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Review Article

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Productıon of Low-Fat High-Fiber Meatballs

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Abstract Numerous studies have been demonstrated the beneficial effects of dietary fiber (DF) consumption in protection against heart disease and cancer, normalization of blood lipids, regulation of glucose absorption and insulin secretion and prevention of constipation and diverticular disease. Meat and meat products are undoubtedly major source of food proteins with high biological value in many countries. However, most of the meat products are deficient in complex carbohydrates such as DF. Fibers generally can be introduced into meat products, to reduce the caloric content by fat substitution and improve the texture and stability of meat product. So, DF is one of the ingredients to provide meat products with low-fat and high-fibers. Different types of dietary fibers (wheat bran, oat bran, rye bran, rice bran, peach fiber, carrot fiber, lemon albedo, sugar beet fiber, brewer's spent grain, etc.) have been studied either alone or combined with other ingredients for development of nutritionally balanced diet. Meatballs are ground meat rolled into small balls, sometimes along with other ingredients, such as bread crumbs, minced onion, eggs, and seasonings and are very popular meat products in Turkey with different recipes. Dietary fibers such as brans (wheat, oat, rye, maize), inulin, legume flours (blackeye bean, chickpea, lentil, rusk) and citrus fiber have been studied in the formulation of low-fat high-DF meatballs. In the present review, various DF sources and their applications in meatballs and effects on quality attributes have been reviewed.

Keywords Dietary fibers, meatballs

1. Introduction

Dietary fiber (DF) is defined as the remnant of edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in human small intestine [1]. The beneficial effects of fiber consumption in protection against heart disease and cancer, normalization of blood lipids, regulation of glucose absorption and insulin secretion and prevention of constipation and diverticular disease have been demonstrated by numerous studies [2]. DF can also impart some functional properties to foods, e.g., increase water holding capacity, oil holding capacity, emulsification and/or gel formation. Indeed, DF incorporated into food products can modify textural properties, avoid synaeresis, stabilise high fat food and emulsions, and improve shelf-life. Meat and meat products are undoubtedly major source of food proteins with high biological value in many countries [3]. However, most of the meat products are deficient in complex carbohydrates like DF. The suitability of DF incorporation in meat products is increasing because of the numerous functional properties like water retention, lubrication, ability to decrease cooking loss, texture modification and neutral flavor [4-5]. So, DF is one of the ingredients to provide meat products with low-fat and high fibers.

Dietary Fiber Applications to Meat Products

In recent years, the consumer demands for healthier meat and meat products with reduced level of fat, cholesterol, decreased contents of sodium chloride and nitrite, improved composition of fatty acid profile and incorporated health enhancing ingredients are rapidly increasing worldwide [6]. Most of the meat products are

rich in fat and protein but deficient in dietary fiber [7] and its incorporation in the meat products from health point of view have been further emphasized a lot. Various fiber sources like oat, rice, sugar beet, soy, pea, brewer's spent grain etc. have been tried in formulation of some meat products such as patties and sausages for development of nutritionally balanced diet. DF is also being used as a fat replacer in manufacturing of various meat products. In our previous study, various dietary fibers as functional ingredients in different meat products were reviewed [8]. In this study, the utilization of dietary fibers and their effects on the quality of meatballs (köfte) are discussed. A comprehensive list of different dietary fiber sources utilized in formulation of various meat products has been presented in Table 1.

Dietary Fiber Applications to Meatballs

Wheat bran is the best known source of insoluble dietary fiber. Once called roughage, this type of fiber helps to prevent and control bowel problems and is the fiber linked to lower cancer risk. Yılmaz [9] studied the addition of wheat bran into meatballs at the levels of 5, 10, 15 and 20%. The lower total *trans* fatty acids were found and the ratio of total unsaturated fatty acids to total saturated fatty acids was higher in the samples with added wheat bran than in the control samples. The wheat bran added samples were lighter and yellower in color than the control meatballs. Yılmaz [9] also determined a decrement in fat and moisture contents but an increment in protein and ash percent with increasing level of wheat bran viz. 5, 10, 15 and 20% in low-fat meatballs.

Hydrated wheat fibers (bran and white and red beeswings) were added at three levels (5, 10 and 15%) to beef burgers instead of fat and evaluated for chemical, physical, caloric values and sensory traits. The cholesterol content of uncooked and cooked beef burgers decreased as level of wheat fibers increased or fat content decreased. The addition of wheat fibers reduced the cholesterol content by about 6-45% for uncooked beef burgers and 7-39% for cooked beef burgers. The caloric values of uncooked and cooked beef burgers were lower than that of control by about 6-42%. It can ve summarized that indigested fibers from wheat bran, can be added to replace some of the fat in beef burgers, reducing levels of cholesterol and improving their cooking yield, diameter and texture. So, hydrated wheat fibers can be used successfully as a fat substitute in ground meat products [10].

