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Review Article

Fat Spread with Added Functional Ingredients as Replacement for Butter

Suman Kharb[1], Dilip Kumar Thompkinson[2] and Harshita Kumari[1]*

[1]*James L. Winkle College of Pharmacy, University of Cincinnati, Cincinnati, OH, USA*

[2]*National Dairy Research Institute, Karnal, Haryana, India*

***Corresponding Author:** Harshita Kumari, James L. Winkle College of Pharmacy, University of Cincinnati, Cincinnati, OH, USA.

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Abstract

There is a basic temptation in human beings to lean towards the natural products. All such developments over the last decade have resulted in increasing number of potential nutritional products with medicinal and health benefits. Due to these developments in health sector, consumers demand products like margarines and spreads with better health profile, such as, high polyunsaturated fatty acid and low energy content. There are a variety of fat spreads which serve as replacement of butter and have flooded the shelves of supermarkets to meet the ever-increasing demand of health-conscious consumers. The fat spreads are formulations that have excellent spreadability for use in our bread, and toast, etc. Low-fat spreads containing modified fat and fat replacers have been in fashion for long in western markets. Lately consumers' demand for healthy fat spreads with specific functional attributes including fortification with micronutrients. The sole purpose of this article is to provide an overview of how the consumption of these modern fat spreads containing different functional ingredients (e.g. antioxidants, fibres, phytochemicals and micronutrients) has benefited consumers in disease prevention and has contributed to a healthy lifestyle.

Keywords: *Inulin; Omega-3 Fatty Acids; Plant Sterol; Micronutrients; Fat Replacers*

Introduction

With the influence of social media, food industry is rapidly transitioning its focus to developing newer products designed to compete with or replace existing products, based on their superiority, convenience, cost and quality. The apparent connection between diet and health has increased awareness for 'healthier' eating that involves reduced-fat diet. This trend is reflected in the increased market for low-fat products including low-fat spread particularly in the USA and Europe. The wide acceptance of bread in regular diet among urban consumers (75 percent of all household) reflects around 8 percent growth in bread consumption [1]. With this increase, the requirement of a suitable spread to complement bread consumption has also increased. Fat spreads include a variety of spreadable semi-solid products, such as, fat spreads, cheese spread, peanut butter, etc. The demand for butter as table/fat spread has declined due to its high cost, poor spreadability, high saturated fat and cholesterol content. Furthermore, World Health Organization (WHO) [2] reported that cardiovascular disease (CVD) is one of the foremost causes of death in the world, accounting for almost 29.3 percent of total deaths. After CVD, the osteoporosis is the next large-scale global health issue for aged population estimating as high as 40 percent in women and 13 percent in men for the osteoporotic fracture worldwide [3].

The dietary pattern of consumers has, therefore, shifted towards foods that have functional attributes and are beneficial for health. This shift has resulted in the growth of functional food market by about 60 percent over a period of five years [4]. Attempts to improve the nutritional status/benefit of edible fat spread have focused on reducing total fat and cholesterol contents, changing the fatty acid profile and eliminating trans-fatty acids (TFA). The positive impact of some of these compositional changes on consumer health has resulted in the use of spreads with functional ingredients that could prevent the ever-increasing coronary heart disease (CHD) problems. The demand for such products is likely to escalate in the near future. It is time for the dairy industry to plunge into low-fat spreads with functional attributes for health-conscious customers and encourage the use of dairy by-products and functional nutrients as ingredients in composite products. India, being the world's leading producer of peanut oil, the food industry of the country can capitalize on this source for marketing 'healthy' fat spreads.

Definition and classification

Although low-fat spreads of both dairy and non-dairy types have been known since late sixties, evolution of fat spreads has continued along the lines of achieving lower and lower fat levels without losing the age-old sensory appeal of the high-fat products viz., conventional table butter. The spreads, which have been reported in literature, are often referred to as 'high-fat spread', 'low-fat spread' and 'very low-fat spread'. The low-fat dairy spreads fall in the category of 'fat spreads' or 'yellow-fat spreads' [5]. A spread is water in oil (w/o) emulsion with at least 15 percent fat or higher, whereas a low-fat spread is formulated as oil in water (o/w) emulsion with comparatively lower concentration of fat [6].

'Dairy spreads' generally contain butterfat whereas 'non-dairy spreads' contain vegetable fat. [7] According to Weckel and Bullock [8,9] the term 'low-fat dairy spread' are the products, which contain only dairy ingredients and has less fat than commonly used spreads, such as, butter and margarine (See table 1) [11].

Total fat content (%)	Type of fat		
	MF 100%	**Blended fat (MF 15-80%)**	**Non-milk fat (MF 0-3%)**
80 - < 90	Butter	Blend	Margarine
60 - 62	Three-quarter fat butter	Three-quarter fat blend	Three-quarter fat margarine
< 39 - 41	Half-fat butter	Half-fat blend	Half-fat margarine
< 39	Dairy spread	Blended spread	Fat spread
> 41 - < 60	Dairy spread	Blended spread	Fat spread
> 60 - < 80	Dairy spread	Blended spread	Fat spread

Table 1: *Fat content of spreadable milk fat products, and blended non-dairy spreads according to EU guidelines.*
**MF- milk-fat Source: Frede (2003) [11].*

"Low-fat dairy spreads" containing 39 - 41 percent fat are sometimes termed as 'half-fat butter' while those in which caloric reduction is at least 33 percent are termed as 'reduced calorie spreads.' [10] Accordingly, a range of spreadable fat products varying widely in their fat content are identified under the EU guidelines (Table 1). In general terminology, reduced, low-fat, very-low-fat spreads contain 11 to 60 percent fat, 40 percent or less, 5 - 15 percent fat, respectively. Interestingly, extremely low-fat spreads are sometimes also referred to as "ultra-low-fat spreads" [12,13]. In India, the Prevention of Food Adulteration Act (PFA) has defined food spread as a product in the form of w/o emulsion wherein the oil phase is exclusively composed of edible oils and prohibits use of any animal fats. PFA [14] has classified the spreads into the following three groups viz. 'milk-fat spread', 'mixed-fat spreads (mixture of milk-fat with vegetable oils/fat) and 'vegetable-fat spread'. The fat content in each of these groups is around 40 - 80 percent. According to international standards Codex

Alimentarius [15] fat spreads are defined as, "any milk fat content that must be no more than 3 percent of the total fat content" and are divided into two categories: "margarine" and "fat spreads." "Margarine" shall have a fat content more than 80 percent, and "fat spreads" shall have a fat content less than 80 percent.

Spreads are now available in the Indian market but occupy only a small portion of the total yellow-fat market. On the contrary, the fat spread market in the western countries has grown dramatically recently. In the USA, the market share of spreads increased from 5 percent in 1976 to 74 percent in 1995. Similarly, in the European market 75 - 80 percent of the marketed spreadable products were low-fat spreads in 1993, compared to 20 - 25 percent in 1985 [12]. The convenience of the rapidly rising spreadable sector has also given the margarine and spread sectors a much-needed boost. In 2005, the total valuation of the margarine and spreads sector increased to some 375 million Euros. This huge inflation was the result of the comparative success of the spreads sector, wherein healthy spreads (such as soy, olive oil and functional spreads), in particular, are forecast to be an area of real growth [16].

Functional ingredients for spread

The interest in developing functional foods is driven largely by the market potential for food that can improve the health and well-being of consumers. Successful types of functional products have been designed to reduce high blood pressure, cholesterol, blood sugar and osteoporosis. Recently, the functional food research has moved progressively towards the development of dietary supplementation. In this respect, fat spreads containing functional ingredients have been launched in several European and western countries.

Plant sterol/stanol: Plant sterol/ stanol

During the 1980s, the cholesterol lowering effects of foods fortified with plant sterols (PS) were well recognized. Margarines/spread and butter can be utilized as ideal vehicles for incorporating PS because of their strong lipophilic nature [17]. There are now available margarines that have no TFA. An excellent example is a low fat, butter-flavoured non-dairy soya spread (39 percent fat and 6.3 percent protein), which is available in form of an o/w emulsion [18]. Studies have shown that non-dairy soya spread could be a good source of phytosterol as well as omega-3 fatty acids. Constant (2004) mentioned in his report that adding plant sterols (stanol esters) through vegetable oils can lower total serum cholesterol. The trade names for such products in the USA are Benecol, Smart Balance Plus, and Take Control [19]. