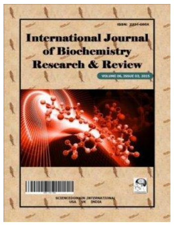

International Journal of Biochemistry Research & Review

19(2): 1-14, 2017; Article no.IJBCRR.36561
ISSN: 2231-086X, NLM ID: 101654445

Fortification of Dietary Fiber Ingriedents in Meat Application: A Review

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2017/36561
Editor(s):
(1) Fatih Oz, Food Engineering Department,Agriculture Faculty, Turkey.
Reviewers:
(1) Pinar Oğuzhan Yildiz, Ardahan University, Turkey.
(2) Oguz Ozcelik, Firat University, Turkey.
(3) Wagih Mommtaz Ghannam, Mansoura University, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/21425

Review Article

Received 31st August 2017
Accepted 5th October 2017
Published 16th October 2017

ABSTRACT

Meat and meat type products have high biological value with rich nutritional compounds such as proteins, vitamins, minerals and trace elements. Increased consumer's demand for convenience and easily available foods such as meat products and their byproducts have the changed due to various socioeconomic factors in recent years. Processing technology in meat industry introduce various benefit compounds to meat and meat products which are essential to human health but in such foods fat and salt contents are high or above moderate level but lack in fiber content and cause a health threat that in some cases shows to be a alaraming signal to various diseases such as cardiovascular, cancer, obesity and diabetes mellitus. Due to consciousness among present generation consumers related to nutritional disease shows towards functional foods. Therefore an increase in level of functional foods such as dietary fiber fortified foods in daily diet has been allotted and prescribed in daily diets. Dietary fiber of 28–36 g/day in adults has been recommended and must contain insoluble fiber of 70–80%. Dietary fiber whether insoluble or soluble type have different functions such as part of soluble type dietary fiber helps in intestinal regulation whereas soluble type fiber helps in reducing cholesterol level and also absorbs intestinal glucose level which otherwise cause a healthy hazard threat. In meat products fiber from various related sources such as cereals, pseudocereals, fruits and vegetables would enhance their desirability and functional

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properties of meat products. In general agricultural byproducts and wastes are comparatively cheap source of dietary products and their incorporation at different levels in meat products reduces cost in economic terms.

Keywords: Meat products; biological value; dietary fiber; diabetes mellitus; soluble fiber.

1. INTRODUCTION

Food has been used to improve the health in people, awareness and various health aspects being used to innovate and modify foods. Approach in promising cared health sector is low to produce effective food products as benefit healthy programme [1]. Meat is a potential source of nutrients like proteins, vitamins of fat soluble type and higher level of bioavailability of minerals as compared to other nutritional sources [2] in which some nutritional components were produced during meat processing which are beneficial to the human health [3] and accepting a relationship between nutrition and health gave a innovative concept of functional foods including meat products [4] which contains health benefit ingredients [5]. Research of epidemiology showed linear relationship between food lack in dietary fiber and diseases including colon cancer, obesity and cardiovascular diseases which are chronic in nature [6]. The relation of energy dense foods and various diseases stresses mainly on components considered as marker of healthy food [7]. American Dietetic Association have recommended fiber intake in range of 25 to 30 g/day and 3:1 insoluble/soluble fibre ratio for adults. Meat is a nutritious, cheap and easily available food, besides water fat and protein are important components of meat. Meat and meat products contains high amount of fat and protein but deficient in dietary fiber [8] and its fortification in meat products have been focused on health point of view. Fiber are important ingredient in meat products on the healthy point of view. The fibers alone or combined with other products such as meat for low fat content such as ground and restructured products and meat emulsions [9] have been studied.

2. MEAT

The term meat is related to the warm blooded muscle of terrestrial animals such as cattle and sheep with four legged. Meat of glands and organs of these animals are also included. By products from animal slaughter, such as sausage casings from animal gut and meat used in the production of lard from fat and gelatin from collagen are also included in meat products. The annual consumption of meat of any countries depends upon its economic status, affluent countries consuming more than others. The average per capita consumption of meat is 67 kg per annum in US which is more than of many countries. The per capita consumption of meat in India is of order of 1.2 kg per annum. Meat is frequently associated with a negative health image due to its high fat content and in the case of red meat is seen as a cancer-promoting food. Therefore a low meat intake, especially red meat is recommended to avoid the risk of cancer, obesity and metabolic syndrome [9]. However this discussion overlooks the fact, that meat is an important source for some micronutrients such as trace elements and vitamins, which are either not present in plant derived food or have a poor bioavailability. In addition, meat as a protein-rich and carbohydrate-low product contributes to a low glycemic index, which is assumed to be beneficial with respect to obesity, diabetes development and cancer [9].