Jamaly *et al.* [11] studied the effects of different levels of wheat flour as dietary fiber on the quality of fresh and preserved beef meatballs during storage. They concluded that meatballs having 5% wheat flour was better in terms of color, odor, tenderness, juiciness and overall acceptability, cooking loss and microbial qualities. Utilization of different fiber sources in meatball production are also presented in Table 1.

Oat bran was used as a fat substitute in meatballs and it has been reported that meatballs containing oat bran had lower concentrations of total fat, and total *trans* fatty acids than control samples [12]. Meatballs made with 20% oat bran had highest protein and ash contents, lightness, yellowness and lowest moisture as well as redness. There was no significant difference among the meatballs with sensory properties and all samples had high acceptability.

Yılmaz [13] also studied the use of rye bran as a fat substitute in the meatballs with respect to fatty acid composition and some physico-chemical as well as sensory properties. Addition of rye bran to meatballs at 5 to 20% levels improved their nutritional value and health benefits. The total *trans* fatty acid content was lower and the ratio of total unsaturated fatty acids to total saturated fatty acids was higher in the samples with added rye bran. The same samples were lighter and yellower in color than the control meatballs.

Huang *et al.* [14] studied the use of rice bran in Kung-wan, an emulsified pork meatball and found that protein, fat and white index of meatballs decreased as the amount of bran increased. Sensory scores of taste, texture and overall acceptability of meatballs with less than 10% bran showed no significant difference from those for meatballs without bran.

Galanakis *et al*. [15] investigated the dietary fiber suspensions from olive mill wastewater as potential fat replacements in meatballs. A dietary fiber containing material, named as alcohol insoluble residue, was recovered from the olive mill wastewater. It was separated into different fractions (water soluble and insoluble). They concluded that water soluble fraction could be utilized together with carrot fibers restricting the oil uptake and thereby giving rise to meatballs with sustained reduced fat content.

Table 1: Various dietary fiber sources utilized for formulation of fiber-rich meat products

Type /source of fiber	Type of meat product	References
Wheat bran	Meatballs	Yılmaz [9].
	Beefburgers	Mansour and Khalil [10].
	Chicken patties	Talukdar and Sharma [16].
	Beef patties	Saricoban *et al.* [17].
Wheat flour	Meatballs	Jamaly *et al.* [11].
Oat bran	Meatballs	Yılmaz and Daglıoğlu [12].
	Frankfurters	Chang and Carpenter [18].
Rye bran	Meatballs	Yılmaz [13].
Rice bran	Pork meatball	Huang *et al.* [14].
Peach dietary fiber	Frankfurters	Grigelmo-Miguel *et al.* [19].
Carrot dietary fiber	Sobrassada	Eim *et al*. [20-21].
	Pork sausages	Grossi *et al.* [22].
Lemon albedo	Sausages	Fernandez-Gines *et al.* [23]; Aleson-Carbonell *et al.* [24].
Sugar beet fiber	Frankfurters	Ozboy-Ozbas *et al.* [25]. Vural *et al.* [26].
	Turkish type salami	Vural *et al.* [27]; Javidipour *et al.* [28].
Brewer's spent grain	Frankfurters	Özvural *et al.* [29].
	Chicken sausages	Choi *et al.* [30].
Cereal brans	Meatballs	Yasarlar *et al*. [31].
Inulin	Meatballs	Yılmaz and Gecgel [32].

Troy *et al.* [33] studied the eating quality of low-fat beef burgers containing fat-replacing functional blends. Tapioca starch, carageenan, oat fiber, pectin, whey protein and a commercial mixture of carrageenan and locust bean gum were assisted for their ability to mimic fat characteristics in cooked low-fat (10%) beef burgers. Results indicated that blends of these ingredients can be used to offset the poor quality associated with low-fat beef burgers.

Meatballs were extended with black eye bean flour (BBF), chickpea flour (CF), lentil flour (LF) and rusk (R) at level of 10%. Moisture, fat, protein and ash contents of raw and cooked meatballs were analyzed for cooking properties and colour parameters. BBF and LF resulted in greater cooking yield, fat and moisture retention values. Meatballs extended with LF were lighter than other samples. Meatballs formulated with BBF had the lowest reduction in diameter. Meatballs with BBF and CF had higher water holding capacity (WHC) than other treatment groups. All meatballs incorporating legume flours were tougher (lower penetration values) than the R treatment. According to sensory evaluation results all meatball treatments had high acceptability and received high scores (6.8 and above). Meatballs with BBF and CF had lower TBA values than meatballs with LF and R at 3rd month of frozen storage at -18 °C [34].

