Application of fats in some food products

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Abstract

Fats and oils are very important raw materials and functional ingredients for several food products such as confectionery, bakery, ice creams, emulsions, and sauces, shortenings, margarines, and other specially tailored products. Formulated products are made with just about every part of chemistry, but they are not simple chemicals. In general, they consist of several, and often many, components. Each of these components has a purpose. Most formulated products have a micro- or nano-structure that is important for their function, but obtaining this structure is often the big challenge. Due to a rise in overweight or obesity, health concerns have increased. This fact has led to the need to the develop products with low fat content, which have become a market trend. In addition, the development of new products using fat substitutes can be a good option for companies that are always trying to reduce costs or substitute *trans* fat or saturated fat. However, the successful development of these products is still a challenge because fat plays multiple roles in determining the desirable physicochemical and sensory attributes, and because the consumers who want or need to replace these ingredients, seek products with similar characteristics to those of the original product. Important attributes such as smooth, creamy and rich texture; milky and creamy appearance; desirable flavor; and satiating effects are influenced by the droplets of fat, and these characteristics are paramount to the consumer and consequently crucial to the success of the product in the market. Therefore, it is important to identify commercially viable strategies that are capable of removing or reducing fat content of food products without altering their sensory and nutritional characteristics. This paper intended to provide an overview about the role of fat in different food systems such as chocolate, ice cream, bakery products like biscuits, breads, and cakes considering the major trends of the food industry to meet the demands of modern society.

Keywords: fat replacer; ice cream; breadmaking; chocolate; microstructure; new trends.

1 Introduction

Usually lipids are defined as a heterogeneous group of biological compounds almost insoluble in water but soluble in fats, hydrocarbon type and other fat solvents. Fats and oils are example of lipids and are composed largely of triglycerides with great importance in food systems, and they are formed by esters of a molecule of glycerol and three fatty acid molecules (Rosenthal, 1998; Rao, 2003; Stolyhmo, 2007; McClements & Decker, 2010; Nichols et al., 2011).

Fats and oils are important ingredients in a variety of foods. They confer desirable characteristics on several foods, contribute to tenderness to shortened cake, and by aerating batter, fats aid in establishing texture in cakes; they also add flavor to foods and influence the order in which components of flavor are released when foods are eaten, besides having a lubricating effect and producing a sensation of moistness in the mouth. They are a medium for transferring heat to foods (Charley & Weaver, 1998).

For consumers, textural attributes of fats that arise from their molecular states are of primary importance. Food texture is affected by fats by forming structures of crystalline networks and by disruption of structure by interfering with non-fat networks. Fats present polymorphism, an ability to exist in different crystal forms and the three major are α, β, and β' that differ in melting points (Rao, 2003).

The melting profile of the fat crystals play key roles in determining properties such as texture, stability, spreadability, and mouthfeel. The texture of products such as chocolate, shortenings, and especially butter is determined by the concentration, morphology, and interactions of fat crystals. Shortenings are fats that provide specific functional properties (softness, texture, mouthfeel, structural integrity, air incorporation, heat transfer, and shelf life increase) to pies, breads, pasta and others (McClements & Decker, 2010).

There has been an increase in the percentage of the population that is either overweight or obese over the last years (Wu et al., 2013). The growing concern with the relationship between health, feeding, and maintenance of healthy weight has boosted the market of foods with reduced energy value (Santos, 2009; Boff et al., 2013). Since fat has higher caloric density than that of most nutrients in foods (Wu et al., 2013), reducing fat and cholesterol content is currently one of primary trends in food product innovation (Ma & Boye, 2013). However, the successful development of these products remains a challenge because fat plays multiple roles in determining their desirable physicochemical and sensory attributes. Important attributes such as smooth/creamy/rich texture, milky/creamy appearance, desirable flavor, and satiating effects are influenced by the droplets of fat. Therefore, it is important to identify

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commercially viable strategies that are capable of removal or reducing fat content of food products (Wu et al., 2013) without altering their sensory and nutritional characteristics (Boff et al., 2013).

This article provides an overview about the role of fat in different food systems, considering the major trends of the food industry to meet the demands of modern society. Therefore, aspects of some products in which fat plays important structural role, such as chocolate, ice cream, and bakery products like biscuits, breads, and cakes, are discussed.

2 Use of fat in chocolate products

Chocolate is enjoyed by people of all ages, socioeconomic classes, and gender (Sato & Pepece, 2013); and they can be defined as a suspension of solid particles derived from components such as sugar, milk, and cocoa solids in a continuous fat phase, which in turn contributes to the flavor, aroma, and color, in addition to providing form to the final product (Afoakwa et al., 2007; Leite et al., 2013).

Primary chocolate categories are dark, milk, and white, and they differ in content of solid cocoa, milk fat, and cocoa butter. Dark chocolate, milk chocolate, and white chocolate contain 28, 30.7, and 30.9 % of fat respectively (Afoakwa et al., 2007).

Of the different components in chocolate, the fat phase has the greatest influence on its quality. The fat phase affects the rheological properties of fluid chocolate, release from the mould, snap, gloss, prevention of bloom, melting properties, and flavor release. Milk fat and cocoa butter are the two main forms of fat used in chocolate manufacture to provide these properties (Beckett, 2009).

Chocolate manufacturing process generally follows the common steps. Initially, the ingredients such as cocoa liquor, sugar, cocoa butter, and s**kimmed milk powder** (depending on product category) are combined. Then, refining process takes place in a 2, 3, or 5-roll refiner (Afoakwa et al., 2007). This is an important step to obtain a smooth texture required in current chocolate products, and the final particle size critically influences the rheological and sensory properties (Afoakwa, 2010). Next, conching, which is normally carried out by agitating chocolate at more than 50 °C for few hours, takes place. One of the main aims of conching is to produce the optimum viscosity for the subsequent processing, and in this stage fat is very important. Finally, there is the tempering of mass, following the most commonly steps such as: complete melting, cooling to the point of crystallization, crystallization, and melting out of unstable crystals. The objective of tempering is to generate an adequate number of seed crystals to promote the total fat phase to crystallize in a more stable polymorphic form. This in turn will generate a more stable product and a better overall contraction (Beckett, 2009). The most stable form crystals of cocoa butter, which is the form V, is achieved through of systems for heating/cooling (maintained at 35 °C) (Afoakwa et al., 2007).

Afoakwa et al. (2009a) studied the fat bloom development and structure-appearance relationships during storage of under-tempered dark chocolates, and the results obtained indicated that the bloom development influenced melting properties causing polymorphic transformation from βIV to βV within 24 h of storage, with further transformation to βVI after 72 h. Within 24 h of storage, liquid and unstable (crystallized) fat appeared on the surface of products with the initiation of bloom. The hypothesis argued is that the fat bloom is initiated by the movement of the liquid and unstable fat on the product surface by capillary generated by hydrodynamic forces within the pores and gaps between particles, followed by growth of the recrystallized fat by diffusion gradient across the entire chocolate mass. Svanberg et al. (2013) investigated two pre-crystallization processes (βVI-seeding and conventional pre-crystallization) with various degrees of temper and verified that the two pre-crystallization processes generated significantly different structures and storage stability.

In another study, Afoakwa et al. (2009b) analyzed the effect of different tempering (under-tempered, optimally-tempered, and over-tempered regimes) on the melting point and particle size in dark chocolate and found that the final structure and melting properties of dark chocolate is defined primarily by the fat crystallization behavior during tempering. With respect to the crystal size distribution (CSD), the under-tempered chocolate showed a broadening in CSD and increases in melting properties, whereas over-tempering caused moderate increases in CSD and melting properties. Under-tempered products showed re-arrangement and re-crystallization of unstable fat crystals to smaller numbers of larger agglomerates with formation of solid bridges between the crystalline network structures with no influence on crystallinity of products, at all temper regimes, the variations in particle size distribution.

Cocoa butter is a main ingredient responsible for the rheological behavior of chocolates. Glicerina et al. (2013) observed that the addition of fat and lecithin in the conching and tempering phase covering the sugar and cocoa particles, reduced interactions and created more void space between them, which is filled with cocoa butter causing an action of lubrication, which involved a decrease in all rheological, textural, and thermal parameters at the end of the process.

Cocoa butter consists mainly of palmitic acid (C16), stearic acid (C18:0), Oleic acid (C18:1), and linoleic acid (C18:2), but it has low amount of lauric acid (C12) and myristic acid (C14). The constitution of fatty acids may be different depending on the location of production, and cocoa butter produced in Brazil has high amounts of linoleic acid (3.5-3.6 %) and minor amounts of stearic acid (33.3-33.8 %) compared with those produced in Ghana, Indonesia, Ecuador, and Malaysia. Brazilian cocoa butter also has around 34.5-36.5 % of oleic acid and 25.1-27.9 % of palmitic acid (Jahurul et al., 2013).

Reis et al. (2011) analyzed three Brazilian commercial chocolate brands and found that white chocolate showed higher levels of lipids, followed by diet chocolate. This was also verified by Suzuki et al. (2011), who analyzed the fatty acid composition of five major Brazilian chocolate brands and observed that diet chocolates from the same brands had larger lipid contents. The main fatty acids observed were myristic acid (14:0), palmitic acid (16:0), estearic acid (18:0), oleic acid (18:1n-9), linoleic acid (18:2n-6), and *trans* fatty acid; elaidic acid (18:1n-9t) was identified and quantified in all chocolate brands analyzed; however, its concentration was below the Brazilian regulation values.

However, for the chocolate industry, cocoa butter is the raw material of high cost and in the leading countries of production, the price of cocoa is affected by weather, pests, and political factors (Medeiros & Lannes, 2009). Coupled with the fact that there is a current trend in the food market to offer consumers low-fat foods and the challenge to reduce fat in chocolate is to find technological solutions to produce a system with increased solid volume fraction and acceptable flow properties (Do et al., 2010), growing interest, in an alternative to cocoa butter (Jahurul et al., 2013).

Some vegetable fats are similar to cocoa butter in triglyceride composition, and cocoa butter equivalents (CBEs) can be added in any proportion to chocolate without causing a significant effect on texture (Afoakwa et al., 2007). The use of alternative products depends on the similarity of their physical, chemical, and functional properties to those of cocoa butter; they do not form an eutetic mixture and reduce the product melting point (Suzuki et al., 2011).

Thus, several studies have been conducted seeking production of cocoa butter replacers (CBRs), cocoa butter equivalents (CBEs), and cocoa butter substitutes (CBSs) from various natural sources (Jahurul et al., 2013) such as palm kernel oil (PKO) and palm oil (PO) (Calliauw et al., 2005; Hashimoto et al., 2001; Kaphueakngam et al., 2009; Undurraga et al., 2001; Zaidul et al., 2006). The development of functional chocolate spreads with palm olein and cotton seed oil (El-Kalyoubi et al., 2011) and studies on mango seed fat (Kaphueakngam et al., 2009; Solis-Fuentes & Duran-de-Bazua, 2004), kokum butter (Maheshwari & Reddy, 2005), partial replacement of the cocoa butter with cupuassu fat obtaining a product similar to traditional products (Lannes et al., 2002) and others such as salt fat, shea butter, illipe butter, soya oil, rape seed oil, cotton oil, ground nut oil, and coconut oil have been carried out (Jahurul et al., 2013).

