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Mini Review

Impact study of using dietary fibers as lipid substitutes in food products

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ABSTRACT:

This review provides an overview on the compositional data of lipid substitutes for usage in food products. Some studies showed that there was a strong relationship between animal fat consumption and the incidence of many chronic diseases. So, the low fat and free-fat food products should be developed, which have low calories that meet with the consumer requirements. In the present review, the process of manufacturing low-fat and free-fat food products which is not easy due their important role in improving the texture, consistency and taste of food products were discussed. The low-fat and free-fat food products showed obvious defects in textures, consistency and taste. Therefore, the lipid substitutes were used to enhance those texture, consistency and taste of food products.

Keywords:
Dietary, Fibers, Lipid substitutes.

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INTRODUCTION

The consumer has developed more perception about the link between diet and healthy food; so, the demand began to increase on functional food processing using natural alternatives that provide certain health benefits (Renaldonia *et al.*, 2014). Therefore, global markets tend to satisfy consumer desires for providing functional foods with health benefits (Renda *et al.*, 2015). The positive effect of functional foods has motivated food manufacturers to develop new products that have health characteristics by determining the type of these alternatives in terms of nutritional and functional properties (Stephen *et al.*, 2017). The recent studies indicated that more than 70% of the fatty acids in milk fat are saturated fatty acids represented as lauric, myristic and palmitic acid which are main responsible for heart disease and atherosclerosis (Mc Sweeny and Fox, 2013). It can be replaced with fat substitutes which increases the moisture and protein content in these products (Bi *et al.,* 2016).

Fats play a major role in food and can be considered the main contributors for highlighting flavor, texture, and consistency. Reducing the fat content along with maintaining sensory quality and texture is the biggest challenge for food producers (Wu *et al.,* 2013). Studies showed that removal of fat from dairy products negatively affected their texture and consistency (Lukman *et al.*, 2016). Nowadays, studies tended to add some substances as substitutes of fats called as fat mimetic to improve the rheological characteristics of the products, as fat substitutes have the chemical composition different from fats, but they have similar physical properties of fats such as soft texture, viscosity and creamy taste in the mouth (Food safety network, 2014). The oligosaccharide and polysaccharide, which may be fully or partially digested or not digested, is a good source of lipid substitutes and carbohydrates that are not digested by small intestinal enzymes can be used as lipid substitutes in the manufacture of functional fat-free foods (Bi *et al.,* 2016).

Cereals contain different types of soluble and insoluble fibers, oats and barley contains a high percentage of insoluble fibers, such as β-glucan, which are highly viscous and fermented by the intestinal flora. Therefore, it is used as good sources for production of fat-free functional foods (Vlatrka *et al.,* 2011). Dietary fiber such as β-glucan could be used as substitutes of fat in some food products due to its use as prebiotic stimulants, increasing body immunity, reducing cholesterol in blood and diabetics, in addition to its effects on loss of weight (Knudsen *et al*., 2017). Ningtyas *et al*. (2017) used β-glucan for improving the consistency and texture of cream cheese as well as improve the taste, flavor and viscosity of juices (Steven *et al.,* 2015).

Other soluble fibers used as substitutes of fats are galacto-oligosaccharides (inulin), which are polysaccharides that are non-digestible and non-absorbed by digestive enzymes and small intestine, respectively. While, the other soluble fibers were fermented in the colon. The inulin is found in many vegetables and fruits, such as dandelion roots, tuber of diamonds, garlic etc., (Mohammed *et al.,* 2014).

Al-Badrani (2016) and Mohammed (2017) stated that the use of inulin to replace fat in the manufacture of low-fat soft cheddar cheese could improve the consistency and texture of these processed products. In recent years, many studies have been conducted on the manufacture of different types of low-fat cheeses such as mozzarella, cheddar, kashkaval and edam using lipid substitutes due to its functional and nutritional properties (Renda *et al.,* 2015). The recent trend is the use of lipid substitutes in the dairy industry due to the, high levels of bioactive compounds, in addition to their effective role in enhancing the immune system and also reducing energy and cholesterol as well as could improve the consistency and texture of many free or low-fat dairy products (Maarten *et al*., 2015).

Functional foods

Functional foods have been defined by a range of definitions, including "foods that provide health benefits in addition to their basic nutritional benefits (Danik and Jaishree, 2015) or the foods that are similar in appearance to the traditional food intended for daily consumption, but are structured to play physiological roles as well as their essential role as food needs" (Dhiman *et al.*, 2014). The functional foods contain auxiliary products that include a modified food or a food ingredient that could provide health and nutritional benefits (Martirosyan and Singh, 2015). Fiber as a food ingredient can offer physiological functionalities such as laxative, reduction is the risk of chronic diseases and reduction of blood cholesterol and also their other properties such as water holding capacity, viscosity, antioxidant capacity, stabilizing agent and their water solubility. In most parts of the world, there is no legal simplification of the term. The boundary line between the traditional foods on the one hand and functional foods on the other hand, is a barrier even for nutrition experts who have several working definitions used by vocational groups and marketers of diverse organizations in different regions.