2.1 Protein

A typical muscle consists of around 75 % water, 20 % protein, 3 % fat and 2 % soluble nonprotein substances. Proteins are the major component of the dry matter of lean meat [10]. Nine of the amino acids present in proteins are essential (or semi-essential) because the human body cannot synthesize them from other compounds, and therefore must taken them up from food. Therefore, the requirement for dietary protein consists of two components; (a) a requirement for the nutritionally essential amino acids, and (b) the need to meet the requirement for non-specific nitrogen in order to supply the nitrogen necessary for synthesis of the nutritionally not essential amino acids and other physiologically important nitrogen containing compounds (nucleic acids, creatine, porphyrins) [11]. Meat contains generally high levels of the major essential amino acids, lysine, total sulfur amino acids, threonine and tryptophane [11]. Protein quality is usually defined according to the amino acid pattern of egg protein, which is regarded as optimal. It is not surprising that animal proteins, such as meat, milk and cheese tend to be of a higher protein quality than plant proteins. Animal proteins have a better digestibility compared to plant proteins. This can be explained to some extent with the fact that plant proteins are mostly embedded into polysaccharide matrices (cell walls) where they cannot be reached by the proteolytical enzymes. A healthy nutrition requires a balanced mix of different food proteins. By combining plant and animal food the nutritional quality of the protein can be increased because of the complementing effect.

2.2 Fat

Fat is the richest dietary source of energy and supplies essential nutrients such as essential fatty acids as well as precursors of compounds that regulate a number of physiological functions (e.g. prostaglandins) and helps to absorb fat-soluble vitamins (A, D, E and K). Further fat has a decisive relevance as the most compact energy store of the body, as fixation as well as a protection of the organs and as source of fatty acids which again act as structural element of cell membranes. Fat also provides palatability and flavor to food. In the right proportions it is therefore an essential component of any balanced diet, and hence the degree of fat reduction must not only take into account sensory or technological factors but it must also be such as to avoid loss of nutritional benefits [12]. Meat is looked at very critically because of its fat content being generally included under the heading of fatty foods. The fat in animals is mainly found in their fatty tissue and is distinguished between depot fat (largely subcutaneous fatty tissue), intermuscular and intramuscular fat. The last of these is called marbling. The amount of intermuscular and depot fat present in a meat cut varies, depending on the fat excretion of the animal and how the cut has been trimmed [13]. Contrary to the widespread belief that animal fat is mainly composed of saturated fatty acids (SFA), roughly half of the fatty acids in meat are unsaturated. Meat lipids usually contain less than 50% SFA, and up to 70% (beef 50-52%, pork 55-57%, lamb 50-52% and chicken 70%) unsaturated fatty acids.

2.3 Minerals and Trace Elements

Beside the macronutrients protein and fat, meat contains micronutrients (minerals and vitamins) which are involved in essential metabolic processes. Meat, fish, poultry and offal are the only foods that contain the better available heme iron besides the inorganic iron (non-heme iron) [14]. Meat is not only an important source of available iron, but also of zinc. It is well known that absorption of dietary zinc from animal protein based meals is higher compared to wholegrain cereal based meals [15]. The trace element selenium (Se) is a crucial nutrient for human health. It is a component of a number of important selenoproteins including enzymes required for such functions as antioxidative defense, reduction of inflammation, thyroid hormone production, DNA synthesis, fertility and reproduction [16].

2.4 Vitamins

Vitamins are a complex group of organic compounds that are generally present in small quantities in foodstuffs. Vitamins are important as cofactors in enzymatic processes and also possess hormonal activity. Traditionally, vitamins have been classified on the basis of their solubility in either lipid or aqueous solvents, and they are therefore broadly divided into fat and water-soluble vitamin categories [17]. Fat-soluble vitamins tend to be mainly stored in the liver and adipose tissues of animals, in association with stored fat, and they are not readily excreted. Water-soluble vitamins, on the other hand, tend to be stored to a far lesser extent in the body. The vitamins contained in animal and human diets are predominantly derived from either plant or microbial synthesis. Animal cells maintain the ability for de novo synthesis of some vitamins, such as vitamin D and, depending on the species involved, niacin and ascorbate, as well as the ability to convert precursors (provitamins) to their active form. Additionally, commensal microorganisms in both the ruminant and non-ruminant digestive tract can serve as source of vitamins, such as vitamin K and the water-soluble B-complex vitamins [18]. Meat has long been recognized as a good source of B vitamins for human nutrition. Meat, especially pork has long been recognized as a good source of thiamine [10].