Palm kernel and/or coconut oil have characteristics in terms of hardness, mouthfeel and flavor release similar to those of cocoa butter. However, these fats contain a high level of lauric fatty acids and a completely different triglyceride composition from cocoa butter resulting in a considerable degree of incompatibility with cocoa butter (Talbot, 2009).

Milk fat and cocoa butter are the two main forms of fat used in chocolate manufacture. *Milk fat* is a complex mixture of triglycerides (98 %) and other minor lipid components. Milk fat and cocoa butter have different stable crystal forms, and therefore the two fats will not mix completely in the solid state. It changes the temperatures at which the various crystal forms and tends to slow the rate of cocoa butter crystallization in mixtures of cocoa butter and milk fat. Adding increased amounts of milk fat changes the physical and functional properties of chocolate including hardness, ability to temper, and melting point. To cause changes in the crystal forms of cocoa butter it is necessary to add around 50 % of milk fat (Haylock & Dodds, 2009). Butteroil is also considered.

Sonwai & Rousseau (2010) studied the effects of partial replacement of cocoa butter with milk fat or milk chocolate and observed that the presence of milk fat is beneficial in preventing fat bloom, but only at a concentration above 2.5% of the final product, because lower concentrations of milk fat causes a transition from a form V to form VI of crystals, in addition to increasing surface crystal growth in cycling process. In order to keep the sensory properties of chocolate without changing the temperature-cycling, 5% milk fat should be added.

However, so far, alternatives of cocoa butter fats that could meet the exact demand of cocoa butters have not been found yet. It is necessary to conduct further research on this subject to discover the alternatives of cocoa butter fat that could be able to fulfill the demands of cocoa butter fat (Jahurul et al., 2013).

There is a growing market demand for zero or low-fat food products; therefore, new ingredients and knowledge are needed in order to manipulate these types of product (Van Puyvelde & Moldenaers, 2003). According to Do et al. (2007), reducing fat content causes an increase in the molten chocolate viscosity, leading to losses of eating quality in the final product and resulting in difficulties in the processing, poor in-mouth melting properties, remain hard, and difficult to swallow. Accordingly, many studies have been conducted with the aim of obtaining products with a lower fat content without changing properties when compared to traditional products.

Richter & Lannes (2007) formulated chocolate confectionery with replacement of fat by Benefat® and sugars by sweeteners (sucralose) and body agents (polydextrose – Litesse® and Inulin – Raftiline® ST) obtaining a filling with a suitable texture to fill the molds. The results from the sensory analyses for flavor and texture attributes of the products indicated high acceptance in addition to high levels of purchase intent. Melo et al. (2009) verified the sensory acceptability of milk chocolates with reduced calories using sucralose and whey protein concentrate as partial fat replacement. There was no difference between conventional and experimental chocolate in brightness, cocoa aroma, aroma cocoa butter, and cocoa flavor.

Some fat replacers are used commercially, such as caprenin and salatrim (Benefat®). Caprenin (caprocaprylobehenic triglyceride) is a product of esterification of glycerol with caprylic, capric and behenic fatty acids and its combination with polydextrose was commercially available briefly in reduced-calorie and reduced-fat chocolate bars. On the other hand, salatrim consists of differing amounts of short chain fatty acids and long chain fatty acids. It provides a range of melting points, hardness, and appearance in various products such as chocolate-flavored coatings (Ognean et al., 2006). Also, Olestra, a sucrose polyester, which has large molecule and is very fatty, cannot be broken down and digested in the human body, and therefore it does not contribute to caloric intake. On the other hand, it will bind cholesterol and fat soluble vitamins (A, D, E, and K) and minerals increasing their removal from the body and preventing their absorption from dietary sources. Protein-based fat substitutes (Simplesse) and carbohydrate-based substitutes (Avicel -microcrystalline cellulose, Carrageenan, Dextrins, Inulin -soluble fibre) must be also mentioned (Food Safety Network, 2014).

Another possibility to replace fat is the use of hydrocolloids. Schneider & Souza (2009) studied chocolate milk added with different levels of gelatin (5, 10 and 15 %) and found that chocolate with 15 % gelatin resulted in a fragile product and with sandy texture. In tests of sensory analysis, it was found the best medium for chocolate with 5 % gelatin, which in turn, had the lowest reduction in fat (3 %). Therefore, a more detailed study on this subject should be carried out in order to achieve a product with reduced fat content. Amir et al. (2013) studied different substitutions (5, 10 and 15 %) for cocoa butter by Xanthan gum and Guar gum blends in dark chocolate. The results showed an increase in hardness jointly with the increasing additional of gums as the development of gel networks. With respect to the melting point, the changes in the amount of cocoa butter had little and insignificant impact on melting profile.

The hydrocolloids used as fat substitutes derived from carbohydrate-based and are mainly hydrophilic biopolymers with high molecular weight with great water retention capacity (Lim et al., 2010). An oat β-glucan-rich hydrocolloid (C-trim30) was evaluated by Lee et al. (2009) to be used as a cocoa butter substitute in chocolates; and the use of Casson model in the analysis of the flow behavior showed that the Casson viscosity and yield stress increased with increasing concentration of C-trim30 in the chocolate. The cocoa butter replacement with β-glucan-rich hydrocolloid up to 10 % produced soft chocolates with improved boundary lubrication properties besides resulting in a product with a lower caloric value.

With a more functional focus in relation to nutritional enrichment, Shumacher et al. (2010) evaluated the addition of quinoa in dark chocolate obtaining a product with high protein concentration and essential amino acids. The samples had an index of acceptance above 70 %. As can be seen, there are several possibilities in the food area in search for new agents that can replace fat in chocolates and provide health benefits; however it requires a solid understanding about the impact of using these new agents in complex food system.

3 The importance of fat in Ice cream

Colloidal dispersions are small particles in a phase (solid, liquid or gaseous) dispersed in another continuous phase, in which the surface properties of the phases exert a great influence on the structure as a whole. There are eight different types of colloidal dispersion that are classified as solid sol, solid emulsion, solid foam, sol, emulsion, foam, and two types of aerosol (Clarke, 2004). Ice cream is a colloidal complex food, which contains fat globules, air bubbles, and ice crystals (Goff et al., 1999; Lannes & Silva Jr., 2013) dispersed in an aqueous phase of high viscosity (Silva Jr. & Lannes, 2011) consisting of proteins, salts, sugars, and polysaccharides (Goff et al., 1999). Therefore, ice cream is simultaneously an emulsion (fat globules), a sol (ice crystals), and a foam (air bubbles) (Clarke, 2004). Ice cream usually contains about 30 % of ice, 50 % of air, 5 % of fat, and 15 % of sugar solution in volume; therefore, it is composed of all states of matter: solid (ice and fat), liquid (sugar solution), and gas.

An emulsion comprises two immiscible liquids (usually oil and water), with one liquid dispersed as spherical droplets in the other (McClements, 1999). The emulsions are thermally unstable systems that require energy to increase the surface area between the oil phase and water (Akoh & Min, 2002), maintaining the droplets dispersed in the continuous phase. The stability of the emulsion can be increased by adding surface active agents, called emulsifiers (Araújo, 1995). Some emulsifiers such as yolk substitutes are included in most manufactured products due to the positive effect they have on the structure of the fats (Goff, 2008).

Sols are dispersions of solids in a liquid continuous phase, for example, ice crystals in ice cream, the pigment particles in the ink, soil particles in the slurry, the particles in the blood. Foam is a dispersion of gas bubbles in a continuous phase liquid. The solid and the gas are small particles dispersed in a continuous phase (Clarke, 2004).

Many advances have been made in the ice cream processing in the last years, in such as the recognition of the importance of adsorption of interfacial material to the fat globule and formation of the fat globule membrane in terms of product behavior and ingredient functionality. In addition, microscopy techniques have been successfully applied to examine the structure of the product. Advances in rheology and their applications have also been made during this period. Thus, all technological advances and research have led to a more complete understanding of the importance of fat and the coalescence of fat globules and how to control it in ice cream (Goff, 2008; Lannes & Ignácio, 2013).

The setting up of ice cream structure comes from the manufacturing process as well as from the various components used in the formulation (Granger et al., 2005). The importance of the structure of fat and colloidal aspects of the ice cream is now widely recognized (Goff, 2008). Fat appears to contribute largely to the properties of ice cream during freezing and whipping, through the partially coalesced continuous three dimensional network of homogenized globules helping in the air phase stabilization because fat globules surrounds air bubbles, and increased levels of fat aggregation are also correlated to improved melting resistance (Granger et al., 2005).

Fat is a multifunctional ingredient in ice cream and promotes flavor, color, texture and mouthfeel. A reduction of fat content in the ice cream can result in the loss of texture and sensory properties (Su & Lannes, 2012; Karaca et al., 2009) because fat is the main carrier of flavor for many compounds, and low flavor intensity may not be overcome by addition of flavoring alone (Ohmes et al., 1998). Fat is essential to explain the "dryness" of ice cream, shape retention, melting in the mouth (Goff, 2008), and textural creaminess, which is a highly desirable attribute that is contributed by milk fat (Ohmes et al., 1998; Lannes & Ignácio, 2013).

Milk fat is determinant of the body of ice cream because it interacts with other ingredients developing texture, mouthfeel, creaminess, and sensation of lubricity. Typically, ice cream contains 10 to 16 % of fat, but in recent years, some ice cream manufacturers have reduced the amount of fat and replaced those fat solids with carbohydrates or proteins (Adapa et al., 2000; Lannes & Ignácio, 2013) in order to create products that meet the demands of health-conscious consumers

(Prindiville et al., 2000). It is essential to understand how to create corresponding structures of fats (Goff, 2008) because a fat replacer should match the texture, mouthfeel, and functionality of the original fat and should convey the desired flavor profile (Ohmes et al., 1998).

Milk fat and vegetable fats can be replaced in order to reduce the fat content or to test new sources. Formulations with low fat or fat free are usually tested adding body agents to minimize the lack of fat in the structure. In addition, fat replacers have been tested due to the availability of new sources, to reduce costs, and to create new products.

The green coconut pulp has been studied as a possible ingredient in chocolate ice cream formulation. The substitution of fat resulted in a very similar product to standard ice cream and was approved by 93 % of participants in the sensory panel. The results of the physicochemical analyzes showed that the coconut pulp has foaming capability and emulsifying action which enables it to be used to produce ice cream, even at low pH values. The frozen product that does not contain milk solids is called Sorbet by law. However, with the composition of coconut pulp it was possible to produce a very similar product with the properties of the real ice cream. Fresh pulp is suitable for producing the "ice cream" because it has little odor and flavor, which makes it the appropriate ingredient to produce products with different flavors. Another positive factor is that the medium chain fatty acids predominate in the coconut pulp (especially lauric acid), which are considered beneficial to health (Santana et al., 2011).