Many organizations provided determination for this increasing food expulsion quickly, most notably the cosmopolitan counselor on food information (AVIC) on the basis of food technology experts. In the United States of America, it is recognized officially that a functional food must function as a regulatory food as per the food and drug administration (Nogues *et al.,* 2009). The concept of functional foods defined by the American dietetic association must have many features, such as being part of the daily food intake, naturally present in food, and have positive effects on certain physiological functions after consumption. It reduces the risk of disease and improves health. Research on functional foods began early in the 1980 in Japan, focusing attention on foods that prevent or reduce chronic disease in the elderly (Lee and Foo, 2014). Functional foods are made in compositions that can be consumed as a diet containing bioactive compounds that are believed to be of great health benefit (Danik and Jaishree, 2015). The European and American markets are the most famous markets for the sale of these foods, as there is a special system for the approval of functional foods known as FOSHU (Food for Specified Health Uses). Some of the most popular functional foods are fermented dairy products, meat products and other fermented foods. The main purpose is to avoid the chronic disorders including high cholesterol, atherosclerosis, hypertension and heart disease, and to stimulate the immune system (Cara, 2014).

There has been a growing interest in the development of foods that have important functional characteristics so that they can bring health advantage to the human body (Huggett and Schliter, 1996). The most important functional food that was produced for reducing disorders such as high blood pressure, high cholesterol, diabetes and osteoporosis (Sanders, 1998). In recent years, the research in functional foods has focused on the development of these foods and the introduction of the term probiotics and prebiotics, which can effect on the various activities of intestine (Ziemer and Gibson, 1998). The prebiotic is a nutritional component that can be digested by the digestive enzymes present in the human digestive system; but it is beneficial by its effect on selective stimulation of the bacterial growth in the colon which in turn improves the humans health (Gibson and Roberfroid, 1995). Fiber is an important source of carbohydrate that can be obtained from plant cell walls and cannot be degraded by human digestive enzymes. There are specific forms of fiber that can be fermented by colonic bacteria such as bifidobacteria and lactobacilli species, which help to produce short chains of fatty acids, in particular propionic, acetic, and butyric acid that helps in the host's metabolic ability and development of acidity in the intestine (Sghir *et al.,* 1998). Many researchers reported that food fiber

can elevate physiological advantages, which in turn lower blood cholesterol. (Spiller, 1994) and also reduce the glucose in blood (Bijlaini, 1985). It may help in he prohibition of cancer (Mcann *et al.,* 2001), blood sugar (Wang *et al*., 2001), fatness (Iwata and Ishiwatari, 2001), and heart disease (Fernandez, 2001).

Dietary fibers

Dietary fiber is the food components that cannot be break down or decomposed by enzymes in the human intestine into simple units. Thus it cannot be absorbed or reach the blood, including hemi-cellulose, pectin, gums, gel and other undigested carbohydrates, including cellulose. The raw fiber is the residue of the food after being treated with a solvent and then hot acid and base where the remaining forms the faeces or in other words are the residues made of fatty, carbohydrate and nitrogenous compounds (Danik and Jaishree, 2015). The Food and Drug Administration (FDA) defined dietary fiber as a substance that was deposited in a 78% ethanol solution. Dietary fiber is physiologically defined by Cara (2014) as the product of a combination of nutrients with physiological effects due to undigested carbohydrates such as inulin and includes both systemic and site effects. As mentioned by Ringel *et al*. (2015), the source of dietary fiber is mainly from plant cell walls (cellulose, pectin and lignin), as well as from other sources such as seaweed and microorganisms. It also includes digestion-resistant carbohydrates, polysaccharides and alcoholic sugars.

Classification of food fibers

Food fibers can be classified according to their water solubility into soluble and insoluble fibers. They have different physiochemical properties and hence different biological effects (Lee and Foo, 2014).

Insoluble fibers

The main advantage of insoluble fiber such as cellulose is its health benefits related to the passage of undigested nutrients in the gut, preventing constipation, helping to push waste and has a negative effect on cancer and other colon diseases (Lee and Foo, 2014).

Soluble fibers

Soluble fibers, such as undigested polysaccharides, including inulin and β-glucan, are important in preventing some nutrition-related disorders such as high body fat, hyperlipoproteinemia and cardiovascular diseases. The beneficial effects of fermented fibers, especially undigested polysaccharides is high. This is achieved when eating more plant foods or fortifying foods with different concentrations of fiber. The poly-Fructo-Oligosaccharide (FOS) also called neosugar has its commercial name as nutraflora and polyfructose is also called fructan and the main sugar is oligosaccharides and its commercial name is raftilose and xylooligosaccharides its commercial name is xylooligo (Porras *et al*., 2015). When comparing the soluble and insoluble fibers in the food industry, it was observed that the soluble fibers had the ability to become viscous, produce gel and emulsions, without affecting the texture or taste and easier to mix during food processing than the insoluble fiber in the foods and drinks. Marine algae is one of the most important sources of soluble fiber such as hijiki, arame, nori and *Ulva rigida* (Prooskey *et al*., 1988; Lahaye, 1991; Goudard *et al.,* 2009) followed by fruit pulp such as lemon pulp and date dietary fiber concentrate (Mañas *et al*., 1994; Elleuch *et al*., 2007 and 2008), vegetables such as cucumber and potato (Englyst *et al.,* 1994; Englyst and Hundson, 1996) and cereals such as rice and oats (Prosky *et al.,* 1988 and 1985).

