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Dietary fibre as functional ingredient in meat products: A review

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Abstract
Functional foods are a modified food or food ingredient that provides a health benefit beyond satisfying traditional nutrient requirements. The development of functional foods are those foods fortified with vitamins and/or minerals such as vitamin C, vitamin E, folic acid, zinc, iron and calcium. Functional foods could help in prevention and/or management of obesity and type 2 diabetes and could involve food products that help management of 'hunger' or increase 'satiety'. The selection of best source of nutrients for the incorporation, inclusion and replacement is very important at the same time to evaluate the optimum level of inclusion of source materials for development of functional meat products is also important. Since the meat and meat products are low in dietary fibre there are many research have been done in the aspect of dietary fibre incorporation, their role and their level in the final products with different sources of dietary fibre. Hence, this article will help on to understand the functional meat products in detailed with dietary fibre enrichment.

Keywords: Functional foods, functional meat products, dietary fibre, proximate composition

Introduction

Functional meat products are those which provide health benefits beyond basic nutrition and are similar in appearance to conventional foods that are intended to be consumed as part of a normal diet, but have been modified to serve specific physiological roles. These products are generally produced by reformulation of meat by either incorporation of ingredients that have health promoting abilities like variety of fibres, protein, polyunsaturated fatty acids (PUFA), antioxidants, and/or by reduction or replacement of certain ingredients like salt, fat, etc. Meat and meat products are very low in dietary fibre content and hence the intake of dietary fibres along with them has a great role in the nutrition/digestive system. These dietary fibres are concentrated in cereals, pulses, fruits and vegetables and their daily intake helps in prevention of many nutritional disorders, gut related problems, cardiovascular diseases, type 2 diabetes, certain types of cancer and obesity. Meat, which generally lacks dietary fibres, could be incorporated with variety of different sources during product processing to make them healthier. Selection of suitable fibre rich ingredients and their proper incorporation can improve the functionality of meat products. There is a rapid development and attraction towards fast foods with more spices, salt and less dietary fibre resulting in ill effects on the health of consumers/people, especially in urban areas. This article exclusively focuses on dietary fibre enriched functional meat products to obtain knowledge about the importance of dietary fibre and the level of incorporation in variety of meat products.

Functional food

There are three basic requirements for a food to be regarded as functional: (1) it is a food (not capsules, tablets, or powder) derived from natural occurring ingredients; (2) it can and should be consumed as a part of the daily diet; and (3) once ingested, it must regulate specific processes such as enhancing biological defence mechanisms, preventing and treating specific diseases, controlling physical and mental conditions, and delaying the ageing process (Goldberg, 1994) [1]. According to Health Canada (1998) [2], the governmental authority that oversees the approval of food health claims in Canada reported that a functional food is similar in appearance to, or may be a conventional food that is consumed as part of a usual diet, and is demonstrated to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions, i.e. they contain bioactive compounds". Sanders (1998) [3] defined functional food as a modified food or food ingredient that provides a health benefit beyond satisfying traditional nutrient requirements. Roberfroid (1999) [4] studied the health benefits and the concept of functional food and concluded that the development of functional food is a scientific challenge before facing the marketing challenge. It requires a new way of looking at nutrition and food science. Japan was the first country that developed the idea of functional foods and has established regulations for the use of functional foods, which are "any food or ingredient that has a positive impact on an individual's health, physical performance, or state of mind, in addition to its nutritive value" (Hardy, 2000) [5]. Roberfroid (2000) [6] mentioned that a functional food must remain food and it must demonstrate its effects in amounts that can normally be expected to be consumed in the diet; it is not a pill or a capsule, but part of the normal food pattern. Sloan (2000) [7] stated that most early developments in functional foods includes those foods fortified with vitamins and/or minerals such as vitamin C, vitamin E, folic acid, zinc, iron and calcium. Hill and Peters (2002) [8] opined that functional foods could help in prevention and/or management of obesity and type 2 diabetes and could involve food products that help management of 'hunger' or increase 'satiety'. Rafter (2002) [9] stated that one of the most promising areas for the development of functional foods lies in modification of the activity of the gastrointestinal tract by use of probiotics, prebiotics and synbiotics.