A survey tested the quality and structure of ice cream formulations after the partial replacement of skimmed-milk powder for soy extract. The results showed an improvement in the protein content, pH, coefficient of consistency, and it also reduced carbohydrate. The formulations containing soybean extract exhibit improved melting resistance, greater amount of small crystals, and minor crystal growth after heat shock. A substitution of 20 % can be made without affecting the sensory acceptability (Pereira et al., 2011).

Studies using inulin in ice cream with reduced fat have demonstrated positive results in the texture of the products. Samples containing 4 % and 6 % of inulin have showed the same standard viscosity of the sample. The texture evaluation showed that "low fat" and reduced fat ice cream had a similar response comparing with that of the standard sample. Samples with inulin showed similar consistency and viscosity to that of the standard sample, while samples made with whey protein isolate had higher viscosity than the standard, resulting in a very thick product (Meyer et al., 2011).

In a study on the structure of blends/fats as substitutes for hydrogenated fats used in ice cream, same formulations were made by varying only the addition of hydrogenated fat, low *trans* fat, palm fat, or cupuassu fat. A product with Longan, a sweet fruit pulp that has components that are beneficial to health and is commonly used in Asian countries, has also been formulated in order to verify its structure and acceptance. Based on the results of the physicochemical and sensory analyzes, the study concluded that cupuassu fat was effective as a substitute for hydrogenated fat, with a similar profile to that of the standard formulation and a good melting profile. The ice cream made with fruit Longan produced a product with a 25 % reduction of sugar and had good acceptance and purchase intent in sensory analysis. However, the sample made with palm fat showed a significant difference between the formulations in the study of the rheology and had a worse melting profile (Su & Lannes, 2012). Another study showed that the use of palm fat instead of hydrogenated fat caused changes in the melting point of the ice cream formulations (Silva Jr. & Lannes, 2011); it also investigated the use of oat extract as fat substitute in ice creams (Silva Jr. et al., 2010).

Improvements in product formulation to obtain lower fat ice cream are required to compensate the lack or the replacement of fat (Karaca et al., 2009) since changes to a food system can impart an imbalance in the flavor profile through various mechanisms (Prindiville et al., 2000). Hence, strategies have been studied by many researchers that have focused on producing highly palatable reduced fat ice cream that meets the demands of health conscious consumers (Karaca et al., 2009), and there have been favorable results. The development of products with good acceptance and the perceived advances in this area are very positive for the consumer market, which is increasingly looking for healthier alternatives with higher added value.

However, ice cream has not followed the trend in consumption of low-fat products in U.S and Canada as it has been observed in other food categories. Contrary to this trend, in the last 20 years, the development of premium ice cream with around 12 % of fat and super premium ice cream with around 16 % of fat has increased. Healthier options have become popular in recent years in Canada since producers have introduced more all-natural, functional, low-fat, and low-calorie varieties. Smaller, multi-pack products for portion control have seen significant growth (Agriculture and Agri-Food Canada, 2012). According to Goff (2008), U.S. consumption is 70 % of ice cream that contains more than 10 % of fat, 28 % of low fat ice cream, and 2 % of fat-free products. According to the IDFA-International Dairy Foods Association (2012), premium ice cream, which tends to have lower amount of aeration and higher fat content than regular ice cream, is the most popular product among consumers according to a recent survey of U.S. ice cream manufacturers. In this survey, 79.3 percent cited premium ice cream as the most popular product, while 10 percent said that novelties are most popular. Novelties are defined as separately packaged single servings of a frozen dessert, such as ice cream sandwiches and fudge sticks.

4 The role of fat in biscuits

Biscuits are one of the most popular bakery items consumed all over the world (Okpala & Okoli, 2012), and they can be defined as small products from a dough or batter (Tireki, 2008) whose mainly ingredients are flour, fat, sugar, milk, water, eggs, and salt and that is viscous enough to allow the pieces of dough to be baked on a flat surface. They come in an infinite variety of sizes, shapes, texture, composition, tenderness, tastes, and colors (Sudha et al., 2007; Tireki, 2008).

In the formulations of biscuits, sugars and fats appear in large amounts, while moisture content appears in low proportions (1-5 %) (Sciarini et al., 2013; Pareyt et al., 2009). Fat functionality is very important in baked products, and it is responsible for tenderness and overall texture of the final product improving mouthfeel, structural integrity, lubrication, incorporation of air, heat transfer, and extended shelf life (O'Brien, 2009; Ghotra et al., 2002).

All cookie fillers have the same basic ingredients in order of prominence, sugar, shortening, salt, flavor, and lecithin. The filler consistency and eating character are determined to a large extent by the shortening used. The requisites for a good sandwich cookie or wafer filler shortening have been identified as: Quick getaway in the mouth, oxidative stability, and others (O'Brien, 2009).

In cookie production, plastic shortening is creamed with sugar to incorporate air bubbles that are trapped in the liquid phase of the shortening. While the liquid phase is necessary for air incorporation, fat crystals have a structural role and retain air at the end of mixing and during early baking stages (Sciarini et al., 2013).

The fats used for the production of cookies need to be at room temperature on solid or semisolid state to facilitate handling of the batter during the manufacturing, which implies an increase in the content of saturated fatty acids (SFA) (Tarancón et al., 2013).

Epidemiological studies have identified the consumption of trans fatty acids (TFAs) as a risk factor in the development of cardiovascular disease (Lemaitre et al., 2006; Sun et al., 2007).

Rutkowska et al. (2012) carried out a study with respect to the amounts of saturated, monounsaturated, and polyunsaturated fatty acids, and the researchers found that 9 of 12 biscuits examined contained low amounts of total fat. It was also observed that due to the diversity of the fats employed in formulations, the saturated and polyunsaturated fatty acids are dominant. In five biscuits analyzed, it was found 20 % and significance presence of alpha-linolenic acid. The content of *trans* fatty acids was relatively low (0.03 to 2.0 g/100 g product). In this case, it can be seen that due to the negative aspects of *trans* fatty acids, manufacturers are working to improve the quality of these fats and consequently decrease the content of TFAs.

