International Journal of Livestock Production Vol. 2(4), pp. 45-54, April 2011
Available online at http://www.academicjournals.org/IJLP
ISSN 2141-2448 ©2011 Academic Journals

Review

Dietary fibers as functional ingredients in meat products and their role in human health

A. K. Biswas*, V. Kumar, S. Bhosle, J. Sahoo and M. K. Chatli

Department of Livestock Products Technology, College of Veterinary Science, Guru Angad Dev Veterinary and Animal Sciences University, PAU Campus, Ludhiana- 141 004 (Punjab), India.

Accepted 30 December, 2010.

The article evaluates the effect of dietary fibers as functional ingredient in meat products and their physiological role in human health. Fibers are naturally occurring compounds present in variety of vegetables, fruits, cereal flours etc in abundance, and act through their solubility, viscosity, gel forming ability, water-binding capacity, oil adsorption capacity, fermentability, and mineral and organic molecule binding capacity which affect product quality and characteristics. Beside these, high-fiber intake tends to reduce risk of colon cancer, obesity, cardiovascular diseases, and several other disorders. Moreover, based on their physiochemical properties, many fibers can help to improve colour, texture and sensorial characteristics instead of nutritional benefits. Fiber inclusions could help in diminution of calorie content in foods.

Key words: Dietary fiber, functional food, colour, texture, health

INTRODUCTION

The meat we eat is an integral component in our diet. In the food pyramid, they are considered as protein food along with other food category like poultry, fish and eggs. Undoubtedly, meat is a major source of food proteins with high biological value in many countries. Meat is also an excellent source of some essential fats, soluble vitamins and minerals, and all these components have specific function to our body. But recently, negative campaign about muscle foods, and their possible health hazard effects, shows that consumers are increasingly interested about health oriented functional meat products. According to them, food they consume should not only taste better but also be attractive, safe and healthy, since time constraints prevent them from spending enough time for exercise to keep them fit. Consumers are getting educated with nutritional information and are beginning to understand. This powerful influence of diet on health and well being, increasing scientific evidence confirms that specific components in diet may tend off certain chronic diseases such as cardiovascular diseases, various cancers and neurological disorders (Ames et al., 1993). It has revitalized the interests not only in consumer, but also among researchers and meat food product processors to develop formulated products, which are “natural, functional and nutritional” as well.

Functional meat products either possess nutritional ingredients that improve health or contain lesser quantity of harmful compounds like cholesterol, fat etc (Yue, 2001; Diplock et al., 1999). These products are generally produced by reformulation of meat by incorporating health producing ingredients like variety of fibers, protein, polyunsaturated fatty acids (PUFA), antioxidants etc. Meat products that contain dietary fibers are excellent meat substitutes due to their inherent functional and nutritional effects (Hur et al., 2009; Kumar et al., 2010).

*Corresponding author. E-mail: biswaslpt@gmail.com. Tel: +91-161-2414025(O), +91-9463320622(Mb). Fax: +91-161-2400822

Further, dietary fiber intake through meat substituted with fruits, vegetables and certain grains is associated with reductions in plasma and LDL-cholesterol, reduce the risk of major dietary problems such as obesity, coronary diseases, diabetes, gastrointestinal disorders, including constipation, inflammatory bowel diseases etc (Schneeman, 1999). Besides health benefit effects, dietary fiber supplementations increase the bulk and prevent cooking loss in meat products with no or fewer changes in textural parameters by enhancing water binding capabilities and carries great economical advantages for both the consumers and processors (Grigelmo- Miguel et al., 1999).

FUNCTIONAL PROPERTIES OF DIETARY FIBERS

Fiber is suitable for meat products preparation because of its water retention property, decreases cooking loss and neutral flavor. Dietary fibers isolated from various plants have diverse functional properties namely solubility, viscosity, gel forming ability, water-binding capacity, oil adsorption capacity, and mineral and organic molecule binding capacity, which affect product quality and characteristics (Tungland and Meyer, 2002). Dehydrated fruit, vegetable and cereal fiber can be used in the food industry as functional ingredient with excellent results (Viuda-Martos et al., 2010). However, fruit and vegetable fibre has better water and oil binding capacity, colonic fermentability, as well as lower phytic acid content and energy. Highly soluble fibers and those that have low viscosity such as gum arabic, inulins and oligosaccharides and they are generally used to modify texture, manage water migration, and improve the marketability of the meat products. However, gelation generally occurred through interaction with water molecules and depends on the type of fibers, its concentration, temperature, and presence of ions, pH, and other rheology modifier. Oil binding is in part related to its chemical composition, but is more largely a function of the porosity of the fiber structure rather than the affinity of the fiber molecule for oil. By hydrating a fiber with water, the water occupies the fiber pores, significantly reducing oil-binding. Some dietary fibers of fruit, vegetable and cereal have cation exchange capacity (CEC) through unmethylated galacturonic acid residues and phytic acid and bind cations such as calcium, cadmium, zinc, and copper (Thibault et al., 1992), while other absorb organic molecules (lignin binds bile acids, and wheat bran binds benzopyrazine). However their effect is pH dependent. The main technological functions in food of isolated fiber components, such as pectin and guar gum, are as gelling and thickening agents. The functional properties of some important dietary fibres are shown in Table 1.