Foods can be fortified with various micronutrients such as omega-3 fatty acid, phytosterol and soluble fibre to promote good health or to prevent diseases such as cancers (Sloan, 2002) [10]. Doyon and Labrecque (2008) [11] performed an exhaustive analysis on 26 proposed definitions for 'functional food' in literature and generated the following working definition: *"A functional food is, or appears similar to a conventional food. It is part of a standard diet and is consumed on a regular basis, in normal quantities. It has proven health benefits that reduce the risk of specific chronic diseases or beneficially affect target functions beyond its basic nutritional functions".* Functional foods are evolving as a potential chronic disease preventative strategy as they are purported to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions (Hasler and Brown, 2009) [12]. The EC (European Commission) Concerted Action on Functional Food Science in Europe (FUFOSE, 2010) [13] proposed a working definition for functional food: a food that beneficially affects one or more target functions in the body beyond adequate nutritional effects in a way that is relevant to either an improved state of health and well-being and/or reduction of risk of disease. It is consumed as part of a normal food pattern and is not a pill, a capsule or any form of dietary supplement. International Food Information Council Foundation (2011) [14] mentioned that "functional foods," are thought to provide benefits beyond basic nutrition and may play a role in reducing or minimizing the risk of certain diseases and other health conditions. Academy of Nutrition and Dietetics (2013) [15] defined functional food as "Whole foods along with fortified, enriched, or enhanced foods that have a potentially beneficial effect on health when consumed as part of a varied diet on a regular basis at effective levels." Bornkessel *et al.* (2014) [16] stated that functional foods can be interpreted as the carrier for functional ingredients with certain health benefits.

Meat as functional food

Yilmaz and Daglioglu (2003) [17] developed meatballs by replacing fat with oat bran and studied the effect on fatty acid composition and physicochemical properties. They concluded that the total trans fatty acids were lower and the ratio of total unsaturated fatty acids to total saturated fatty acids was higher in the samples with added oat bran than in the control meatballs. Yilmaz (2004) [18] studied the effects of rye bran addition on fatty acid composition and quality characteristics of low-fat meatballs and he observed that the total trans-fatty acids were lower and the ratio of total unsaturated fatty acids to total saturated fatty acids was higher in the samples with added rye bran than in the control meatballs. Yilmaz (2005) [19] developed low fat meatballs with added wheat bran as a functional ingredient to study the physicochemical and sensory characteristics. He observed that the total trans fatty acids were lower and the ratio of total unsaturated fatty acids to total saturated fatty acids were higher in the samples with added wheat bran than in the control meatballs. Eim *et al.* (2008) [20] studied the effects of addition of carrot dietary fibre on the ripening process of a dry fermented sausage (sobrassada). They added different percentages of carrot dietary fibre (DF) [3, 6, 9 and 12 per cent (w/w)] and analysed for various Physico-chemical and microbiological parameters and sensory attributes. The ripening process was monitored throughout storage. The pH of DF-supplemented sobrassadas was critically affected during ripening by the amount of DF incorporated. Hence they concluded that sobrassada samples containing over 3 per cent of DF suggested that the fermentation process in these samples was not successful.