3. DIETARY FIBER

Most of meat foods are rich in fat and protein but deficient in complex carbohydrates like dietary fiber [8] and agricultural byproducts and wastes are comparatively cheap source of dietary products and their incorporation at different levels in meat products reduces cost in economic terms. The term dietary fiber was first coined by Eben Hipsley in1953 to carbohydrate content in diet which is unavailable for digestion with property of lowering pregnancy toxaemia [19] while as crude fiber somehow related to dietary fiber is actually the analytical term for components that escaped acid and alkali extractions process [20]. Dietary fiber in broad term may be defined as “total content of polysaccharides and lignin components which are not digested and assimilated in gastrointestinal tract by humans [21]. The dietary fiber and its analysis are under conflict zone and little tough in terms of definition and classification for public health agencies and food industries [22]. American association of cereal chemists have defined dietary fiber as the edible part of plants which are remanant that in small intestine escaped digestion and absorption process [23]. The various types of components from cereals, fruit and vegetables and other cheap sources that constitute dietary fiber are listed in the Table 1.

3.1 Dietary Fiber Classifications

On the basis of sources, dietary fiber were classified and categorized from which they are derived into plant polysaccharides, animal polysaccharides or synthetic sources. The linear or non linear polysaccharides are classification on the basis of the structure. But basis of solubility and/or the fermentation are the most widely accepted and valid system of classification on the basis of behavior using enzyme component in an in vitro system of human alimentary canal. According to property of solubility in water, insoluble dietary fiber (IDF)/less fermented fiber and soluble dietary fiber (SDF)/well fermented fibers are the two types of classification. Insoluble fiber such as cellulose, part of hemicelluloses and lignin in the dietary fiber system of classification while as pentosans, pectins, gums, mucilage [24] and whole grains were insoluble dietary fibers [25]. Dietary fiber of insoluble nature were maximum interms of hemicellulose in various foods is contributed by bran and husks [26]. On the basis of solubility dietary fiber were classified as shown in Table 2.

3.1.1 Cellulose

Cellulose is a polymer of linear glucose monomer chain by β (1→4) linkage and in green plants and vegetables it is cell wall structural component. It is a dietary fiber which is water insoluble and in

Table 1. The components and sources that constitute dietary fiber

Fiber components	Principal groupings	Fiber sources
Non starch polysaccharides and oligosaccharides	Cellulose Hemicellulose Polyfructoses Gums and mucilages	Cellulose plants (vegetable, sugar beet, various brans) Arabinogalactans, β-glucans, arabinoxylans glucuronoxylans, xyloglucans, galactomannans, pectic substances Inulin, oligofructans Seed extracts (galactomannans – guar and locust bean gum), tree exudates (gumacacia, gum karaya, gum tragacanth), algal polysaccharides (alginates, agarcarrageenan), psyllium
Carbohydrate analogues	Pectins Resistant starches and maltodextrins Chemical synthesis Enzymatic synthesis	Fruits, vegetables, legumes, potato, sugar beets Various plants such as maize, pea, potato Polydextrose, lactulose, cellulose derivatives Neosugar or short chain, guar hydrolyzate Fructooligosaccharides, levan, xanthan gum, transgalactooligosaccharides, oligofructose, xylooligosaccharide, curdlan
Lignin and lignin associate	Lignin	Woody plants
Nonstarch polysaccharides	Waxes, cutin, Suberin	Plant fibers
Animal origin fibers	Chitin, chitosan, Collagen fibers, chondroitin	Fungi, yeasts, invertebrates

