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CHANGES IN CALORIE INTAKE WITH FAT MODIFIED FOOD

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ABSTRACT

Replacing a part of the fat content of foods can prevent increasing weight, risk of cardiovascular and many other diseases. According to the statistic, chronic diseases are growing, so research and produce of low fat, safe and healthy food with desirable quality and acceptability are necessary. Fats provide calorie more than other macronutrients and this additive calorie intake causes appearing obesity and different cancers. Fat replacers, which provide some or all of functional properties of fat, have a fewer calories than the fat being replaced. The four broad categories of fat replacers are including the carbohydrate-based, the protein-based, the fat-based and the combination of all fat replacers. Carbohydrate-based fat mimetic absorbs water, form gels and influence texture and mouth-feel of food similar to fat. The mimetic is kind of dietary fiber that are useful for the digestive system health and also they effect on healthy consumer with reducing weight, blood lipids, blood pressure and cholesterol and transferring biliary acids into lower parts of intestine for more repelling of them. Protein-based fat mimetic made from milk, egg, blood and whey proteins. They are used proportional to type of food. These proteins effect on satiety more than other macronutrients and also they can provide a creamy mouth-feel similar to fats. The fat based substitutes are similar to fats but they have differed from nutritional values, calorie and digestibility's point of view from fat.in general Fat replacers are attributed to make many functional properties in different foods. They can play a role as binder agents, body agents, bulking agents and thickeners. Also, they enhance flavor, moisture retention, water-binding capacity, emulsions and foams stabilization and slow melt-down. However, such useful compounds can have undesirable textural and sensory effects in some foods. These problems can be improved by different compositions like carotenoids which improve color quality. In this context, an up to date review of the fat replacer and their effects in different food is presented.

Keywords: *Fat replacers, Functional properties, Calorie intake.*

INTRODUCTION

Nowadays, consumers' demand for low-fat/calorie products has significantly raised in an attempt to limit health problems, to lose or stabilize their weight, and to work within the frame of a healthier diet [1]. Fat is still the number one nutritional concern for most people in developed countries. Excessive intake of fat in the diet has been linked to certain diseases, such as heart disease, cancer, obesity, and possibly gallbladder disease [2]. In general, the more fat in the diet, the lower the immune response. More recentepidemiologic data suggest that individuals with higher fat intakes are more likelyto develop disturbances of glucose metabolism, type 2 diabetes, and impaired glucosetolerance than individuals consuming lower amounts of fat [2,18]. limiting total fat intaketo no more than 30% of daily energy intake, with saturated fats no more than 10% and monounsaturated and polyunsaturated fats accounting for at least two-thirds of daily energy intake is recommended [3].

Functional roles of dietary fat

Fats have several sensory and physiologic benefits. As compared with proteins and carbohydrates, they supply more than twice as many calories per gram, that is, 9 kcal/g (37.7 kJ/g). Fat-soluble vitamins A, D, E, and K, are obtained from the lipid fraction of the diet [4]. Fat is essential for growth and development, and provides essential fatty acidsneeded for maintaining structure of cell membrane and for prostaglandin synthesis [5] and regulating many body functions [2].Functionally, fats affect the meltingpoint, viscosity and body, crystallinity,and spreadability of manyfoods[5].

Fat can also carrylipophilic flavor compounds, act as a precursorfor flavor development (e.g., by lipolysis or frying), and stabilize flavor [3]and also contributes to the palatability and flavor of food and hence contributes to the enjoyment of eating [2]. Fat helps control the release of moisture from the inner layer of theproduct, which is a necessary step for efficient fermentation and flavordevelopment [6]. Fat confer a feeling of satiety [4] but they are overeaten because it affects satiety and satiationless than carbohydrate and protein [7].

Reducing fat in foods and utilization of fat replacers

Individuals have a tendency to consume a constant weight or volume of food irrespective of the energy and fat content [5]thusThe volume of a preloadindependent of its energy density can influence satiety [8].Increasing the satietyvalues of foods while keeping energydensity low can be a strategy for preventingover consumption and energyimbalances. A 10% reduction in the proportion of fat in the diet can result in a corresponding reduction of 238 kcal/day of total energy intake.With reduction of fat in foods, palatability and preference of consumers decrease. That's why fat replacers are used to offset these defects, Hence, fat replacers can potentiallyhelp to prevent passive over consumption.On a populationlevel, replacing 1 to 2 g fat/day byusing fat replacers and fat-modifiedfoods can potentially prevent weightgain and associated chronic diseasesand assist in promoting healthful eatingbehaviors [5]. Fat may be replaced in food products by traditionaltechniques such as substituting water or airfor fat, using lean meats, skimmilk instead of whole milk in frozen desserts, andbaking instead of frying for manufacturing orpreparing snack foods. Fat may alsobe replaced in foods by fat replacers [3]. Under the FDA regulations, fat replacers fall into one of two categories**:** food additives or generally recognizedas safe (GRAS) substances [5]. Labels on food made with fat replacersmust comply with the NutritionLabeling. Overall, the majority of fat replacerspose no health concerns foradults [2,5].