Kumar *et al.* (2010) [21] developed chicken nuggets formulated with green banana and soybean hulls flours and concluded that addition of GBF and SHF to chicken nuggets represented an improvement in their nutritional quality and has some beneficial effects due to presence of dietary fibres. Verma *et al.* (2010) [22] developed low fat chicken nuggets by replacing sodium chloride with the addition of apple pulp and concluded that low salt, low fat and high fibre functional chicken nuggets can be developed with very good sensory rating (6.9-7.4) by replacing 40 per cent common salt and incorporation of apple pulp. Verma *et al.* (2012) [23] developed low fat chicken nuggets by replacing sodium chloride with the addition of chickpea (*Cicer arietinum* L.) hull flour. They observed that replacement of 40 per cent common salt by blend did not affect organoleptic qualities except appearance and flavour. Addition of chickpea hull flour resulted significant increase in dietary fibre while decreased total cholesterol content. Verma *et al.* (2013) [24] developed sheep meat nuggets by incorporating Guava (*Psidium guajava* L.) powder as a functional source of Antioxidant and Dietary Fibre. They observed that incorporation of guava powder could protect cooked sheep meat nuggets against lipid oxidation during refrigerated storage. Hence, incorporation of guava powder up to one per cent level did not affect products organoleptic attributes and it can be used as a source of antioxidant and dietary fibre in sheep meat nuggets without affecting their acceptability. Santhi and Kalaikannan (2014) [25] developed low-fat chicken nuggets with the addition of oat flour and concluded that up to 10 per cent oat flour can be added for better sensory qualities and texture. Zargar *et al.* (2014) [26] developed comparatively low-cost fibre enriched chicken sausages by utilizing chicken meat and further replacing the same with pumpkin as a functional ingredient and also they studied the effect of pumpkin on the quality characteristics and storage quality of aerobically packaged chicken sausages. They found that the crude fibre content increased significantly ($P < 0.05$) with increasing levels of pumpkin. The pumpkin incorporated sample had higher crude fibre (1.81 per cent) content than control sample (0.78 per cent). This increase in crude fibre might be due to high fibre level present in pumpkin.

Dietary fibre incorporated meat products

Dietary fibre unquestionably has an important role in maintaining normal laxation and microbial population in the large bowel. Populations with long transit times and small stool weights typically have very low fibre intakes while populations with relatively short transit times and large stool weights have relatively high fibre intakes (Spiller, 1986) [27]. Viscous fibre sources are likely to play a role since they reduce lipid risk factors for Coronary Heart Disease (CHD) including total and low density lipoprotein cholesterol and Apo lipoprotein B by increasing faecal bile acid losses. Soluble fibre may reduce the rate of nutrient absorption thereby altering chylomicron synthesis and reducing postprandial glucose and insulin levels and other risk factors for CHD (Jenkins *et al.*, 1998) [28]. Schneeman (1998) [29] stated that a dietary pattern that is high in fibre and starch content is typically low in total fat, saturated fatty acids and cholesterol contents. These properties are higher in plant than animal protein, and in addition plant sources are rich in phytochemicals that have physiologic activity. Walker (1998) [30] studied the effect of changing fat and fibre intake on patients with CHD and observed that dietary changes in fat and higher fibre intake caused a partial regression of lesions in the coronary vessels, colon, and in the rectum.

Dietary fibres have the potential to reduce low density lipoprotein cholesterol in blood. Various soluble fibres (pectin, oat bran, guar gum, and psyllium) can reduce total and LDL cholesterol by similar amounts. The effect is small within the practical range of intake but 3 g soluble fibre from oats (3 servings of oatmeal, 28 g each) can decrease total and LDL cholesterol by <0.13 mmol/L. Increasing soluble fibre can make only a small contribution to dietary therapy to lower cholesterol (Brown *et al.*, 1999) [31]. Dietary fibre is one of the ingredients that could be added to meat products for the development of low-fat and high fibre functional meat products. Dietary fibre is defined as the remnant of edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in human small intestine (Prosky, 1999) [32]. Fibre from plant sources has previously been used in cooked meat products because of their ability to bind water and fat thereby improving cooking yield and texture (Cofrades *et al.*, 2000) [33]. Kritchevsky (2000) [34] opined that a diet high in fibre generally promotes a healthier life style and amount of fibre intake can be viewed as a marker of healthy diet.

Consumption of fruits and vegetables imparts the dietary fibre and health benefits that are mainly attributed to organic micronutrients such as carotenoids, polyphenolics, tocopherols, vitamin C and others (Scheieber *et al.*, 2001) [35]. Prakongpan *et al.* (2002) [36] studied extraction and application of dietary fibre and cellulose from pineapple cores (PC) and they concluded that pineapple cores have a potential to be a good source of dietary fibre and cellulose, which can be used as functional ingredient in preparation of bakery and meat products depending on its type and particle size. Small-size PC (>170 mesh) was more suitable for reducing shrinkage and improving texture of beef burgers. The water interaction of fibres, especially water retention capacity appeared to have a marked influence on their functional properties. A high dietary fibre intake, particularly water soluble fibre is strongly and independently associated with a lower risk of coronary heart disease and cardiovascular diseases (Bazzano *et al.*, 2003) [37]. Liu *et al.* (2003) [38] studied the relation between changes in intakes of dietary fibre and grain products and changes in weight and development of obesity among middle-aged women and concluded that weight gain was inversely associated with the intake of high-fibre, whole-grain foods but positively related to the intake of refined-grain foods, which indicated the importance of distinguishing whole-grain products from refined-grain products to aid in weight control.

Based on the solubility in water, fibre can be divided into soluble fibre and insoluble fibre, which also has a difference in the physiological properties. Properties of water-soluble fibre include forming a viscous solution, have great water holding capacity but are unable to maintain the water, and easily get fermented while, insoluble fibre is less viscous, lesser water-binding capacity, but greater ability to maintain water (Marsono, 2004) [39]. American Dietetic Association (2008) [40] recommends consumption of 14 g of dietary fibre per 1,000 kcal, or 25 g and 38 g for adult women and adult men per day respectively.

Sayago-Ayerdi *et al.* (2009) [41] studied the effect of grape antioxidant dietary fibre on the lipid oxidation of raw and cooked chicken hamburgers and concluded that the addition of GADF in breast chicken meat inhibited oxidation upto 13 days of refrigeration storage, increasing the lipid stability and the shelf life of the food. Addition of dietary fibres to a meat product enhanced the health beneficial properties and improves the stability without affecting the acceptability of the food. Kendall *et al.* (2010) [42] opined that high fibre diets directly reduce heart disease risks by modifying serum lipid risk factors as well as other biomarkers. Kumar *et al.* (2010) [21] studied the addition of green banana and soybean hull flours in chicken nuggets and observed that addition of fibre sources improved their nutritional quality as well as had more beneficial effects due to presence of dietary fibres. Potential dietary fibre sources from various cereals, legumes, fruits and vegetables could be used as functional ingredients in meat products by different processing methods (Verma *et al.*, 2010) [22]. Bhat and Bhat (2011) [43] concluded that meat and meat products can be modified by adding fibre sources to decrease the possibility of chronic diseases associated with them. The use of these ingredients in meat products offers processors the opportunity to improve the nutritional and health qualities of their products. As per Food and Drug Administration (2014) [44] the total dietary fibre intake should be 25 grams per day, out of which about 25 per cent (about 6 g) should be soluble fibre. Current dietary guidance recommendations encourage decreased consumption of dietary fat, especially saturated fat and cholesterol, and increased consumption of fibre-rich foods to help lower blood LDL-cholesterol levels.

Proximate composition of dietary fibre enriched meat products

Trout *et al.* (1992) [45] observed a decrease in moisture per cent of low fat ground beef patties with the addition of fat replacers containing poly dextrose (PD), potato starch (PS) and pea fibre (PF). Patties with fat replacers lost less moisture during cooking than controls and patties with PD-PS-PF had less moisture initially and lost as little as 3.3 per cent moisture during cooking compared to its control (6.7 per cent). Yilmaz (2004) [18] reported that the meatballs produced with the addition of 20 per cent rye bran had the lowest (57.77 per cent) moisture content compared to control meat balls (67.29

per cent). The moisture contents of the low fat meatballs decreased constantly with increasing levels of rye bran addition. Yılmaz (2005) [19] reported a decrease in moisture content in low fat meatballs added with different levels (5, 10, 15 and 20 per cent) of wheat bran. The meatballs produced with the addition of 20 per cent wheat bran had the lowest (58.13 per cent) moisture content compared to control meat balls (66.82 per cent). Jackson *et al.* (2006) [46] studied the utilization of rice starch in the formulation of low-fat, wheat-free chicken nuggets. The samples formulated with rice batter had lower moisture content than samples formulated with wheat batter in all treatments except for the wet batter and baked treatments. This was probably due to increased moisture loss during the heating process and chemical changes in rice as well as due to increased carbohydrate percentage in samples formulated with rice batter. Verma *et al.* (2012) [23] reported that addition of chick pea hull flour as a sodium chloride replacer significantly decreased (P<0.01) the moisture per cent and the moisture was further reduced with addition of chickpea hull flour with significant effect at 10 per cent level. Higher moisture per cent in control product could be due to higher concentration of common salt content, which allowed more meat protein extraction and thus more moisture binding (Somboonpanyakul *et al.* 2007) [47].

Suradkar *et al.* (2013) [48] observed that the moisture content of chicken nuggets prepared without the incorporation of bread crumbs (59.34 per cent) was significantly higher than the treatments (56.53 per cent) and there was no significant difference among treatments. Verma *et al.* (2013) [24] observed that the moisture content in the nuggets added with guava powder (1 per cent) was significantly lower (P<0.05) than that of control. This could be due to the loss of water/moisture, temporarily bound by the guava powder during cooking and that guava powder comprises mainly of insoluble dietary fibre which could not have retained moisture content during cooking. Malekian *et al.* (2014) [49] observed that the moisture content of the raw sausages decreased slightly in response to increased rice bran percentage, whereas the moisture content of cooked sausages decreased linearly in response to increasing rice bran percentages. This was due to the addition of ample water to the batter before rice bran was added and exposure for 6-7 hours of cooking and smoking. Santhi and Kalaikannan (2014) [25] observed that the addition of oat flour in low fat chicken nuggets significantly (P<0.05) increased the moisture level in the treatments (62.12 per cent) compared to control (57.40 per cent).

Yilmaz and Daglioglu (2003) [17] found an increase in the protein percentage, with an increase in the oat bran addition in the meat balls prepared from veal. The differences in the protein content of the meatballs were significant (P<0.05) and the highest protein content (18.8 per cent) was recorded in meat balls incorporated with 20 per cent oat bran. Ahamed *et al.* (2007) [50] observed that protein content of batter and cutlets with refined wheat flour was significantly higher than other flours viz. potato starch, corn flour and tapioca flour which can be probably due to higher protein content of wheat flour as compared to other flours. Lukman *et al.* (2009) [51] studied the physicochemical and sensory properties of commercial chicken nuggets and observed that the protein value ranged from 12.52 per cent to 16.62 per cent. They opined that the difference in protein content depends on the raw meat that is used in the manufacturing of chicken nuggets. Kumar *et al.* (2010) [21] studied the quality evaluation of chicken nuggets formulated with green banana and soybean hull flours and observed that the control samples had significantly higher protein content (20.59 per cent) than treatment (nuggets with GBF 4 per cent) sample (18.84 per cent).

Biswas *et al.* (2012) [52] developed low-fat, low-sodium functional chicken meat patties with the incorporation of carrageenan and broken wheat and observed that the protein content of control (41.03 per cent) was lower than the treated sample (44.52 per cent). Hence, they concluded that addition of wheat had a potential as a good source of DF and valuable protein. Das *et al.* (2013) [53] studied the effect of addition of fermented bamboo shoot on the quality of nuggets prepared from desi spent hen and observed that the fermented bamboo shoot addition resulted in a significant increase (P<0.01) in the crude protein level of the treatment products (15.24 per cent) compared to control (17.83 per cent). Melekian *et al.* (2014) [49] studied the composition and fatty acid profile of goat meat sausages with added rice bran and observed that the percentage of protein was greater in the cooked sausages (21.1 per cent) than the raw sausages (12.8 per cent). This probably was due to the moisture loss during the treatment and cooking process. Santhi and Kalaikannan (2014) [25] studied the effect of addition of oat flour in low-fat chicken nuggets and observed that the crude protein level of chicken nuggets decreased significantly with the increased in the level of oat flour. Crude protein content of control was 18.03 per cent compared to 15.79 per cent in oat flour added chicken nuggets.

Fat is an important constituent of human nutrition and is a source of vitamin and essential fatty acids, and provides most of energy in diet. Fat also can contribute to the flavour, tenderness, juiciness, appearance, and texture of meat products (Cavestany *et al.*, 1994) [54]. Yilmaz and Daglioglu (2003) [17] studied the effect of replacing fat with oat bran on fatty acid composition of meatballs and observed that oat bran addition at 20 per cent level resulted in a significant (P<0.05) reduction in the fat content (8.4 per cent) and the highest fat content was obtained from the control meatballs (21.2 per cent). Yilmaz (2004) [18] studied the effects of rye bran addition on fatty acid composition of low-fat meatballs and observed that rye bran addition at 20 per cent resulted in a significant (P<0.05) reduction in the fat content (8.5 per cent) and the highest fat content was obtained from the control meatballs (11.2 per cent). Yilmaz (2005) [19] studied the physicochemical and sensory characteristics of low fat meatballs with added wheat bran and observed that rye bran addition at 20 per cent resulted in a significant (P<0.05) reduction in the fat content (8.8 per cent) and the highest fat content was obtained from the control meatballs (11.7 per cent). Yang *et al.* (2007) [55] developed low fat pork sausages with added hydrated oatmeal and tofu and observed that the fat content has decreased slightly by the addition of both hydrated oatmeal and tofu, with values of 3.14 g/100 g and 3.43 g/100 g at a 25 per cent addition level respectively, while the control sample was having 4.09 g/100 g. Talukder and Sharma (2010) [56] developed dietary fibre rich chicken meat patties using wheat and oat bran and observed that there was no significant difference in fat content of baked and steamed patties in both control and bran added patties.

Viuda-Martos *et al.* (2010) [57] studied the effect of orange dietary fibre, oregano essential oil and packaging conditions on the shelf-life of bologna sausages and reported that fat improves flavour because of its balance intensity, distribution and migration. However, fat changes the texture of the product by influencing binding, rheological and structural properties of comminuted meat products. Yogesh *et al.* (2013) [58] studied the characteristics of chicken nuggets added with variable fat and salt contents. They concluded that even up to 5 per cent level of chicken fat with 1.5 per cent added salt did not give any adverse effect in terms of Physico-chemical, proximate composition and sensory qualities of cooked chicken nuggets. Singh *et al.* (2014) [59] developed low fat chicken nuggets using extenders viz. soya chunk and chick pea flour and found that the fat content was highest in control (22.05 per cent) and lowest in treatment sample (15.24) which was containing 15% soya chunk and 15% chickpea flour as extenders.

Field (1976) [60] observed that the ash content of mechanically deboned chicken meat is higher compared to traditional deboned chicken meat (chicken meat deboned by hand). This is because during the process of mechanical deboning, the bones of the meat were crushed and mixed into the mince causing higher ash content. Yilmaz (2004) [18] studied the effects of rye bran addition on fatty acid composition and quality characteristics of low-fat meatballs and reported that ash contents of the samples were significantly (P<0.05) affected by rye bran addition. Ash contents increased with more rye bran addition. The highest value was obtained in the 20 per cent of rye bran added samples and the lowest in the control meatballs. Talukder and Sharma (2010) [56] developed dietary fibre rich chicken meat patties using wheat and oat bran and found that the ash content of wheat bran added patties was significantly higher at all levels of incorporation than oat bran added patties. Higher ash content of wheat bran added patties was contributed by the higher ash content of wheat bran (5.8 per cent) as compared to oat bran (2.1 per cent). Verma *et al.* (2012) [23] studied the effect of sodium chloride replacement and added chickpea (*Cicer arietinum* L.) hull flour on the quality of low fat chicken nuggets and found that the ash content in the control nuggets (3.14 per cent) was significantly higher (P<0.01) than the nuggets containing chick pea hull flour (2.68 per cent). However no significant differences in the ash content were observed between different levels of inclusion of CHF.