Polysaccharides are the principal structural elements of plant cell walls. The cell wall polymers consist of cellulose, interconnecting structure between hemicelluloses and pectin within a matrix of globular and non-globular protein. In view of structural and functional properties, pectin is probably one of the most interesting cell wall polymers because of its abundance, solubility, response to chemical reaction (van Buren, 1979) and numerous industrial applications. The ubiquitous presence of pectin in fruits and vegetables emphasizes its critical importance in determining the texture of plant derived processed products. Structurally, pectin represents a group of heterogeneous polysaccharides of substantial diversity depending on its botanical origin (Huisman et al., 2001). It is mainly characterized by α-(1, 4) linked D-galacturonic acid units esterified with methanol in different compounds (O'Neill, 1990). The major antioxidants in the sweet potato are phenolic acids, anthocyanins, and carotenoids. These bioactive compounds act as free radical scavengers and also contribute to the distinctive colors of sweet potatoes.

A distinctive characteristic of the soy polysaccharide, improves textural property through water binding capacity (WBC). All soy preparations exhibited good WBC, but differences exist. These differences of WBC reflect variations in soybean quality, processing conditions and types of processing. The increasing soybean hull content in meat leads to a sharp drop in specific expansion index (SEI) values of fibers thereby hold less water content, whereas at higher water levels this effect is reduced (Lai et al., 2003). The increased in volume just followed the tendency of SEI. Thus the texture of the final product (Fan et al., 1996) is directly related to bulk density (BD), since light density means soft structure which is desirable in such product types (Koksel et al., 2004). Shrinkage ratio sharply increases when the water content of the mixture increases particularly at low hull content. As soy hull increased, its fiber competes for water increasing the viscosity, which causes less shrinkage when added in meat products.

Water absorption property, swelling power and solubility of banana fibers are temperature dependent; it also depends on the degree of intermolecular bonding while starch depolymerisation is caused by the thermal treatment (Alexander, 1995). Increasing of temperature exhibits a higher swelling pattern than those shown by at low temperature (Kayisu et al., 1981). This was due to high thermal treatment that produces a total disruption of the granular structure of the starches (Colonna et al., 1984; Perez, 1997). The banana fibers start gel formation at initial pasting temperature of 63°C. This rheological property provides a rapid viscosity building effect comparatively at that temperature. This property is

Table 1. The functional properties of some important dietary fibres.

Fibre type	Functions in meat products
Alginate oligosaccharides stabilizer)	Functional foods (humectants, thickener and stabilizer)
Konjac (flour) mannan carrageenan and gum for gelling	Binder in meat, often used with k-
Xanthan gum	Thickener, texture modifying agent etc
Guar gum oligosaccharides	Functional foods
Inulin-type (onion, chicory root etc) modification	Fat/sugar replacement, texture modification
Pectin (apples, citrus, sunflowers, sugar beet)	Gelling agent, texture modifying agent etc
Carrageenan (from red algae)	Fat replacer, improves water holding capacity
Microcrystalline cellulose extracted from(wood pulp, bamboo, wheat, cottonseed hulls)	Improves water holding capacity,
Modified cellulose (MC, CMC, MHPC) by chemical reaction of cellulose	Thickener, stabilizer, humectants
Chitosan (shrimp, crabs etc)	Improves viscosity, gelation
β-glucan (oat, barley, wheat flour etc)	Binder, extender etc.
Psyllium seed husk	Functional food development as a fiber source

important for industrial applications in instant or quick cooking products.

EFFECT OF DIETARY FIBERS IN CONVENIENCE MEAT PRODUCTS

Inherent functional property and health beneficial effects of fibers make them a useful ingredient in the development of various meat products. But increasing fiber consumption in the diet is always a difficult challenge. That is why fiber usually used in food products, should not only supply fiber, but also provide enhanced functional properties to make high-fiber foods like taste better, thus and encouraging continued high fiber intake. Dietary fibers from oat, sugar beet, soy, pea, apple, and wheat have been included in the formulations of several meat products such as patties, sausages and bologna (Backers and Noll, 2001; Mansour and Khalil, 1997). In many instances, these dietary fibers not only have beneficial physiological effects, they also generate important technological properties that offset the effect of fat reduction.

Physicochemical properties

Fiber retains water, decreases cooking losses and has neutral flavor. It has been reported that oat bran and oat fiber provide the flavor, texture and mouth feel of fat in ground beef and pork sausages (Chang and Carpenter, 1997; Desmond and Troy, 2003). The use of water and dietary fibers from pea and wheat for meat replacement in beef burger patties improved water binding capacity thereby increased cooking yield, decreased the shrinkage and minimized the production cost without degradation of sensory properties (Besbes et al., 2008). The inclusion of pea fiber at 3% level resulted in a significant decrease in cook loss values, but inner pea fiber had potential to be a useful ingredient in the development of meat products as they retained maximum amount of fat during high temperature heating. Turhan et al. (2005) reported that addition of hazelnut pellicle fiber was found to be effective in improving cooking yield, dimensional changes and thickness of beef burgers. In addition cellulose was added to processed meats to improve texture (Todd et al., 1989). In the beef burger model, incorporation of cauliflower fiber improved the yield, for stem and floret samples by about 10%. The upper stem gave a higher yield and firmer texture compared to florets, which confirmed the functional properties measured for each preparation. Firmness of products also improved when stem and floret sample were incorporated, but the effect was variable.