Types of Fat replacers

The terms and definitions used to describefat replacers vary among authorsand are often confusing and misunderstood.Fat replacers chemically resemblefats, proteins, or carbohydrates and aregenerally categorized into two groups—fat substitutes and fat mimetics [3,5].

1. Fat mimetics: The protein-based and carbohydrate-based replacersare widely regarded as fat mimetic [2,3,5]. They cannot replace calories from fat on a 1:1 weightbasis [2,3,5]. They have diverse functional properties that mimic some of the characteristic physiochemical attributes and desirable eating qualities of fat [66]. They provide lubricity, mouth feel and viscosity, appearance and other characteristics of fat by holding water.The additional water makes them unsuitable for frying operationsbecause they can be denatured (protein-based substances) or caramelized (thosebased on carbohydrates) [2,3,5].They can however be used for baking and retort cooking operations. The caloric value of fat mimetics ranges from0–4 kcal/g [5,11].

- Carbohydrate-based fat mimetics:

Most carbohydrate-based fat replacers mimicfat by stabilizing the added water in a gel-like matrix that can releasethe water in a way similar to fat release[5,9].These fat replacerscan provide up to 4 kcal/g but, becausethey are often mixed with water,they typically provide only 1 to 2kcal/g and some (such as cellulose)provide zero calories [5].

Cellulose: it isindigestiblefiber that can replace 50% of fat in bakery products without compromising sensory characteristics [5].
Inulin: is considered to have functionalproperties that enable it to act asa fat mimetic without adversely affectingflavor, based on its ability to stabilizestructure of the aqueous phase, creating an improved creaminess mouth feel [5,14]. Some studies indicate that inulin lowers the level of cholesterol in blood plasmaandalso increases calcium, magnesium and ironabsorption [12,13,14].Inulin is a non digested in the small intestine, but is fermented in the colon [13,14,19] and contains between a third and quarter of the sugar calories [16].
Konjac: Konjac flour is a water-soluble dietary fiber. It can be used as a gellingagent, thickener, stabilizer, emulsifier and film former. Konjac readily dissolves in water and absorbs 100 times its volume in water and cause the particle to swell to200 times its original volume, producing a viscous liquid [9].

β-glucan: β-glucan is described as a polymer of glucose. One important source of β-glucan is the cell wall of yeast (*Saccharomyces cervisiae)*. It functions as a non-caloric food [15].β-glucanobtained from brewer's yeast can be used in food products as thickening, water holding or oil binding agent and emulsifying stabilizer [16]. Different physiological effects of β-glucan are related to its viscosity [17]. Powdered soluble oat fiber (containingβ-glucans) have been observed to lowerbody weight, blood lipids, and serum cholesterol levels [5,16,17].
Pectin: Pectin has become highly valued since it is a dietary fiber [5,20]. When was used in food products pectin functions as a gelling and thickening agent to modify texture and rheology. Accumulatingevidence suggests that it can reduce cholesterol, delay gastric emptying, and induceapoptosis of colon cancer cells [20].
Maltodexrin: Maltodextrins, a nutritive polysaccharidederived from hydrolysis ofcornstarch and can be substitutedfor 25% to 35% of fat in cookies [5,9,19,21].
Polydextrose: A glucose polymer, resistantto digestive enzymes, providesabout 1 kcal/g, is used to replacesugar or fat in foods, keeps thefood moist, and acts as a bulkingagent replacing fat and sugar volume[5].
Methylcelluloses: They reduce adsorption of fat in productsbeing fried. The gel structure produced by thermogelation provides a barrier to oil, holds moisture, and acts as a binder and fat-like properties [4].
Corn syrups, syrup solids, and high-fructose cornsyrups: are used as fat replacers in manyfat-free and reduced-fat cookies to controlwater activity [3].
Gums: Gums are used inbaked goods and salad dressings, in which they act as stabilizers andthickeners and retain moisture inthe reduced-fat product [5]. Gums which are used as fat replacers are: carrageenan, alginate, xanthan, guar and locust bean gum [9].