The effects of fat level (5, 10 and 20%) and corn flour (CF: 0, 2 and 4%) on chemical composition, cooking characteristics and sensory properties of Turkish type meatballs were evaluated by Serdaroğlu and Değirmencioğlu [35]. Cooking characteristics were evaluated by measuring cooking yield, fat and moisture retentions, reduction in diameter and thickness and shrinkage. At each fat level, incorporation of CF significantly increased protein content but had no significant effect on fat content of cooked meatballs. Decreasing the fat content from 20% to 5% significantly increased the cooking yield and fat retention. Meatballs formulated with 20% fat had the highest reduction in diameter. CF had no effect on reduction in diameter. CF reduced shrinkage in meatballs formulated with 5% or 10% fat and increased moisture retention in treatments formulated with 5% or 10% fat. Sensory evaluation indicated that decreasing fat level resulted in lower texture and overall palatability scores. CF had no detrimental effect on sensory properties except appearance.

Ergezer *et al.* [36] studied the effects of different amounts of potato puree (PP) (10 or 20%) and 10% bread crumbs (BC) addition as an extender and also control samples (C) with no added extender on chemical composition, energy values, cooking analyses, colour measurements, water holding capacity (WHC), penetration values, thiobarbituric acid value (TBA) and sensory analyses of meatballs. Meatball samples were cooked in a pre-heated 180 °C electric oven. Uncooked meatballs formulated with 20% PP had the highest moisture content. No significant differences were recorded for protein contents of uncooked samples. The highest cooking yield was found in samples extended with 10% BC. Increasing PP from 10% to 20% increased cooking yield of meatballs. 20% PP increased moisture and fat retention values and WHC of meatballs. Meatballs with 10% BC had the lowest and meatballs with the 20% PP had the highest penetration values in the texture. Formulating meatballs at a level of 20% resulted lower *L** values. TBA values of control samples were higher than in PP added samples at the end of the storage period. Flavour scores for meatballs formulated with PP were higher than control and meatballs formulated with BC. Meatballs formulated with 10% PP had similar overall acceptability with meatballs added with 10% BC.

Yıldız-Turp and Serdaroğlu [37] investigated the effects of using different amounts of plum puree (5, 10 and15% PP) on some properties of low-fat beef patties. Moisture content decreased with increasing concentration of PP. Increasing amounts of PP decreased beef patty pH. The highest cooking yield and moisture retention were found in 5% PP samples. Diameter reduction increased and thickness reduction decreased with increasing amounts of PP. The addition of PP to the formulation significantly affected the color of samples. Higher PP concentrations in the formulations led to increased juiciness and texture scores. The results indicated that 5% or 10% PP can be used as an extender in low-fat beef patties.

Cereal brans (oat, maize, rye and wheat) were used as dietary fibre source in the production of meatballs [31]. The effects of bran addition on chemical composition, weight losses, dietary fibre content, color (*L*, *a* and *b* values) and. sensory properties of Turkish type meatballs were studied. Meatball samples were produced with four different formulations including of 5, 10, 15 and 20% bran addition and bran added samples were compared with the control meatballs. The control meatballs had the highest weight losses. Meatballs with added bran had lower *L*, *a* and *b* values than control samples. There was significant decrease ($p < 0.05$) among sensory properties of meatballs in respect to bran addition. 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.

Demirci *et al*. [38] evaluated the effects of xanthan gum, guar gum, carrageenan and locust bean gum on physical, chemical and sensory properties of meatballs. Meatball samples were produced with three different formulations including of 0.5, 1.0, and 1.5% each gum addition and gum added samples were compared with the control meatballs. Physical and chemical analyses were carried out on raw and cooked samples separately. Moisture contents of raw samples decreased by addition of gums. There were significant decreases ($p<0.05$) in moisture and fat contents of raw and cooked meatball samples formulated with gum when compared with control. Ash contents and texture values increased with gum addition to meatballs. Meatball redness decreased with more gum addition in raw and cooked meatball samples, which means that addition of gums resulted in a lighter-coloured product. According to sensory analysis results, locust bean gum added (1%) samples were much preferred by the panelists.

Gedikoğlu [39] studied the use of citrus fiber in ground beef meatballs as a functional ingredient. Citrus fiber was used at four different addition levels (0, 1, 5 and 10%) in ground beef meatballs and tested over four different days at 0, 3, 6 and 9. While addition of citrus fiber increased cooking yield and water holding capacity, when it was used at 5% and 10%, the levels caused detrimental change in texture of cooked meatballs and Hunter color *L*, *a*, *b* values of raw ground beef.

Conclusions

Meat and meat products are generally recognized as good sources of high biological value proteins, fat-soluble vitamins, minerals and bioactive compounds. DF is one of the valuable components that can be incorporated in meat products from health point of view. Meatballs are very popular meat products in Turkey, so selection of appropriate fiber rich ingredients and their proper incorporation can improve the health image of meatballs.

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