Reducing the fat content of sausages decreased the quality of the products, particularly in terms of cook loss. Hughes et al. (1997) added oat fiber at 1 to 2% levels to low fat frankfurters and demonstrated that oat fiber can partially offset some of the changes that occur in these products and improve some of the quality parameters. But when Grigelmo-Miguel et al. (1999) used peach fiber in the development of low fat pork sausages non-acceptable products were obtained with the levels in excess of 5%. Sausages formulated with inulin (oat fibers) were comparable to control sausages (McDonagh et al., 2005). These authors again reported normal fat beef burgers had lower water-holding capacity and therefore experienced higher cook losses. However, reducing the fat content decreased the textural quality of the products. Choi et al. (2007) reported that meat batters containing dietary fiber form from rice bran have higher pH values, but lower cooking loss and emulsion stability than counterpart control. Similar effects also were reported on low fat meat balls, when Serdaroglu et al. (2005) used blackeye bean flour (BBF), chickpea flour (CF), lentil flour (LF) and rusk (R). BBF and LF resulted in the highest cooking yields. The lowest cooking yield was obtained with meat balls incorporating R.

Cooked lemon albedo fibers (2.5 to 5%) in bolognas showed higher moisture content than control (Fernandez-Gines et al., 2004). The presence of albedo decreased the fat. These decreased was found higher in bolognas with raw albedo than cooked albedo. Protein, fiber and ash contents were increased depending on albedo concentration, but no differences were found between bolognas with raw and cooked albedo. They again reported that pH values of bolognas did not show differences between types or albedo concentrations as added in the formulations. However, contradictory results also reported that carboxymethy cellulose incorporated into breakfast sausages exhibited highest cooking loss than high fat control (Morin et al., 2004). Vural et al. (2004) found that the use of sugar beet in frankfurter increased the dietary fiber content and water holding capacity without any significant changes in sensory scores.

Fat reduction and incorporation of dietary fibers from apple, peach and orange or cereal flours like wheat and oat used in preparation of fermented pork sausages did not affect pH and water activity of the products (Garcia et al., 2002). The moisture content was more in the products with increased levels of dietary fibers. So incorporation of fibers in meat emulsion formulation promotes water retention capacity by the products, and also non-significance differences in pH values were found among the different formulations which comprised of polydextrose (PD), sugar beet fiber (SF), oat fiber (OF), potato starch (PS) and pea fiber (PF) in meat patties. As fat level increased from 5 to 30%, moisture and protein percentage was decreased (Trout et al., 1992). Patties with PD-PS-PF had less moisture initially and lost as little as 3.3% moisture during cooking compared to its control. Low fat control patties 5 and 10% fat and those with PD alone generally had higher cooking losses than low fat products with other ingredients. Products with SF, PF and PS consistently had cooking losses 20 to 40% less than those of low fat controls without added substances. Todd et al. (1989) reported that restructured pork products made with microcrystalline cellulose and pure cellulose had less cooking loss than the control sample. Generally, as the ingredient concentration increased from 3.5% to 7.0%, the cooking loss decreased. However, products with 3.5 and 7.0% levels of a soluble gum were not different from control. Sosulski and Wu (1988) observed that addition of 5 and 10% soy polysaccharides (SP) and bran to the meat emulsion increased water absorption and mixing time, however, decreased loaf volume but increased texture values with increasing levels of fiber.

Textural properties

Texture, appearance and flavour are the three major components of food acceptability. Though there is no alternative of human perception for texture, Instron Texture Analyzer is popularly used. Other instruments used for texture analysis of food products are Warner Bratzler shear press and Kramer Shear apparatus. The use of full-fat soya paste (FFSP) in development of goat meat patties increased the moisture and fat contents, but decreased the protein, shrinkage, hardness, springiness, chewiness, and shear force values (Das et al., 2006). Meat balls with rusk showed highest penetration values than meat balls with the chickpea flour (Serdaroglu et al., 2005), as swelling of the starch component of rusk interacted with the protein of meat to form a softer texture thus leading to an increase in penetrometer values.

