N.W., Shinnick, F.L., Hack, V.S. and Story, J.A. (1994). Mechanism of serum cholesterol reduction by oat bran. *Hepatol*. **20:** 1450-1457.

Marquez, E.J., Ahmed, E.M., West, R.L. and Johnson, D.D. (1989). Emulsion stability and sensory quality of beef frankfurters produced at different fat or peanut oil levels. *J. Food Sci*. **54**(4): 867-870, 873.

Mauro, D.J. and Wang, Y.J. (1997). Breakfast food ingredients. *Cereal Foods World* **42**: 440-443.

Modi, V.K., Mahendrakar, N.S., Rao. D.N. and Sachindra, N.M. (2003). Quality of buffalo meat burger containing legume flour as binders. *Meat Sci*. **66:** 143-149.

Nath, R.L., Mahapatra, C.M., Kondaiah, N. and Singh, J.N. (1996). Quality of chicken patties as influenced by microwave and conventional oven cooking. *J. Food Sci. Technol*. **33**: 162-164.

National Cancer Institute (1984). US Department of Health and Human Services, NIG Pub. 85-2711.

Newbold, R.P. and Harris, P.V. (1972). Effect of prerigor changes in meat tenderness- A review. *J. Food Sci*. **37**(1): 337-340.

Przybyla, A.E. (1988). Formulating fiber into foods. *Food Engineering* **60**(10): 77-88.

Ranhotra, G.S., Gelroth, J.A., Glaser, B.K. and Reddy, P.V. (1994). Nutritional profile of a fraction from air-classified bran obtained from a hard red wheat. *Cereal Chem*. **71**(4): 321-324.

Rao, K.H., Singh, R.R.B., Anjaneyulu, A.S.R., Rao, K.V.S.S. and Yadav, P.L. (1997). Effect of caseinases and refined wheat flour on quality of chicken nuggets form spent hens. *Indian J. Anim. Sci.* **67:** 1004-1006.

Sadler, M.J. (2004). Meat alternatives-market developments and health benefits. *Trends Food Sci. Technol*. **15:** 250-260.

Schneeman, B. (1986). Physical and chemical properties, methods of analysis, and physiological effects. *Food Technol*. **40**(2): 104-110.

Schweizer, T.F. and Wursch, P. (1979). Analysis of dietary fibre. *J. Sci. Food Agri*. **30**: 613-619.

Serdaroglu, M. and Tomek, S. (1995). Yagi azaltilmits et urunleri uretim teknigi (low fat meat products technology). *Gida*. **20**: 237-241.

Sharma, A., Yadav, B.S. and Ritika (2008). Resistant starch: physical role and food application. *Food Reviews International*. **24**: 193-234.

Shinnick, F., Mathews, R. and Ink, S. (1991). Serum cholesterol reduction by oat and other fiber sources. *Cereal Foods World* **36:** 815-821.

Slavin, J.L., Martini, M.C., Jacobs, D.R. and Marquart, L. (1999). Plausible mechanisms for protectiveness of whole grains. *Am. J. Clin. Nutr*. **70(**supp. 1): 459s-463s.

Southgate, D.A., Hudson, G.J. and Englyst, H. (1978). The analysis of dietary fibre: the choice for the analyst. *J. Sci. Food Agri*. **29:** 979-998.

Spiller, G.A, Blake, J.A. and Shipley, E.A. (1978). Recent progress in dietary fiber (plantix) in human nutrition. *Rev. Food Sci. Nutr*. **10:** 31-34.

Steenblock, R.L., Sebranek, J.G., Olson, D.G. and Love, J.A. (2001). The effects of oat fibre on the properties of light bologna and fat-free frankfurters. *J. Food Sci*. **66**: 1409-1415.

ACCEPTED MANUSCRIPT

Talukder, S. and Sharma, D.P.(2010). Development of dietary fiber rich chicken meat patties using wheat and oat bran. *J. Food. Sci. Technol*. **47**(2):224-229.

Terrell, R.N. and Brown, J.A. (1981). Salt, water and oil seed proteins affect brine content of sausages. *J. Food Prot*. **44**(1): 43-46.

Theander, O. and Aman, P. (1979). Studies on dietary fiber, Analysis and chemical characteristics of water soluble and water insoluble dietary fiber. *Swedish J. Agric. Res*. **9**: 97-106.

Thebaudin, J.Y., Lefevre, A.C., Harrington, M. and Bourgeois, C.M. (1997). Dietary fibers: nutritional and technological interest. *Trends Food Sci. Technol*. **8**: 41-48.

Trowell, H., Burkitt, D. and Heaton, K. (1985). Definition of dietary fiber, In "Fiber depleted food and diseases". Trowell, H., Burkitt, D. and Heaton, K. (Eds.), Academic Press, New York. pp.27.

Trowell, H.C. (1972). Ischemic heart disease and dietary fibre. *Am. J. Clin. Nutr*. **25**: 926-932.

Van Soest, P.J. (1976). Fiber composition of some food stuffs. *Am. J. Clin. Nutr*. **31**: 5282-5284.

Vendrell-Pascuas, S., Castellote-Bargallo, A. I. and Lopez-Sabater, M.C. (2000). Determination of insulin in meat products by highperformance liquid chromatography with refractive index detection. Journal of Chromatography A, 881, 591–597.

Wirth, F. (1991). Reducing the fat and sodium content of meat products. What possibilities are there? *Fleischwirtschaft*. **71**(3): 294-297.

Yasarlar, E.E., Daglioglu, O. and Yilmaz, I. (2007). Effect of cereal bran addition on chemical composition, cooking characteristics and sensory properties of Turkish meat balls. *Asian J. Chem.* **19**(3): 2353-2361.

Yilmaz, I. (2004). Effects of rye bran addition on fatty acid composition and quality characteristics of low fat meat balls. *Meat Sci.* **67**: 245-249.

Yilmaz, I. (2005). Physicochemical and sensory characteristics of low fat meat balls with added wheat bran. *J. Food Eng*. **69:** 369-373.

Yilmaz, I. and Daglioglu, O. (2003). The Effect of replacing fat with oat bran on fatty acid composition and physicochemical properties of meatballs. *Meat Sci.* **65**: 819-823.

Table 1**. Dietary fiber intake related to relative risk for disease based on estimates from prospective cohort studies**

Disease	No. of subjects (no. of studies)	Relative risk	95% CI
Coronary heart disease	158,327 (7)	0.71	0.47–0.95
Stroke	134,787 (4)	0.74	0.63–0.86
Diabetes	239,485 (5)	0.81	0.70–0.93
Obesity	115,789 (4)	0.70	0.62–0.78

(Source: Health benefits of dietary fiber, Anderson, 2009)