- Protein-based fat mimetics:

The tertiary (three-dimensional) structure of proteins can be alteredby pH, heat or enzymatic denaturation enabling them to behavemore like fat. These fat mimetics including: vegetable-based proteins (soy, wheat, pea, and peanut) [9], whey protein or milk and egg protein [5], blood [23], collagen [9].These fat replacers provide1 kcal/g to 4 kcal/g[5]. Someof these protein-based fat mimetics aremicroparticulated (sheared under heat) toform microscopic coagulated round deformableparticles that mimic the mouthfeeland texture of fat[3].Many functional properties of proteins, such as waterholdingcapacity, gelation and emulsification depend on water-protein interactions [24].
Whey proteins: Whey protein isolate and its hydrolysate can also inhibit lipid oxidation [9]. Whey products contribute to creaminess, texture, water binding, opacity and adhesion in a variety of food systems [11].Simpless and Dairy-Lo are derived from whey protein concentrates; they are GRAS food ingredients [24].Provides4 kcal/g [5,26]. Simpless mimic emulsified fat by forming a dispersed phase of particles that are free to move independently.Dairy- Lo forms a gelled network when heated above the protein denaturation temperature [25].
Collagen: Becauseof binding water and compatibility with meat protein, it is a good fat replacer [9].
Soy protein: Soy protein can be added to meat products as soy flour (50% protein), soy concentrate (70% protein) or soy protein isolate (90% protein) [9].
Blood proteins: They were used in meat products ieadind to a reduction in fat content without negative effects [23].

2. Fat-based substitutes:

Fat substitutes are macromolecules thatphysically and chemically resemble triglycerides (conventional fats and oils) [3] and can replace fat on a gram-forgrambasis. Because they are fatbased, they are often stable at cookingand frying temperatures and provideall the functions of fat while yielding 9 kcal/g, which could be zero calories if none is absorbed [5].Lipid-based fat substitutes are subject to oxidation just like conventional triacylglycerols [2].

- Emulsifiers
They are fat-based substances thatare used with water to replace all orpart of the shortening content in cakemixes, cookies, icings, vegetables, and dairy products. They provide thesame calories as fat but less is requiredin the product, resulting in areduction in total fat and energy [5].
- Carbohydrate polyesters:
Mono-, oligo- and polysaccharides yield fatlikeproducts when esterified with fatty acids.In the best known product, Olestra, is sucrose polyester [19].Olestra provides zero calories [5]. Food made with SPE has 10–50% fewer calories than foodmade with regular oils and shortenings [2].

- Altered triglycerides:

Triglycerides containing short-, medium-, and long-chain fatty acidsrandomly distributed on the glycerol backbone are only partially digestedand absorbed and provide 5 kcal/g [5].Structured lipids (SLs) combinethe unique characteristics of component fatty acids such as melting behavior, digestion,absorption, and metabolism to enhance their use in foods, nutrition, and therapeutics [2]. Oxidation of SLis more rapid than for normal TAGS [5].Captex, Caprenin and Benefit are examples of SLs [26].

Food and Drug Administration (FDA) for use of caprenin in soft candies such as candy bars, and in confectionery coatings for nuts, fruits, cookies, and so on.It can be used as a cocoa butter substitute.

Benefit is intended for use in baking chips, chocolate-flavored coatings, baked and dairy products, dressings, dips, and sauces, or as a cocoa butter substitute in foods [2].

3. Combinations:

Protein–hydrocolloid interactions play an important role in textural and mechanical properties of foods. Combinations of gums can overcome individual deficits [9].A combination of protein, starches, and hydrocolloids has been suggested to have synergistic effects for lowering fat and retaining textural characteristics of the products [5].

Reduced and modified fat foods:

- ***Ice cream***

The formation of the ice cream structure is hindered when the fat content is reduced and attributes related to quality, are affected. Microbial Transglutaminase (TG) is an enzyme. The cross-linking between proteins through the action of TG can modify several functional properties of foods, such as solubility, heat stability, and the gelation, emulsifying and rheologicalproprieties [30,31]. Table 1.

- ***Cheese***

It is not easy to make desirable low-fat or fat-free cheeses with good flavor and texture. As fat content decreases, the protein matrix becomes more compact and the cheese texture is more chewy [37,38]. Table 1.