Table 2. Classification of dietary fiber based on solubility

Class	Examples
Insoluble	Cellulose
Soluble (only in hot water)	Agars, amylose, aligns, kappa-type carrageenans (in the presence of K+ or Ca2+), gelan, konjac, mannan, locust bean gum, low methoxyl pectins, granular starches and starch derivatives
Soluble (in water at room temperature but insoluble in hot water)	Curdlan, hydroxylpropylcelluloses, hydroxylpropylmethylcelluloses and methylcelluloses
Soluble (in water at room temperature and hot water)	Alginates, amylopectins, carboxymethylcelluloses, dextrins, iota type carrageenans, guar gum, gum Arabic, high methoxyl pectins, polydextrose and xanthan gum

(Source: BeMiller, 2001)

the small intestine where it is not digested by enzymes. However, it can be digested by producing short chain fatty acids in gut through microbial fermentation to a certain degree. Basically, this class of dietary fiber can be classified into crystalline and amorphous. The crystalline component is large portion of cellulose and insoluble in water due to intra and intermolecular non covalent hydrogen bonds which gives great mechanical strength to cellulose and makes resistance to microbial decomposition while as the amorphous portion is water soluble and consists of (10–15%) part of total cellulose type of dietary fiber [27].

3.1.2 Hemicellulose

Hemicelluloses are similar to cellulose but interms of size it is smaller than cellulose having chain of glucose monomers linked by β (1→4) type of linkage. Hemicellulose is branched in nature with variety of sugar moieties like xylose, mannose and arabinose [28].

3.1.3 Resistant starches (RS)

Resistant starch type of starch which is not digested in the small intestine and have behavior like soluble fiber without compromising palatability and mouth feel property. Four basic types RS has been classified as - Type 1 (RS1) is a type in which starch granules is surrounded by an indigestible plant matrix part, Type 2 (RS2) is available in natural form such as potato in uncooked form and maize in high amylase, Type 3 (RS3) are starches formed by unique cooking and cooling processes in crystallized form and Type 4 (RS4) is a chemically modified starch by various methods such as esterification, crosslinking, or transglycosylation and is not available in nature form. The greater glucose lowering effect is found more in cross-linked RS4 than the more commonly tested RS2 [29].

3.1.4 Lignin

Lignin is a oxygenated phenyl propane polymer in which complex dehydrogenative polymerization occurs in coniferyl, sinapyl and p-coumaryl alcohols units [30]. Lignin type of dietary fiber is naturally inert and has a greater resistance property than any other naturally occurring dietary fiber [31].

3.1.5 Pectin

Pectin is a galacturonic acid linear polymer linked by α (1→4) bonds. It is a water soluble type of dietary fiber that doesn’t undergoes any enzymatic digestion in small intestine but is easily digested by the colon’s microbiota. At food point of level, gelling or a thickening agent are the typical properties which make them available as use in food applications. Inside the gut, pectin forms gelling behavior, which gives pectin beneficial and good effects on health point of view such as dumping syndrome [32], lower cholesterol level and helps in lipid metabolism [33] and prevents diabetes [34].

4. TECHNOLOGICAL FUNCTIONALITY OF DIETARY FIBRE

Dietary fibre is complex polysaccharide which show wide range of functionality such as emulsification, fat replacement, gel-forming, cryoprotectant, thickener & stabilizer. These technical functionalities are highly influenced by the physico-chemical properties of dietary fibres, such as water-holding & binding capacity, oil binding capacity, solubility & viscosity which are discussed [35].

Table 3. Factors effecting techno functionality properties of dietary fiber

Factor	Techno-functional properties
Type of fibre	Water holding capacity of soluble fibre is higher than insoluble Flaxseed gum in dairy beverages resulted in better sensory & rheological properties
Particle size	Decrease in hydration with decrease in particle size of wheat bran Increase with reduction in coconut fibre particle size
Molecular weight	High molecular weight β-glucan difficult to dissolve in water even at low concentration of 0.5%
Nature of chain	Highly branched guar gum & pectin more soluble & viscous

5. RECOMMENDED DIETARY ALLOWANCES (RDA) For Dietary Fiber

The dietary fiber been an important part of the balanced diet and it is recommended that a 30–40 g/day fiber intake is preferred. Out of recommended level, this content of dietary fiber should be derived from cereal bran and other fruits and vegetables [36]. The cereal based dietary fiber content in balanced foods are depends on the source and the degree of processing of dietary fibers. For example, in refined wheat flour the fiber content is low as 2.5 g/100 g while in unrefined flour source, it is five times higher 12 g/100 g than refined one. During refining process dietary fiber gets removed at large mostly the insoluble fraction [37]. In all countries intake of dietary fiber recommendations are not same because of different causes such as different eating habits and lifestyles and the processing technologies involved in food products preprations [38]. Crude fiber of 6–8.5 g is available in average Indian diets [39]. As per International Committee suggestions and recommendations for the total dietary fiber intake in food per day has been presented in Table 4.