Structural features of dietary fibers

Dietary fiber consists of a complex chemical composition. Therefore, the choice of the appropriate method for the analysis and examination of these fibers depends on its components and structures. Dietary fiber consists of non-digestible substances such as carbohydrates and lignin. The fibers contain non-digestible carbohydrate such as β-glucan, cellulose, hemicelluloses,

mucilage, gums, inulin, pectin, resistant starch: oligosaccharides such as: oligofructose, fructo-oligosaccharides, galacto-oligosaccharides, polydextrose, and soybean oligosaccharides stachyose and raffinose. Chitosan is an animal fiber and can be obtained from chitin which is available in the outer shell of crustaceans and squids (Bordrías, 2005). The total dietary fiber content of some cereal such as rice bran, sesame coat, leaf sheathes from king palm, peach dietary fiber, lime peel, grapefruit peel, mango dietary fiber concentrate and arame algae are 27.04, 42, 70.85, 30.7, 66.7, 44.2, 28.05 and 74.6 respectively (Normand, 1987; Abdul-Hamid and Luan, 2000; Vries and Furda, 1988; Elleuch *et al.,* 2007; Elleuch *et al.,* 2010; Lee *et al.,* 1992; De Simas *et al.,* 2010; Grigelmo-Migeul and Martina Belloso, 1999; Ubando *et al.,* 2005; Figuerola *et al.,* 2005; Vergara-Valencia *et al.,* 2007). The properties of the polysaccharide came as a result of its constituents of sugar residues and natural bonding between them. One of the main reasons fiber made compounds are more complex is their chemical property, polymerization degree, existence of oligosaccharide and polysaccharide. It needs to different analytic methods for the measurement of food fiber, to exactly assess its composition in food and food by-products.

Dietary fibers as lipid substitutes in food products

Different dietary fibers were utilized in some products of food such as gum, inulin and cocoa which have potential advantage on human body due to its capacity to bound water form and build, gel, structure (O'Shea *et al.,* 2012). The lipid substitutes could increase gel formulation and stickiness for supplying savor and texture, and to increase the ability of water detention (Dervisoglu *et al.,* 2006). Fats found in dairy products play a key role in textural and rheological, characteristics (Baarclay *et al.,* 2010; Brennan and Tudorica, 2008; Dave, 2012). Fats have nutritional significance in cheese. In addition, fats participate in sensory and feasible characteristics of the products (Miočinović *et al.,* 2011). The demand for foods with certain functional characteristics has been increased, such as those with low calories, health and nutritional benefits (Carmichael *et al.,* 1998; Peterson *et al.*, 1999). However, the low-fat in foods are less acceptable from consumers due to its effect on the properties of those foods such as taste, flavor and odor (Hamilton *et al.,* 2000; McEwan and Sharp, 2000). Hence, certain implementation and possible effects of lipid substitutes is necessary (Akoh, 1998; Ognean *et al.,* 2006). Recently, milk fat in cheese has been replaced, while retaining as much as possible the sensory, functional and organic properties of whole cheese. (Kebary, 2002). Where, some defects appeared when replacing milk fat with some dietary fiber such as defects of rubber texture, weak flavor and bitterness, poor solubility and the appearance of undesirable colors, that leads to the appearance of some defects in rheological, histological and sensory of cheese (Mistry, 2001; O'Connor and O'Brien, 2011). It is difficult to produce low or fat free cheeses with acceptable characteristics (Fadaei *et al.,* 2012). The protein matrix becomes more consolidated and the becomes texture. Some nutrients such as fats are necessary to achieve its role in maintaining the taste, odor and flavor properties of the food (Mattes, 1998). Therefore, using lipid substitutes to develop the flavor and texture in low-fat cheese is unavailable (Sandrou *et al.,* 2000). The studies determined that cheese containing 50% fat could be considered as low fat cheese (FAO/WHO, 2008). While, in Europe, the cheese can be considered as low-fat when the fat content is at least 30% (Eu, 2006). Whereas, in the United States, a low-fat cheese contains at least 25% fat. Karimi *et al.* (2015) reported some aspects of the microstructure, textural, rheological, prebiotic and sensorial effects of the inulin which is incorporated in cheese as a fat replacer, prebiotic and texture modifier. Lafta *et al.* (2019) reported that utilizing arabic gum could improve the functional and nutritional properties of low fat soft cheese. Martínez-Cervera *et al*. (2011)

assessed the effects of a soluble cocoa fiber used as a fat replacer in chocolate muffins.

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