Melekian *et al.* (2014) [49] studied the composition and fatty acid profile of goat meat sausages with added rice bran and observed that addition of rice bran did not affect the ash per cent of raw sausages, but the ash per cent of cooked sausages decreased linearly in response to the increasing level of rice bran. They attributed this decrease may be due to the moisture loss during cooking process. Zargar *et al.* (2014) [26] added pumpkin as a source of fibre and its pulp was incorporated at different levels i.e. 0, 6, 12, and 18 per cent in the formulation by replacing lean meat in the preparation of chicken sausages and observed that a significantly (P < 0.05) lower value (2.36) for ash at all incorporation levels of pumpkin as compared to control (2.81 per cent). Vural *et al.* (2004) [61] studied the effects of inter esterified vegetable oils and sugar beet fibre on the quality of frankfurters and found that the use of sugar beet in frankfurter increased the dietary fibre content and water holding capacity without significant changes in sensory scores. Talukder and Sharma (2010) [56] developed dietary fibre rich chicken meat patties using wheat and oat bran and observed that oat bran meat patties had significantly lower Total Dietary Fibre (TDF) than wheat bran added patties. This was on expected lines as TDF content of wheat bran (47.1 per cent) was much higher than the oat bran (16.5 per cent). Verma *et al.* (2013) [24] studied the guava (*Psidium guajava* L.) powder as an antioxidant dietary fibre in sheep meat nuggets and observed that incorporation of guava powder in the formulation of sheep meat nuggets significantly increased (P<0.05) the total dietary fibre content and total phenolics at each level (0.5 and 1 per cent) of incorporation. Das *et al.* (2014) [53] developed goat meat nuggets with the addition of Bael Pulp Residue (BPR) as a new source of antioxidant dietary fibre and reported that BPR contains good amount of total phenolic (15.16 mg Gallic Acid Equivalents/g dry weight) and dietary fibre (56.91 per cent). The addition of BPR significantly improved total phenolic and dietary fibre of the meat products.

Caceres *et al.* (2004) [62] studied the effect of short-chain fructo-oligosaccharides, non-digestible oligosaccharides in reducing energy levels of cooked sausages and reported decrease in energy values from 279 kcal/100 g in the conventional control to 187 kcal/100 g in the reduced-fat sausages with 12% added fibre. Huang *et al.* (2005) [63] studied the effect of rice bran on sensory and Physico-chemical properties of emulsified pork meatballs and observed that the carbohydrate percentage of rice bran (15 per cent) added sample (7.90 per cent) was significantly (P<0.05) higher than the control sample (0.87 per cent). Carbohydrate content in chicken nuggets ranged from 7.52% - 26.49%. The increase of carbohydrate content in modern chicken nuggets could be due to an increase in starch content (acts as extender) to substitute raw meat in the manufacturing of chicken nuggets. (Lukman *et al.*, 2009) [51]. Melekian *et al.* (2014) [49] studied the composition and fatty acid profile of goat meat sausages with added rice bran and observed that the carbohydrate percentage of raw and cooked sausages did not change significantly in response to the increasing rice bran percentages. This could be due to cooking and smoking process. Cooking process decreased the carbohydrate percentage from raw (4.3 per cent) to cooked (1 per cent). Singh *et al.* (2014) [59] developed low fat chicken nuggets using chickpea flour and soya chunk as extenders and studied the physicochemical characteristics. The carbohydrate content increased significantly (P>0.01) from 14.827 to 19.690 per cent in different treatments. The increase in carbohydrate content of chicken nuggets could be due to increase in starch content to substitute raw meat in the preparation of chicken nuggets.

Conclusion

Dietary fibre incorporation in meat products are well suited because of its various functional properties like water retention, emulsion stability, texture and flavour modification etc. Apart from the nutritional properties, dietary fibre is now used in meat products for quality parameters up gradation like improvement in rheological properties, cooking yield, emulsion stability, texture profile and reducing the formulation costs. The dietary fibre enriched meat products are comparatively better than traditional meat products in the aspect of clinical point. Even though the real challenge lies in effective development and marketing of functional meat products, a lot of research is still needed in this area.

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