6. DIETARY FIBER ROLE IN PHYSIOLOGICAL AND HEALTH ASPECTS

Prevention of several diseases, symptoms and maintenance of health dietary fiber plays a key role. Protective action and mechanism of dietary fiber exerts varies with the type and composition of that fiber in the body.

6.1 Dietary Fiber and Cardiovascular Diseases

Dietary fiber acts as a nutraceutical ingredient against cardiovascular diseases by acting hyperlipidemia and hypocholesterolemia reducing agent [40] however exact mechanism for lowering serum LDL cholesterol levels is not known but some evidence showed that it interfere with lipid and/or bile acid metabolism. Uronic acid, glucomannans and galactomannans are rich in coconut and its dietary fiber are easily metabolized in large intestine by microflora and short chain fatty acids such as acetates, propionate and butyrate are produced that have very contributing power to lowering serum cholesterol levels. Dietary fibers from oat bran, guar gum sources [41] and psyllium [42], also have property in lowering the serum cholesterol levels. Other mechanisms are inhibition of hepatic lipoprotein production and cholesterol synthesis, increased insulin sensitivity due to delayed absorption of macro nutrients and protective membrane formation around lipid droplet by dietary fibers through which action of lipase is prevented [43]. Dietary fiber binds to bile acids and cholesterol metabolites in small intestine interfers in digestion and absorption of lipids by interrupting enterohepatic circulation that leads to lower serum cholesterol concentration [44]. The dietary fiber acts as strong inhibitors of pancreatic lipase by affecting the absorption of lipids and lipid metabolism [45]. On the other hand by dilution and excretion of bile acids lowers the cholesterol and low-density lipoproteins in plasma [46].

6.2 Gastrointestinal Health and Dietary Fiber

The fiber can increase in stool weight by binding property of large amount of water [47] which reduces colonic transit time due to increased stool bulk which prevents most common problem such as constipation and lower production of carcinogenic and genotoxic components [48]. Dietary fibers have important function in maintaining immunity in gastrointestinal tract particular, by fermentable fiber portion in diet in which T-cell mitogen response and gut associated lymphoid tissue (GALT) increased [49]. In large intestine dietary fiber by gut microflora fermentation promoting the health of

Table 4. Some International Committee Recommendations regarding RDA for total dietary fiber intake

Source	Recommendation (g/day)
National Cancer Institute	20–30
USDA and USFDA	38 for men and 26 for women
National Academy of Sciences (USA)	30–38 for men and 21–26 for women
UK Department of Health	18 (expressed as Non starch polysachharide)
German Department of Health	30

(Bemiller 2004)

colonic epithelium due to increased level of short chain fatty acids, lowering pH in colonic, which inhibits growth of harmful bacteria and promote favorable lactic acid microflora growth [50].

6.3 Role of Fiber in Preventing Cancer

Dietary fiber and colon cancer well documented relationship between the two, despite its complexity. Anticarcinogenic and antitumerogenic effects imparts by dietary fiber either by reducing concentration of carcinogenic substances in colon [51], or by decreases effective interactions by increasing faecal bulk in faeces between intestinal mucosa and cancer agents [52]. Dietary fiber intake in diet helps in reducing cancer of colorectal in large intestine by incresing fermentation resulting in productions of short chain fatty acids [53]. The short chain fatty acid such as butyric acid plays role in cell differentiation and inhibit in the production of secondary bile acids resulting in lowering in malignant changes in cell [54].

6.4 Dietary Fiber and Diabetes Mellitus

Type 2 diabetes mellitus and intake of high fiber diets shows inversely correlated relationship [55]. The plasma glucose concentration reduction due to consumption of high fiber intake lowers post-prandial glucose peak which decreases insulin demand in blood and over exhaustion protection of pancreas. Ingestion of dietary fiber diets lowers gastric emptying by gel matrix formation due to high water holding capacity [56]. This gel matrix formation by dietary fiber may thicken contents of small intestinal and contact between food and digestive enzymes decreased [57]. In addition, contractile movements in gastro intestinal tracts by the fibers could change and thereby transport of glucose to the absorptive surface decreased [58].