- ***Kefir***

Substitution of skim milk powder (SMP) by inulin allowed for reducing 12% and 35% of caloric value in comparison with SMP and WMP kefir, respectively. Kefirs with inulin exhibited higher firmness as less adhesive and more cohesive than kefir made only from skim milk powder [12].

- ***Mayonnaise***

Mayonnaise must contain at least 78.5% total fat and 6% pure egg yolk [15].

Moreover to avoid or reduce the presence of cholesterol from yolk, use of yeast proteins (single cell proteins) and polysaccharides has increased [33]. Table 2.

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Table 1: Effects of different fat replacers in dairy products

Dairy product	Type of fat replacer	Effects of substitution	In level	Ref
Yoghurt	protein microparticles (stirred yoghurt)	Yielded yoghurts with a structure dominated by dense aggregates and low amount of serum pores.		27
Yoghurt	Dairy-Lo, Simpless (Strained yoghurt)	Imparting desired thickening and retarding syneresis.		25
Dairy desserts	Long chain inulin (milk beverages)	Having the same thickness and creaming as whole milk beverages.	>8%	14, 29
Dairy desserts	Long chain inulin (custard)	Having similar viscoelastic properties to the whole milk samples.	7.5%	14, 29
Ice cream	TG (Ice cream)	Samples with 4g/100g and 8g/100g fat having similar characteristics.		30
Ice cream	Inulin (yog- ice cream)	Increasing viscosity and hardness, improving melting properties.		32
Cheese	Dairy-Lo (cremosoargentino)	Without fat replacers and by using technology in order to obtain curd pieces more moisture than full fat, good quality low fat soft cheese can be obtained.		37
Cheese	Perfectamylgel MB or Dairy-Lo or satiagel ME4 (white pickled cheese)	Were highly acceptable compared to the low fat cheese without fat replacer		38
Cheese	Salatrim (mozzarella cheese)	Lowering fat losses in the whey, increasing actual and moisture adjusted yields.		39
	Inulin (imitation cheese)	Can be used to replace up to 63%of the fat		40
	Simpless or Novagel (cheddar cheese)	Softening low fat cheese with imparting discontinuity to the casein matrix.		41

Table 2: Effects of different fat replacers in mayonnaise

mayonnaise	Type of fat replacer	Effects of substitution	Ref
	β-glucan	Stabilizing emulsion, lowering calorie and increasing storage stability, reducing color. Adding β-caroten and lutein improved color.	15, 34
	6.7% mono &diglycerides, 36.7% guar gum, 56.7% xanthan gum	Was acceptable.	35

Table 3: Effects of different fat replacers in chocolate

chocolate	Type of fat replacer	Effects of substitution	In level	Ref
	Palm olein	Was more accepted as conventional chocolate.	25%	36
	Cotton seed oil	Increasing smoothness.	50%	36
	Caprenin, polydextrose	Is commercially available in reduced-fat chocolate bars.		3

Table 4: Effects of different fat replacers in bakery products

Bakery products	Type of fat replacer	Effects of substitution	In level	Ref
Muffin	Soluble cocoa fiber	Increasing moisture and tenderness, color. Having negative effects such as loss of height, perception of bitter taste.		44
Muffin	pregelatinized dull waxy corn	Decreasing fat content by 5% but preferable in comparison with full fat type (27%).	1-2%	42
Muffin	Corn bran fiber	Decreasing volume and height of muffin with increasing corn bran fiber content.		44
cake	β-glucan concentrate	Increasing the volume, stalling , decreasing hardness. At level of 20% had the same quality as full fat cake.		45
cake	starches	Were satisfactory based on volume and crumb.	Complete substitution	46
biscuit	solouble β-glucan	Have the same quality as full fat sample.	50%	42,48
cheesecake	white bean	Acceptable in terms of texture, after taste. Decreasing calorie and fat content by 6.9% and 12.8% respectively.	30%	49
chocolate chip cookie	C-Trim	Decreasing spreads, increasing moisture contents, providing 45% less fat, 12% less calories and 100% more fiber.		50
bread	polydextrose	Improving water absorption and stability. Improving cookie processing and sensory properties by≤50 substitution.		47

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Table 5: Effects of different fat replacers in meat products