Raw and cooked albedo addition caused an increase in hardness and decrease in fatness and hue perception, regardless of the added dose. The increase in hardness perception was higher in bolognas with raw albedo than cooked albedo, while fatness and hue did not show differences between both types of albedo. Some authors also reported that inclusion of fibers in various meat products increased hardness (Fernandez-Gines et al., 2004). Albedo addition caused a decreased in juiciness perception, regardless of the added dose. This decreased was higher in bolognas with added raw albedo than cooked albedo. Lee et al. (2008) reported that doughnut containing soybean hulls flour had lower fat contents, but increased hardness and crispiness without affecting any sensory quality parameters. The addition of apple, peach or orange fibers, however, decreases the hardness of the products. Springiness, adhesiveness and cohesiveness follow an irregular behavior without compromising added fiber levels. Significant differences from added polydextrose (PD), sugar beet fiber (SF), oat fiber (OF), potato starch (PS) and pea fiber (PF) occurred for Instron textural profile analysis traits for hardness and springiness (Trout et al., 1992). In general, patties containing PD-OF, PD-PS-SF, PD-PS-OF, and PD-PS-OF had lower hardness and springiness than control. Several of that combination were not different in hardness and springiness from 20% fat controls but differed from control with 30% fat.

However, patties containing textured soya protein showed greatest effect on cohesiveness, puncture force, back extrusion force and hardness of both raw and baked patties (Gujral et al., 2002), while added fat patties showed the highest effect on gumminess, chewiness and adhesiveness of raw patties. Mendoza et al. (2001) reported that inclusion of dietary inulin in low-fat sausage resulted in increased hardness, gumminess and chewiness and decreased springiness, cohesiveness and adhesiveness. The main differences were observed in the hardness and gumminess since values obtained for the high fat batch were significantly lower than for the low fat batches containing 10 and 11.55% levels of inulin. The decreased springiness and adhesiveness were proportional to the reduction in fat and these differences were significant between the batches.

According to Ho et al. (1997) frankfurters incorporated with soybean tofu powder though had more moisture and less fat than regular frankfurters, texture profile analysis showed non-significant differences between hardness, cohesiveness, springiness, gumminess, and chewiness. They again reported that hardness and toughness are often problem with lean frankfurters and addition of soybean tofu powder to lean frankfurters improves texture. Lower values were recorded for hardness, gumminess, chewiness, and fracturability of the lean frankfurters incorporated with soybean tofu. In another experiment, they reported that hardness, cohesiveness, springiness, gumminess, and chewiness of regular pork patties was lowest, followed by lean pork and lean pork incorporated with iota carrageenan.

Effect on colour

Colour is one of the most important quality attribute that affects consumer's acceptability of the meat products in market place. Colour is determined by using instrumental (Lovibond tintometer/Hunter colour Labs) aids or sensory evaluation. Use of biological sense for colour determination though logical, but time consuming and required highly trained personnel for accurate results. Hunter colour Lab is the most modern version of instrument that can effectively determine colour of meat products.

Colour attributes (hue, chroma and value) were affected by the addition of fiber. Addition of rice bran in meat batter (Choi et al., 2007) or hazelnut pellicle in beef burgers (Turhan et al., 2005) or other low fat meat products (Dolatowski and Karwowska, 2006) reduced brightness (L*) and yellowness (b*) values, but increased redness (a*) values than control. But contradictory results were also reported (Naveena et al., 2006). Fernandez-Gines et al. (2004) reported, bolognas formulated with lemon albedo showed higher lightness (L*) and redness (a*) compared to control and they were affected by types and concentration of albedo. When cooked albedo was used, only bolognas with low added albedo (2.5 and 5%) showed lower a* values. However, yellowness (b*) did not differ between control and different concentrations of albedo.

Ground beef patties made with or without 3.5% soy protein concentrate (SP), and 10 and 20% Samh flour (SF) showed Hunter colour a* value and saturation index (SI) were decreased with the incorporation of SP or SF (Elgasim and Wesali, 2000), however, Hunter colour L* and b* values did not show any changes with such incorporations of SP or SF. Saturation index (SI) and hue angle decreased and increased, respectively, with the extension of the beef patties with SF or SP. While Devatkal et al. (2004) incorporated buffalo liver in lean meat for development of meat loves reported higher redness (a*) and chroma values in control meat loves (without buffalo liver). Higher values of brightness (L*), yellowness (b*) and hue values were found in liver-meat and liver vegetable loves. Addition of ingredients like polydextrose (PD), oat fiber (OF), potato starch (PS) and pea fiber (PF) alone or combination to low fat meat patties did not affect redness measurements (Trout et al., 1992). Ho et al. (1997) reported that the L*, a*, and b* values of regular frankfurters containing soya tofu powder were comparable with regular frankfurters. Thus, soybean tofu powder did not affect colour of frankfurters with relatively high fat contents.

Effect on sensory quality

Palatability of meat products depends mainly on aroma and flavour, colour, appearance, tenderness and juiciness. Consumer studies showed that flavor and texture are more important among all the quality attributes. According to Risvik (1994), tender and juicy meat is generally preferred by the consumers. In a study, it has been observed that raw and cooked albedo addition caused an increase in hardness and decrease in fatness and hue perception, regardless of the added dose. The increase in hardness perception was higher in bolognas with raw albedo than cooked albedo, while fatness and hue did not show differences between both types of albedo. Some authors also reported that inclusion of fibers in various meat products increased hardness (Fernandez-Gines et al., 2004). Albedo addition caused a decreased in juiciness perception, regardless of the added dose. This decreased was higher in bolognas with added raw albedo than cooked albedo. Lee et al. (2008) reported that doughnut containing soybean hulls flour had lower fat contents, but increased hardness and crispiness without affecting any sensory quality parameters. Turhan et al. (2005) reported that increasing levels of hazelnut pellicle resulted in decreased appearance and colour, flavour and juiciness scores with the lowest values of 3.56. Certain cereal and fruit fibres also affects sensory properties of reduced –fat dry fermented sausage, and according to Garcia et al. (2002) addition of dietary fiber above 1.5 and 3% level from cereal (wheat and oat) and fruit (peach, apple and orange) in dry fermented sausages significantly affected sensory properties of products. The best results were obtained with sausages containing 10% pork back fat and 1.5% fruit fiber.