6.5 Dietary Fiber for Weight Management

Potential of dietary fiber as satiety agent and a contributor to weight management as suggested and examined by number of researches [53]. Increase of mobilization and use of fat depots from body by dietary fiber intake may results in reduction of insulin secretion [59]. The diets rich in fiber content leads to slower rate of nutrient absorption by slowing down in gastric emptying [60].

7. DIETARY FIBER ADDITION ON MEAT AND MEAT PRODUCTS

In recent years changes in socioeconomic factors have increased the consumer's preference for ready to eat foods including meat product which are generally recognized as good sources of high biological value proteins, fat soluble vitamins, minerals, trace elements and bioactive compounds. Their processing leads to generation of many functional compounds which have been proven as beneficial to human health. These processed meat products are found to be rich in fat, added salts but deficient in complex carbohydrates like dietary fiber and pose a health hazard that may be responsible for cardiovascular diseases, colon cancer, obesity including diabetes mellitus.. In developing countries like India rapid urbanization, industrialization, globalization as well as increasing number of women workforce have shifted people towards fast foods. Many of these processed foods including meat products lack minimum amounts of dietary fibre. According to the epidemiological research the emergence of a range of chronic diseases is associated with a diet containing an excess of energy-dense foods rich in fat and sugar and the, including colon cancer, obesity, cardiovascular diseases, and several other disorders which can be reduced by the consumption of fiber[61]. Recent research findings also reveal that a diet high in fibre generally promotes a healthier life style [62] and fibre intake can be viewed as a marker of healthy diet. According to the American Dietetic Association, the current recommended fibre intakes for adults range from 25 to 30 g/day and the insoluble/soluble fibre ratio should be 3:1. In developing countries Dietary fibre has been widely used as key ingredient in nutritionally designed foods due to its significance in health promotion from last few years [63]. Meat, a highly nutritious and versatile food besides water contains principal components (proteins and fats), with a substantial contribution of vitamins and minerals of a high degree of bioavailability. However, with the help of fiber meat and meat products can be tailored into more “healthier” form, beneficial for health [64]. Various types of fibres have been studied either alone or combined with other ingredients for formulation of reduced-fat meat and meat emulsions [65]. Meat which is an important source of all essential nutritional components of our daily diet as it contains 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. Dietary fiber which is very essential component for normal physiological/biochemical process when incorporated into meat and meat products has provided a wide range of health beneficial products. The deficiency of dietary fiber can be improved by supplementation of dietary fiber rich vegetative substances like cereal and pulse flour, vegetable and fruits pulp etc. By this technology 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 used as successful alternatives for unhealthy fat components from the products and might increase acceptability by improving nutritional components, pH, water holding capacity, emulsion stability, 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.

7.1 Effect of Fiber Addition on Physico-chemical Properties of Meat Products

Incorporation of fiber can significantly improve the physicochemical properties of the meat. Fiber addition in meat results in decreasing cooking loss, alteration in pH and an increase in emulsion stability. From technological as well as economical point of view an important parameter higher cooking yield of emulsion based meat products has been achieved by higher emulsion stability. The change in pH on addition of dietary fiber source largely depends upon the pH of the fiber source added. Peach dietary fibre (DF) suspensions (17 and 29%) were used to obtain low-fat high-DF frankfurters (20% fat) which were compared to an all-meat control (25% fat). The viscosity of the meat can also be varied with the incorporation of DF content. The protein (11.5%) and collagen (1.4%) contents of frankfurters were not affected by DF addition, and the higher the DF content, the lower the pH (6.4 to 5.8) due to the fibre solution acidity [66]. Dry-cured sausages with two types of dehydrated lemon albedo (raw and cooked) at five concentrations (0–100 g kg−1 in 25 g kg−1 increments). The addition of albedo improved the nutritional properties as a result of fibre addition and beneficial effects due to the presence of active bio compounds [67]. On the contrary, [68] evaluated dry-cured sausages with added orange fibre. During curing process pH of dry cured fermented sausage can be decreased by addition of dried orange fibre at different concentrations (10, 15 and 20 g/kg)lans it was reported with increasing concentration of fibre, pH decreased progressively. the extracts of fruit by products like kinnow rind powder (KRP), pomegranate rind powder (PRP) and pomegranate seed powder (PSP)above have been reported as potential sources of natural antioxidants in meat products [69]. pH has also been increased by addition of Rye bran [70] and wheat bran [71] at different levels and the highest pH was obtained with addition of 20% wheat bran and rye bran. Incorporation of Wheat bran and oat bran at 5, 10 and 15% levels in chicken meat patties had increased pH of emulsion as well as cooked product [72]. Carrageenan and oat fibre on the hydration/binding properties, colour and flavour characteristics of frankfurters. Addition of carrageenan or oat fibre reduced cook loss and increased both water holding capacity and emulsion stability [73]. Soy fiber (SF) on bologna sausages favored the formation of harder, chewier structures with improved fat and water binding properties [74]. Chicken frankfurters fat content decreased by using various levels of oat bran and added water. Frankfurters with higher levels of oat bran had less expressible moisture and required higher shear stress to break [75]. Pea fiber incorporation in Patties and ground beef patties improved tenderness and cooking yields and showed less change in thickness during cooking, but required longer cooking times [76]. Another functional parameter i.e., water holding capacity was increased in meatballs by addition of Bacterial cellulose (Nata.) but pattern was reversed after cooking because cooking losses of Nata-containing products were higher than that of control [77].

7.2 Functional Properties of Dietary Fiber in Meat Products

With the passage of time utilization and incorporation of dietary fiber in meat products are gaining importance. The demand of fiber incorporation in meat products is increasing because of the numerous functional properties like water holding capacity, lubrication, ability to reduce cooking loss, texture modification and neutral flavor [78] and promising results has been shown by the Dietary fibers isolated from various plant sources such as dehydrated fruits, vegetables and cereal fibers in the food industry [79]. However, the better oil binding capacity of fruit and vegetable fiber is a need in emulsion based products [80]. The hydration and oil binding properties of dietary fiber are related to their chemical structure, pH, ionic strength and particle size [81] (Tables 1-4) which affect the possibility about the use of various fibers as ingredients in meat products. For example, dietary fiber with high oil holding capacity allows the stabilization of fat in emulsion based products whereas, the dietary fibers with high water holding capacity can be used as a functional ingredient to avoid synaeresis and to modify the viscosity and texture of some formulated foods [82]. Various fiber sources like oat, sugar beet, soy, pea, psyllium etc. have been used in formulation of some meat products such as patties and sausages [83]. Fiber is also being used as an extender, binder and fat replacer in development of various meat products [84].

7.3 Effect of Dietary Fiber Addition on Proximate Composition of Meat Products

The alteration of overall composition in meat products by fiber addition has led to the emergence of novel sources of fibers, being offering new opportunities in their use in the industries. Increase in moisture, protein, ash and carbohydrate content has been reported in cooked and uncooked beef burgers with hydrated wheat fiber (1:1) [85]. They reported that the decrease in fat content can be successfully achieved by addition of wheat fiber and hence suggested wheat fiber as a fat replacer. Incorporation of bran in Turkish were also studied and reports demonstrate that they positively affected chemical composition, weight losses, dietary fibre content, colour and sensory properties of Control samples and 10% corn bran added samples had the highest overall acceptability scores and 15% of corn bran addition also led to acceptable products [86]. Addition of low fat soy flour and/or mung bean powder as meat extenders in buffalo meat at a level of 10% reduced the moisture and fat content, whereas increased the fiber and protein contents in the cooked samples [87]. The use of rice bran in kung-wan, an emulsified pork meatball decreased protein and fat contents of meatballs, and in contrast, carbohydrate content significantly increased with increasing amount of rice bran [88].

7.4 Effect of Dietary Fiber on Sensory Properties of Meat Products

The important criteria of meat products to be acceptable by consumers are Sensory which depends on aroma and flavour, colour, appearance, tenderness and juiciness. Out of all the above sensory parameters, consumer are more attracted by flavor and texture and tender and juicy meat is generally preferred by the consumers [89]. Addition of pea cotyledon fiber in low fat (10 and 14%) beef patties resulted in improved tenderness without any negative effect on juiciness or beef flavor intensity [86]. Inulin effect on the textural and sensory properties of mortadella, a Spanish cooked meat product. Textural analysis indicated that powdered inulin increases hardness [90] .It can be established that this product can be enriched with inulin to a maximum level of 7.5% and preferably as gel with a good sensory quality. The incorporated wheat bran as a fat replacer in the production of meatballs with four different formulations including 5%, 10%, 15% and 20% wheat bran addition. Control samples were formulated with 10% fat addition. There was significant difference among the meatball samples in respect to sensory properties and control samples had higher acceptability than the other meatball samples [73]. Dry fermented sausage, known as sobrassada, containing different percentages of carrot dietary fibre from 3 to 12% [91]. Addition of carrot dietary fiber to sobrassada modified the organoleptic properties depending upon the concentration. All the sensory attributes were declined when the level of added dietary fiber was greater than 3%.

7.5 Fiber and Textural Properties of Meat Products

Texture, appearance and flavor are the three important components of food acceptability.

Though there is no alternative of human perception for texture measurement but most common used for measurement is Instron Texture Analyzer. Detrimental effect on textural attributes in Chinese style meatball due to addition of Bacterial cellulose (Nata.) was reported. An increasing level of Nata incorporation has shown a decreasing pattern in hardness, cohesiveness, springiness, chewiness and shear force [77]. In contrast to this Incorporation of inulin increased hardness value of mortadella, a Spanish cooked meat product. In powdered form Inulin increased hardness at 2.5 % level while in gel it affected hardness at 7.5% [85]. Rice bran fiber fortification on the textural properties of heat induced gel and found that hardness was significantly lower in gels with added rice bran fiber than the control samples. Similarly, springiness, cohesiveness, gumminess and chewiness were reported lower in all samples with added rice bran fiber relative to control [59].

7.6 Quality Characteristics of Fiber Rich Meat Products during Storage

During storage of meat and meat products superior quality with shelf stability of a meat product period is of utmost importance. Addition of various types of fiber source in meat products have been found to influence the storage quality in various ways. addition of oat flour in chicken kofta has provided microbiologically safe and sensorily acceptable product during the 15 days of storage due to better inhibition of oxymyoglobin oxidation [74]. Addition of roasted flours in buffalo meat burger has also registered a lower TBA value which signifies lower lipid oxidation than control and these burgers were found to be organoleptically acceptable after storage for 4 months [79]. An efficient protection against lipid oxidation in was attained by the addition of rice bran and their antioxidant activity preserved frankfurters till 14 days of storage showing [85]. On the contrary, higher lipid oxidation was also reported in rice bran supplemented frankfurters [92]. During storage the change in pH of meat products is an important parameter which should be kept in control.

7.7 Challenges and Future Potential of Fiber Rich Meat Products

Because of the numerous functional properties of dietary fiber like water retention, emulsion stability, lubrication, texture modification and neutral flavor the demand of fiber incorporated meat products is increasing day by day. To fulfill this purpose various fiber sources like oat, rice, sugar beet, soy, pea, psyllium etc. have been practiced in formulation of some meat products such as patties and sausages for development of nutritionally balanced diet. Fiber is also being used as a fat replacer in various meat products. For technological improvement of meat products dietary fiber is now used like increase in cooking yields, rheological properties, reducing formulation costs and enhancing the palatability and texture of meat products. The dietary fiber rich meat products have proven to be clinically better than traditional meat products. But the real challenge actually is effective development and marketing of these functional meat products. Even from the consumer perspective, the trust on the composition and desired outcome of fiber rich meat products on regular consumption has to be widely studied. The development of meat products enriched with fiber is indeed a novel area. A lot of work is still left to unfold the real potential of those components which are scarcely used in diet or are now eliminated from diet due to change in food habits [93].

8. CONCLUSION

With the development the people are becoming more conscious towards consumption of food. People are demanding health beneficial products and that is why incorporation of dietary fibers, either soluble or insoluble in the meat products is need of the time. In recent years globalization and consumption of fast foods, dietary fibers can be used as a beneficial ingredient for overcoming the various nutritional and diet related disorders, particularly when the number of patients with such problems are increasing. Various sources of dietary fibers have been explored by different researchers, which are being attempted in the meat products. These sources markedly enhance the dietary fibers content in meat products and making them more functional as well as healthier. An adequate amount of dietary fiber and an appropriate method of incorporation can provide a wide range of fiber fortified foods. Thus it is expected that more acceptable range of novel meat products with promising health benefits will be available in future.

ACKNOWLEDGEMENTS

The first author is very much thankful and appreciable to University Grants Commission for providing fellowship in the form of MANF 16-17.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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