Meat product	Type of fat replacer	Effects of substitution	In level	Ref
Meat patties	Alginate, tapioca	Improving tenderness, juiciness and cooking yield.		57
Meat patties	Carrageenan (meat formulations)	Improving the textural characteristics by decreasing toughness and increasing juiciness.		51
Meat patties	Nutrim-10 (beef patties)	Enhancing moisture, fat entrapment, cooking yield and retaining tenderness.	13.45 %	17
Meat patties	Inner pea fiber (beef patty)	Improving tenderness and cooking yield. Improving sensory properties of low fat ground beef and retaining substantial amounts of moisture and fat.		53
Meat patties	Chickpea meal (beef loaves)	Decreasing intensity of beef aroma and flavor and increasing juiciness.		54
Meat patties	Tapioca starch (low fat buffalo meat patty)	Improving color and appearance, juiciness and texture.	3%	58
Meat patties	blackeye bean flour(BBF), lentil flour (meat balls)	Improving cooking yield, fat and moisture retention.		55
Meat patties	BBF and chickpea flour (meat balls)	Increasing WHC.		55
Meat patties	Textured soy protein(TSP) (beef loaves)	Decreasing intensity of beef aroma and flavor.	%30	54
Meat patties	Soy beans (meat loaves)	More palatable than loaves containing TSP.		56
Meat patties	Soy	Improving cooking yield, lowering evaporation losses and fat oxidation.	30-40%	52
Meat patties	Whey powder, skim milk powder (patty)	Increasing cooking yield, moisture retention.		24
Meat patties	Skim milk powder	Decreasing hardness, cohesiveness of cooked patties.		24
Meat patties	Whey powder	Increasing hardness of cooked patties.		24
Ham pate	Globin and plasma isolate	Increasing moisture and protein content, lowering fat content by 25-35%.	38.2 %	23
Ham pate	Modified potato starch	Similar to 300g kg-1 fat control sausage in color, texture, sensory properties.	20g kg-1	65
Fermented sausages	Amorphous cellulose	Increasing viscosity, decreasing fat and cholesterol level by 45%, 15% respectively.		6
Meat burgers	Poppy seed	Decreasing saturated fatty acid contents and improving flavor.	50%	66
Meat burgers	Tapioca starch, carrageenan, Oat fiber, pectin, whey protein	Best formulation in terms of eating quality.		60, 67
Frankfurters	Citrus fiber, soy	Decreasing fat level by 50% and 75% and also energy	2%	59

	protein concentrate (sausage)	value by 30-40%		
Frankfurters	Dietary fibers (beef sausage)	Improving cooking yield, decreasing hardness, lowering fat content by 20-40% and increasing moisture, protein, ash, carbohydrate contents.		9
Frankfurters	maltodextrin	Decreasing cook loss, emulsion stability, reducing fat content by 5-12%.		63
Frankfurters	Potato starch	Improving lightness, hardness, skin strength of low fat frankfurter.	3%	58
Frankfurters	Lupinkernel fiber	Being the most satiating as compared with the full fat samples.		5
Frankfurters	Soy protein isolate	Improving texture, juiciness and color of emulsion.		61
frankfurters	Soy protein concentrate	Increasing cooking losses in the sausages with 5% and 20% fat, decreasing cooking losses in the sausages with 10% fat, increasing hardness.		62
	Carrageenan,CMC or Apple pectin	Reducing fat content by 10%.		64
Frankfurters	Blend of tapioca starch, Oat fiber and pectin	Was the most acceptable hydrocolloid for blending with whey protein concentrate.		60

- ***Chocolate***

Cocoa beans contain50–55% fat.Cocoa butter has a high content of saturatedacids. However, it has been argued that much of thisis stearic acid (30-36%), which is not considered to be cholesterolemic [29].Table 3.

- ***Bakery products***

Fat replacers in baked products need to be able to act as fat does by aerating the batter, maintaining flavor, and providing a moist mouth feel [42]. Cereal and cereal products contribute approximately 15.6% of dietary fat, of which bakery products contribute at least two-thirds [43]. Table 4.

- ***Meat products***

Different kinds of fat replacers affects on flavor, aroma, texture and color of meat products. All of them are summarized in table 5.

CONCLUSION

Fats have several functional properties in different foods and in each food it has one or more determinative particulars that make a product desirable. To produce low fat foods by using fat replacers, it's so necessary to know these particulars.For instance, in chocolates, melting point properties; in ice cream, creaminess and crystallinity; in chesses, texture; in bakery products, aerating the batter; in yoghurt, forming a stable gel; and in meat, tenderness and juiciness are determinative. Indeed, formulation of low fat foods must be designed by using researches in order to manufacture of low in fat products, similar to full fat counterparts.

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