Eim et al. (2008) reported carrot can be effectively added to sobrassada to improve the textural and sensory characteristics of the developed products. But the result suggested that the addition of carrot in Sobrassada modifies the organoleptic properties, depending on the concentration. All sensory attributes were declined when level of added DF was greater than 3%. Sensory properties also varied depending on added rye bran in meat balls (Yilmaz, 2003), and according to Grigelmo-Miguel et al. (1999), addition of peach though reduced fat content but increased the acceptability. Mansour and Khalil (1997) reported that, overall palatability of low fat beef burgers were not affected by addition of wheat fibers. However, there was a negative correlation between apple, peach or orange fiber contents and texture of sausage (Garcia et al., 2002). This relationship was also observed by other authors in various meat and meat products (Fernandez-Lopez et al., 2008; Keeton, 1994). However, meat products containing cereal and peach fibers were mostly influenced by texture and taste parameters with good acceptability. Keeton (1994) used oat bran in beef burgers at concentration of 3% with favourable results. In another study, sensory traits for cooked ground beef patties showed that, those containing 3.5% sugar beet were less moist, and released less moisture on chewing than other low fat treatments (Trout et al., 1992).

NUTRITIONAL VALUE AND PHYSIOLOGICAL EFFECT OF SOME DIETARY FIBERS

It is very difficult to give pin point precision data relating to nutritive value and physiological effects for all fiber types. These values are again variable depending on processing conditions, ways of addition, fiber types and forms etc. The protective effect of fruit and vegetable fibers has generally been attributed to their antioxidant constituent, including vitamin C and E, carotenoid, glutathione, flavonoids and phenolic acids, as well as other unidentified compounds (Eberhardt et al., 2000). Flavonoids, a group of more than 4000 polyphenolics, are products of plant metabolism and naturally occurring polyphenolics present in fruit and vegetables, and play an integral part in human diet (Hollman et al. (1997). They are effective antioxidants because of their scavenging properties, chelators of metal ions (Kandaswami and Middleton, 1994) and may protect tissues against free oxygen radicals and lipid peroxidation. Flavonoids have been cited as frequently as bioactive agents for health maintenance. Fiber intake through the consumption of meat, rich in dietary component is associated with reductions in plasma and LDL-cholesterol, attenuating glycemic and insulin response, increasing stool bulk, and improving laxation (Schneeman, 1999). Moreover, through its physiologic responses, dietary fiber consumption has reduced risk of most of the major dietary problems such as obesity, coronary diseases, diabetes, gastrointestinal disorders, including constipation, inflammatory bowel diseases like diverticulitis and ulcerative colitis, and colon cancer (Jones, 2000).

When raw carrot (*Daucus carota*) was added as such, it provides richest source of β-carotene, iron, pectin, dietary fibre, complex carbohydrate, and various minerals. β-carotene prevents the appearance or impedes the development of cancerous cells. It has potent antioxidant effect, also provides anti-mutagenic, anti-tumoral, immunostimulant, antiulceric, degenerative properties on human health. Carotenoid possesses such important virtues as to protect our body; it is also helpful for good health of the vision, skin, teeth and gums. Besides β-carotene, iron is very suitable for human health. Iron is very digestible and also favors the formation of the red globules (Lester and Eischen, 1996).

Sweet potato (*Ipomoea batata*) is a nutritionally rich crop (Bhosale et al., 2010). Various types of nutrients are found in sweet potato, including antioxidants, vitamins (B_1, B_2, C and E), minerals (calcium, magnesium, potassium and zinc), dietary fiber, protein and non-fibrous carbohydrates (Suda et al., 1997). Approximately 80% of the dry matter of sweet potato is carbohydrate. Most of the carbohydrate is starch. There is a substantial amount of soluble sugar, cellulose, pectin, and hemicelluloses. The protein concentration is relatively low and is only about 5% of the dry matter in sweet potato. Lipid consists of approximately1.2 to 2.7% of the total fresh weight. It is composed of neutral lipid, glycolipids, and phospholipids, organic acids including malic acid, quinic acid, succinic acid, and citric acid.

Soybean hulls contains up to 19.2% crude protein and 50% dietary fiber (Batajoo and Shaver, 1998). Similarly green banana though rich in fiber, minerals and most of vitamins. Green banana flour contain about 3.2% protein, 1.3% fats, 3.7%, ash, 8.9% neutral detergent fibers, 3.8% acid detergent fibers, 3.1% cellulose, 1.0% lignin and 5.0% hemicellulose (Pacheco-Delahaye et al., 2008). No wonder the banana is considered as an important food to boost the health of malnourished children. In addition to

Table 2. Dietary fibre content of some important vegetables, fruits, cereals, legumes, flax seeds etc with their possible physiological effects.

Legumes	Percentage on fresh basis	Physiological effect
Green peas	5.1	Lower blood cholesterol
Soybeans	9.3	---------do-------
Chickpea	7.6	---------do-------
Mung bean	16.3	---------do-------
Cereals		
Wheat	13.2	-
Oats	11.0	Cholesterol lowering properties
Rye	-	
Chia	-	
Barley	15.6	Regulate blood sugar
Fruits		
Plums	1.4	
Grapes	0.9	
Strawberry	3.3	
Bananas	2.6	Reduce risk of colon cancer, breast cancer, renal cell carcinoma
Apples	2.4	Regulate bowel movements, risk of colon cancer, control weight loss, heart diseases
Pears	3.1	Treatment of inflammation mucus membrane, colitis, gall bladder disorders, arthritis and gout
Vegetables		
Broccoli	2.6	Anti-cancer properties
Carrots	3.0	Digestive problems, tonsillitis, intestinal parasites
Jerusalem artichokes	-	-
Cauliflower	2.5	Reduce risk of prostate cancer
Celery	1.6	Reduce appetite, colorectal cancers and heart diseases
Root tubers/vegetable		
Sweet potatoes	3.0	Stabilize blood sugar levels, lower insulin resistance
Onions	1.7	Anti-inflammatory, anti-cancer, anti-cholesterol activity
Psyllium seed husk Nuts		Reduced constipation and diarrhea
Almond	12.0	Reduce coronary heart diseases, lower blood cholesterol level
Cashew nut	3.3	------ do---------
Peanut	9.0	------ do---------

Table 2. Contd.

Pistachio Seeds	10.3	------ do---------
Potato skins	2.2	Increase bulk of stool, protection against colon cancer, improves glucose tolerance, lowers plasma cholesterol
Flax seed	27.3	------do--------
Skins of tomatoes	1.0	Protect against prostate cancer

Table 3. Some international committee recommendations for total dietary fiber (TDF) intakes.

Source	Recommendation (g/day)	Comments
USDA and USFDA	25	SDF 0.6 g/serving 2000 calorie diet
National Cancer Institute (America)	20-30	From whole grains, fruits, vegetables (10-13 g/d). Eat variety of whole grain products, fruits, and vegetables
American Dietetic Assoc.	20-35	-
Dutch RDA	12.5	Approx. 30 g/d for adult
Nordic Committee on Food	12.5	Approx. 30 g/d for adult
UK Department of Health	12-24	Excludes inulin, FOS, and resistant starch
German	12.5	Approx. 30 g/d for adult

Tungland and Meyer (2002).

these, dietary fibre content of some important vegetables, fruits, cereals, legumes, flax seeds etc with their possible physiological effects are shown Table 2.

RECOMMENDATIONS FOR TOTAL DIETARY FIBER (TDF) INTAKES

Intake of TDF is dependent on the methods used to define their dietary content. So, little variation persists for recommendation of TDF intake by the various governmental or non-governmental bodies and organizations and that mainly vested on types of dietary fibers, analytical techniques used for their determination, and specific requirements. For example, National Cancer Institute (NCI) recommended that the adult fiber consumption should be increased to 20 to 30 g daily but not to exceed 35 g, as at this level it may have some beneficial effects on colon and rectal cancer. Reviewing recommendations for healthy populations from other agencies and countries suggest that fiber intakes should be increased, but the recommendations are somewhat unclear as to the amounts and types of fiber being recommended. The American public, currently consumes about 10 to 15 g/d (Marlett and Slavin, 1997). However, with all its complexities, determining the current fiber consumption continues to be somewhat challenging. There is limited literature for recommendation of fiber consumption pattern in India, however, according to some international committee TDF consumption should follow the recommendation shown in Table 3.

REFERENCES

Alexander A (1995). Pregelatinized starches - what are they all about? Cereal Foods World, 401: 769-770.

Ames BN, Shigenaga MK, Hagen TM (1993). Oxidants, antioxidants and the degenerative disease of aging. Proc. Natl. Acad. Sci., 90: 7915-7922.

Backers T, Noll B (2001). Safe plant based ingredients for meat processing: Dietary fibres and lupine protein. Food Mark. Technol., 15: 12-15.

Batajoo KK, Shaver RD (1998). *In situ* dry matter, crude protein, and starch degradabilities of selected grains and by-product feeds. Anim. Feed Sci. Technol., 71: 165-168.

Besbes S, Attia H, Deroanne C, Makni S, Blecker C (2008). Partial replacement of meat by pea fiber: Effect on the chemical composition, cooking characteristics and sensory properties of beef burgers. J. Food Qual., 31: 480-489.

Bhosale SS, Biswas AK, Sahoo J, Chatli MK, Sharma DK, Sikka SS (2010). Quality Evaluation of Functional Chicken Nuggets Incorporated with Ground Carrot and Mashed Sweet Potato. Food Sci. Technol. Int., (Accepted).

Chang HC, Carpenter JA (1997). Optimizing quality of frank furthers containing oat bran and added water. J. Food Sci., 62: 194-197.

Choi YS, Jong YJ, Choi JH, Doo JH, Hack YK, Mi AL, So YS, Hyun DP, Cheon JK (2007). Quality characteristics of meat batters containing dietary fiber extracted from rice bran. Korean J. Food Sci. Anim. Resour., 27(2): 228-234.

Colonna P, Doublier JL, Melcion JP, de Monredon F, Mercier C (1984). Extrusion cooking and drum drying of wheat starch. I. Physical and macromolecular modification. Cereal Chem., 61: 538-543.

Das AK, Anjaneyulu ASR, Kondaiah N (2006). Development of reduced beany flavour full fat soy paste for comminuted meat products. J. Food Sci., 71(5): 395-400.

Desmond EM, Troy DJ (2003). Sensory and physical characteristics of pork sausages manufactured with dietary fibres. Irish J. Agric. Food Res., 42(1): 161.

Devatkal S, Mendiratta SK, Kondaiah N (2004). Quality characteristics of loaves from buffalo meat, liver and vegetables. Meat Sci., 67: 377-383.

Diplock AT, Aggett PJ, Ashwell M, Bornet F, Fern EB, Roberfroid MB (1999). Scientific concepts of functional food in Europe: Consensus document. Brit. J. Nutr., 81: 1-27.

Dolatowski JZ, Karwowska M (2006). An assessment of fat substitution with buck wheat seed preparation on the quality of communicated meat products. Elect. J., 9(4).

Eberhardt MV, Lee CY, Liu RH (2000). Nutrition-Antioxidant activity of fresh apples. Nature, 405: 903-904.

Eim VS, Small S, Rossello C, Femenia A (2008). Effect of addition of carrot dietary fiber on the ripening process of a dry fermented sausage (Sobressada) Meat Sci., 80: 173-182.

Elgasim EA, Wesali ALMS (2000). Water activity and hunter colour values of beef patties extended with Samh (*Mesembryanthemum forsskalei*) Flour. Food Chem., 69(2): 181-185.

Fan JT, Mitchell JR, Blanshard JMV (1996). The effect of sugars on the extrusion of maize grits. 1. The role of the glass transition in determining product and shape. Int. J. Food Sci. Technol., 31: 55-65.

Fernandez-Lopez J, Sendra E, Sayas-Barbera E, Navarro C, Perez-Alvarez JA (2008). Physico-chemical and microbiological profiles of "salchichon" (Spanish dry – fermented sausage) enriched with orange fiber. Meat Sci., 80: 410-417.

Fernandez-Gines JM, Fernandez-Lopez J, Sayas-Barbera E, Sendra E, Perez-Alvarez JA (2004). Lemon albedo as a new source of dietary fiber: Application to bologna sausages. Meat Sci., 67(1): 7-13.

Garcia ML, Dominguez R, Galvez MD, Casas C, Selgas (2002). Utilization of cereal and fruit fibres in low fat dry fermented sausages. Meat Sci., 60: 227-236.

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

Gujral HS, Kaur A, Singh N, Sodhi SN (2002). Effects of liquid whole egg, fat and textured soy protein on the textural and cooking properties of raw and baked patties from goat meat. J. Food Eng., 53: 377-385.

Hollman PC (1997). Relative bioavailability of the antioxidant flavonoid quercetin from various foods in man. FEBS Lett., 418: 152-156.

Ho KG, Wilson LA, Sebranek JG (1997). Dried soy-tofu powder effects on frankfurters and pork sausage patties. J. Food Sci., 62: 434-437.

Hughes E, Cofrades S, Troy D J (1997). Effects of fat level, oat fiber and carrageenan on frankfurters formulated with 5, 12 and 30% fat. Meat Sci., 45(3): 273-2810.

Huisman M, Fransen C, Kamerling J, Vilegenthart J, Schols H, Voragen A (2001). The CDTA soluble pectic substances from soy meal are composed of rhamnogalactoronan and xylogalacturonan but not homogalaturonan. Biopolymers, 58: 279-294.

Hur SJ, Lim BO, Park GB, Joo, ST (2009). Effect of various fiber additions on lipid digestion during in *vitro* digestion of beef patties. J. Food Sci., 74(9): C653-C657.

Jones JM (2000). Dietary advice in North America: The good, the bad and the unheeded. In: McCleary BV, Prosky L (Ed). Proceedings of 1st International Conference Dietary Fiber. Dublin, Ireland, p. 30.

Kandaswami C, Middleton E Jr. (1994). Free radical scavenging and antioxidant activity of plant flavonoids. Adv. Exp. Med. Biol., 366: 351-376.

Kayisu K, Hood LF and Van Soest PJ (1981). Characterization of starch and fiber of banana fruit. J. Food Sci., 46: 1885-1890.

Keeton JT (1994). Low fat meat products - technological problems with processing. Meat Sci., 36: 261-276.

Koksel H, Ryu GH, Basman A, Demiralp H, Ng PKW (2004). Effects of extrusion variables on the properties of waxy hull less barley extrudates. Nahrung-Food, 48: 19-24.