In order to be effective, shortenings must have plastic properties which are, in turn, exemplified by the correct solid-to-liquid index at dough mixing temperature. High Solid Fat Index (SFI) shortenings do not have enough oil volume for adequate aeration, and low SFI shortenings do not have the ability to hold the air until mixing is complete (O'Brien, 2009).

Another characteristic of fat is its crystalline nature. The three basic polymorphs are designated α, β, and β' (Marangoni et al., 2012). It is essential for the fat to be in the β' crystal form to promote optimum creaming (Wilderjans et al., 2013). Utilization of emulsified bakery shortening helps in the fine dispersion of the fat in the batter or dough system as compared to non-emulsified shortenings (Jacob & Leelavathi, 2007).

Decreasing the amount of fat added to biscuits is a good way to obtain a healthier and lower-calorie product. The effect of partial replacement of fat by different fat replacers on the quality of biscuits has been studied by different authors (Bertolin et al., 2013).

Fat mimetics are substances of carbohydrate or protein origin which can be used in some foods to imitate the functional and sensorial properties of fat (Zoulias et al., 2002).

Rodríguez-García et al. (2013) evaluated the effects of inulin as fat replacer on short dough biscuits and their corresponding dough. A control formulation, with no replacement, and four formulations in which 10, 20, 30, and 40 % of shortening was replaced by inulin were studied. It can be concluded that shortening may be partially replaced, up to 20 %, with inulin. These low fat biscuits are similar to the control biscuits, and they can have additional health benefits derived from inulin presence.

Jacob & Leelavathi (2007) studied the effect of four different fat types on the rheology of the cookie dough, and the consequent effects on the cookie quality using emulsified bakery shortening, margarine, non-emulsified vegetable hydrogenated fat, and sunflower oil. Measurement of the breaking strength showed that cookies containing the oil were the hardest. On the other hand, breaking strength of cookies containing the other three types of fats was not significantly different from each other.

5 The influence of fat in cake

Bakery products are among the most consumed products in the world. Among them, cakes are popular and associated by the consumers as tasty products with particular sensory characteristics (Matsakidou et al., 2010).

Cake batter can be considered as an oil-in-water emulsion (O/W) containing dry ingredients such as sugar, flour, milk powder, salt, and yeast, suspended or dissolved in the continuous aqueous phase (Ronda et al., 2011; Sakiyan et al., 2004).

The cake quality is related to its aerated structure, which is formed by the incorporation of air during whipping as well as the development of bubbles during cooking. Batters with a low viscosity trap air during whipping, which leads to a cake with a low volume expansion (Psimouli & Oreopoulou, 2011).

The role of fat in manufactured cakes and bakery products in general is very important both from the technological point of view and the sensory point of view. Many bakery products require a relatively high fat content, as reported by Sowmya et al. (2009). According to Zhou et al. (2011), shortenings have numerous functions in bakery products; among them are: texture, softness, structure integrity, mouthfeel, lubrication, air entrapment, heat transfer, and extended shelf life.

In many systems like cake batters, the air bubbles are incorporated by the action of fat in whipping cream method, where such bubbles are trapped in the continuous phase of the emulsion, at room temperature (Jacob & Leelavathi, 2007; Goldstein & Seetharaman, 2011; Wilderjans et al., 2013), rather than remain in the aqueous phase. However, as the batter is heated during cooking, these air bubbles are transferred from the fatty phase to the aqueous phase structure providing a voluminous and foamed structure after cooking. The baking powder releases carbon dioxide when heated. The gas formed exerts great pressure on the mixture, resulting in increased volume in the final product (Indrani & Rao, 2008; Cauvain, 2003a).

Several studies have been carried out to reduce fat in baked goods, especially in cakes due to the great amount of this raw material in its formulation, especially the *trans* fatty acids present in some formulations.

Trans fatty acids (TFAs) are strongly correlated with an increased risk of many diseases, among them cardiovascular disease (Ansorena et al., 2013).

There are many researches in favor of replacements of hydrogenated vegetable fats in cakes. These substitutions may vary in their ingredients, and this replacers come from lipids (Sowmya et al., 2009), fibers (Lee et al., 2011) and hydrocolloids (Zambrano et al., 2005; Gómez et al., 2007).

Martínez-Cervera et al. (2012) evaluated the effects of partial replacement of fat by cocoa fiber in chocolate muffins. This study evaluated the sensory characteristics of the final product and showed great difficulty in chewing and swallowing the cake when high cocoa fiber content was added. The bitter taste and the decrease of viscosity were also reported.

In a study conducted by Kumari et al. (2011), the authors used two vegetable oils, namely sunflower oil (SFO) and coconut oil (CNO), emulsifiers, and hydrocolloids in pound cakes to evaluate their rheological properties, fatty acid profile, and quality characteristics (texture, color, specific gravity, volume, and sensory analysis) using hydrogenated vegetable fat in the formulation as the control cake. The results of the fatty acid profiles of cakes showed the presence of 48.9 % of lauric acid in the formulation made with coconut oil in comparison to that of hydrogenated vegetable fat (1.2 %). Pound cake formulated with oil resulted in a decrease in batter viscosity, cake volume, and overall quality score. Cakes made with emulsifiers and oils showed improvements in their characteristics. The authors concluded based on these results that cakes with reduced fat showed better fatty acid profile and quality characteristics similar to those of the control cake can be prepared by replacing hydrogenated fat with SFO or CNO.