Kumar V, Biswas AK, Chatli MK, Sahoo J (2010). Effect of banana and soybean hull flours on vacuum packaged chicken nuggets during refrigeration storage. Int. J. Food Sci. Technol., (In Press).

Lai LS, Liu YL, Lin PH (2003). Rheological/textural properties of starch and crude hsiantsao leaf gum mixed systems. J. Sci. Food Agric., 83: 1051-1058.

Lee S, Kim BK, Park D J. (2008). Preparation of low-fat uptake doughnut by dry particle coating technique. J. Food Sci., 73: E137-142.

Lester GF, Eischen E (1996). Beta-carotene content of post-harvest orange fleshed musk melon fruit. Effect of cultivar growing location and fruit size. Plant Foods Hum. Nutr., 49: 191-197.

Mansour EH, Khalil AH (1997). Characteristics of low fat beef burgers as influenced by various types of wheat fibers. Food Res. Int., 30: 199-205.

McDonagh C, Troy D, Desmond E, McDermott H (2005). Nutritional enhancement of meat products with dietary fibers. Project RMIS No. 4957. The National Food Centre, Ashtown, Dublin 15.

Marlett JA, Slavin JL (1997). Position of the American Dietetic Association: Health Implications of Dietary Fiber. J. Am. Dietetic Assoc., 97: 1157-1159.

Mendoza E, Garcia ML, Casas C, Selgas MD (2001). Inulin as fat substitute in low fat, dry fermented sausages. Meat Sci., 57: 387-393.

Morin LA, Temelli F, McMllen L (2004). Interaction between meat proteins and barley *Hordeurm* spp. β-glucan within a reduced-fat breakfast sausage system. Meat Sci., 68: 419-430.

Naveena BM, Muthukumar M, Sen AR, Babji Y, Murthy TRK (2006). Quality characteristics and storage stability of chicken patties with finger millet flour. J. Muscle Foods, 17: 92-104.

O'Neill M, Albersheim P, Darvill A (1990). The pectic polysaccharides of primary cell wall. In: Dey DM (Ed). Methods in plant biochemistry. London: Academic Press, 2: 415-441.

Pacheco-Delahaye E, Maldonado R, Perez E, Schroeder M (2008). Production and characterization of unripe plantain (*Musa paradisiaca* L.) flour. Interciencia, 33(4): 290-294.

Perez E (1997). Characterization of starch insolate from plantain (*Musa paradisiaca* normalis). Starch/Starke, 49: 45-49.
Risivik E (1994). Sensory properties and preferences. Meat Sci., 36: 67-77.
Schneeman BO (1999). Fiber, inulin and oligofructose: Similarities and differences. J. Nutr., 129: 1424S-1427S.
Serdaroglu M, Yildiz-Turp G, Abrodimov (2005). Quality of low–fat meatballs containing legume flours extenders. Meat Sci., 70: 99-105.
Suda I, Furuta S, Nishiba Y, Yamakawa O, Matsugano K, Sugita K (1997). Reduction of liver injury induced by carbon tetrachloride in rats administered purple sweet potato juice. J. Japanese Soc. Food Sci. Technol., 44: 315-318.
Thibault JF, Lahaye M, Guillan F (1992). Physicochemical properties of food plant cell walls. In Dietary fiber- A Component of Food. Schweizer TF, Edwards CA (Ed), Springer Verlag, London, p. 21-39.
Todd SL, Cunningham FE, Claus JR, Schwenke JR (1989). Effect of dietary fiber on the texture and cooking characteristics of restructured pork. J. Food Sci., 54: 1190-1192.
Trout ES, Hunt MC, Johson DE, Clans JR, Castner CL, Kroff DH (1992).Characteristics of low fat ground beef containing texture modifying ingredients. J. Food Sci., 57: 19-24.
Tungland BC, Meyer D (2002). Non-digestible oligo- and polysaccharides (Dietary Fiber): Their physiology and role in human health and food. Compreh. Rev. Food Sci. Food Safety, 3: 90-109.
Turhan S, Sagir I, Ustun NS (2005). Utilization of hazelnut pellicle in low–fat beef burgers. Meat Sci., 71: 312-316.
Van Buren J (1979).The chemistry of texture in fruit and vegetables Textural Stud., 10: 1-23.
Viuda-Martos M, Ruiz–Navajas Y, Fernandez–Lopez J, Perez–Alvarez JA (2010). Effect of orange dietary fibre, oregano oil and packaging conditions on shelf-life of bologna sausages. Food Control, 21: 436-443.
Vural H, Javidipour I, Ozbas OO (2004). Effects of interesterified vegetable oils and sugar beet fiber on the quality of frankfurters. Meat Sci., 67: 65-72.
Yue Xu (2001). Perspectives on the 21st century development of functional foods: Bridging Chinese medicated diet and functional foods. Int. J. Food Sci. Technol., 36: 229-242.
Yilmaz I (2003). Effects of rye bran addition on fatty acid composition and quality characteristics low fat meat balls. Meat Sci., 67: 245-249.