Lee et al. (2011) studied the effects of β-glucans in cake batters and analyzed texture, color, and volume obtaining satisfactory results as high volume, viscosity, and texture. Texture values were higher than the those of the control cake, whose formulation did not contain β-glucan. Therefore, it was is concluded that the application of these fibers does not degrade the quality parameters of the final product.

Gularte et al. (2012) conducted a study to investigate the effect of different fibers added individually or combined to improve the functional properties of gluten-free layer cakes. The authors applied mixtures of soluble and insoluble fiber in the formulations and obtained better results with the formulations containing oat cakes and inulin than those with oat and guar gum. In all formulations, cake acceptability was related to its specific volume.

Lee et al. (2005) evaluated the physical and rheological properties of cakes using the fat substitute Oatrim®, which is a product obtained by enzymatic hydrolysis of oat flour rich in soluble fiber (β-glucan). The formulations containing fat replacements at 20 % showed no significant differences ($p> 0.01$); softness exhibited properties similar to those of the control without loss in the quality of the final product. There were no significant changes in relation to specific gravity, volume, and rheological properties in formulations with 40 and 60 % substitution.

Salas & Lannes (2010) evaluated the application of fats and margarine on texture and volume of chocolate cakes and showed that these parameters depend on the type of fat base used in the formulation. Rios & Lannes (2012) studied the influence of different fats in cake batter such as vegetable fat, margarine, and soy oil in textural parameters, such as yield value and compression force, showing that they can be considered for the industry very important parameters pointing the need of less energy in processes of pumping to lower the values of these parameters, for example.

6 Lipids in bread making

Lipids originating from wheat flour, fat (shortenings) and surfactants (Pareyt et al., 2011) play an important role in bread making conferring benefits during several steps of the bread process and storage. Typically, the formulations are added with 2 to 5 % fat, calculated based on the percentage of wheat flour. Generally, the balance of fat and application depends on the solid phase and the liquid phase ratio of the fat at a given temperature, with an influence of the ratio of the solid fat/liquid in the bread volume (Pareyt et al., 2011; Manzocco et al., 2012).

Fats are used in bread making to improve gas retention in the dough and thereby increase its volume and softness, to lubricate, to aerate, and to help heat transfer in the dough imparting a desirable texture (Cauvain, 2003b; Shahidi, 2005; Manzocco et al., 2012). The amount to be added depends on the type of flour (whole meal need higher levels than white). A fat fraction should remain solid into the dough until the end of fermentation (45 °C) (Cauvain, 2003b).

Many types of shortenings are used in breads, such as butter, solid and liquid margarines, oils, and commercial fats (Smith & Johansson, 2004)

The oil or oil fraction of a plastic shortening promote softness and impart a wet mouthfeel. The solid fraction contributes to the dough and to final product structure, and it involves the air bubbles in the mixing step (Shahidi, 2005). In baking processes, fat crystals, in terms of gas cells, behave as a cell wall or membrane for these cells making them larger. Therefore, a specific fraction of the solid fat in shortenings is necessary to assure good bread quality. Some emulsifiers can be added to oils to reduce the percentage of the solid fat (Smith & Johansson, 2004).

The lubricating action allows greater expansion during fermentation and bread baking, resulting in a softer final texture (Kaur et al., 2012), improving the dough rise, oven spring, and final loaf volume, and it also contributes to increasing or maintaining its shelf life (Pareyt et al., 2011).

The lipids contained in wheat flour come from the membranes and organelles and spherosomes. Based on the lipid solubility, they can be divided into starch lipids, free lipids, and lipids bonded to non-starch components. Starch lipids are strongly bound in the starch granule, and do not affect the processing of the dough, while raw starch does not undergo gelatinization. Lipids or polar lipids influence the manufacturing process of breads affecting the stability of gas bubbles in the dough because they form a lipid layer at the gas/liquid interface, which favors increased gas retention of the dough (Goesaert et al., 2005).

For a good baking and development of the mass structure, the bakery shortening must have at least 20 % of solid fat content (SFC) at temperature of 25 °C and a minimum of 5 % SFC at temperature of 40 °C (Latip et al., 2013).

Surfactants are amphiphilic compounds that when applied in bread dough can fortify (to interact with the gluten) or act as anti- firming agents. Their usage percentage varies from 0.3 to 1.0 %. Monoglycerides and diglycerides are examples of crumb softeners (Pareyt et al., 2011; Manzocco et al., 2012; Calligaris et al., 2013). Depending on their nature, surfactants can enhance the dough and increase mixing tolerance; they can also improve gas retention, influencing the oven spring and final loaf volume. Therefore, they can replace part of the fat in some types of breads, as well as improve the dispersion of fat, which improves its performance (Pareyt et al., 2011).

Aiming to make breads with low levels of fats or saturated fats, new formulations have been tested. Thus, Calligaris et al. (2013), in order to test new ingredients in breads, applied organogels to verify the effect of the substitution of palm oil in the formulation of sweet bread for monoglycerides organogels (OG: monoglyceride emulsion and sunflower or monoglyceride and palm oil) and hydrogel (HG: emulsion monoglyceride + co-surfactant + water + sunflower oil or monoglyceride + co-surfactant + water + oil palm). The monoglycerides added to oil form a double layer generating a continuous network, which prevents oil flow. This system is considered a stable organogel, thermo reversible, anhydrous, viscoelastic material structured by a three-dimensional molecular network. The organogels are seen as "fats of the future", and a new alternative for reduction of saturated fats and *trans* fats in fatty foods. Breads formulated with OG showed higher specific volumes than that of the control with palm oil and that of the bread with sunflower oil and HG. Breads made with palm oil showed a well aerated structure, while the bread made with sunflower oil had lower aerated structure because the oil was not homogeneously dispersed throughout the flour. The control breads with monoglyceride and the breads with HG had the lowest firmness, which can be the result of less monoglyceride available, trapped in the oil network, preventing its interaction with the other dough ingredients to make it tenderer. It can be concluded that the substitution of palm oil for hydrogel with sunflower oil resulted in a sweet bread with characteristics similar to that of the control palm oil sample, with a saturated fat reduction of about 81 % (w/w). When oil was involved in organogel, the bread had a non-homogeneous distribution of the fat, resulting in a less aerated and firmer bread structure (Calligaris et al., 2013).

Rice bran oil is considered high quality oil for cooking, and its fatty acid composition is considered an excellent source of polyunsaturated fatty acids (Kaur et al., 2012). Kaur et al. (2012) evaluated the shortening substitution for rice bran oil in percentages: 25, 50, and 75 %. Rice bran oil has a linoleic acid content (g/100 g 35 ± 1.04) much higher than the that of bakery shortening (g/100g 5.1 ± 0.07) employed. Samples with 50 % shortening and 50 % oil showed increased the loaf volume. In sensory evaluation, breads with replacement of fat by 50 and 75% rice bran oil obtained higher score for appearance compared with that of the control, while breads with 50 % oil had the highest rating on the overall acceptance. Maximum rating for texture was obtained by the control breads. In the texture evaluation, breads with substitution of 50 % rice bran oil were softer, and breads with 100 % replacement were firmer than the control. Thus, bakery shortening can be satisfactorily replaced by 50 % of rice oil to obtain a good quality bread (Kaur et al., 2012).

The substitution of fat and sugar for inulin and oligofructose in quick bread scones was studied by Röble et al. (2011) to meet the demand for healthy food production. The scone quick bread is a traditional food in Ireland, UK, and USA, and it is consumed by people of all ages. It is a product of soft texture, with high fat (10 %) and sugar (10 %) content. Inulin and oligofructose have been presented as an interesting option for the replacement of fats and sugar to confer similar functional and sensory properties, favoring the development of a high quality food with low calories. They can also be classified as functional ingredients, when taken as prebiotics. A larger volume of bread was obtained with 100 % replacement of fat and sugar. Breads with high concentration of inulin and oligofructose reached the highest browning index (crumb and crust) because oligosaccharides accelerate caramelization and Maillard Reaction. The hardness of bread crusts with inulin and oligosaccharides increased, but it was not as significant as the hardness of bread with sugar. The crumb moisture increased significantly with high percentages of fat and oligofructose, while it was lower in high concentrations of sugar and inulin. The use of oligosaccharides and inulin can support the development of low-fat foods without compromising texture and mouthfeel. Thus, it was concluded that quick breads produced with inulin and oligosaccharides showed similar characteristics to those of the control samples (10 % sugar and 10 % fat), and that some features such as volume were further improved (Röble et al., 2011).

The application of shortenings with different melting points (36-39 °C , 39-40 °C, and 48-52 °C) in formulations of breads made with strong and weak flour was performed to determine the effect of different combinations of fat and flour on volume, oven spring, weight, density, texture, shelf life, and appearance of baked loaves. The better volume was achieved with the combination of strong flour with 4% shortening of 39-40 °C. The breads made with strong flour showed the largest oven spring, which decreased with the addition of 4 to 10 % fat. Fats with higher melting point provide higher content of solid fraction and can supply crystals that attack denatured proteins involving gas cells, strengthening the gluten network, which improves gas retention and oven spring. The weight of the breads increased based on the percentages and types of fats used; it was higher for the strong flour than that obtained with the weak flour. The density was lower with the application of 4 % fat for all types of fat (Chin et al., 2010).

Studying the replacement of fat in bread, O'Brien et al. (2003) found that breads made with 2.5 and 5 % fat showed higher volume and softer crumb than those of the control bread without fat and then those prepared with 2.5 and 5 % formulations substitutes: inulin gel, powder, and Simpless® inulin. Considering all of the factors studied (water absorption, loaf volume, crumb hardness, and modulus dough complex), the substitution with 2.5 % inulin was more effective.

Esteller et al. (2004) and Esteller et al. (2006) studied the addition of fat replacer (structured fat), such as Benefat®, in hamburger buns, in properties as texture, volume, and color, and found a good substitution to vegetable hydrogenated fat to this product.

7 Conclusion

In this overview, it could be verified the importance of the application of various forms of lipids (fats, monoglycerides, organogels and others) in food products, as well as the importance of their proper balance in the formulation since they will greatly influence the structure (aeration, lightness), rheological properties (fluidity, plasticity, texture), and sensory characteristics (taste, color, odor, crispiness, creaminess, melting) of the products evaluated. *Trans* fatty acids (TFAs) and saturated fats are strongly correlated with an increased risk of many diseases. It was observed the influence of fat on each of the components. In chocolates, fat has special functions such as providing rheological and melting properties, gloss, snap, flavor and others. Fat is a multifunctional ingredient in ice cream and promotes flavor, color, texture and mouthfeel. Milk fat and hydrogenated fats that have usually been used in ice cream can be properly replaced in order to reduce the fat content, *trans* or saturated fat acids, or to test new sources. Bakery products such as breads, cakes, and biscuits usually have significant amounts of fat. Fat generally have numerous functions in bakery products such as: improve gas retention, lubrication , aeration, heat transfer in dough, and desirable texture in the final product (in breads), incorporation of air, softness, lubrication, mouthfeel, and structural and sensory properties (in cakes and biscuits). There is a very wide range of fat replacers for fat foods including carbohydrates, proteins, and even lipids, which must be considered.

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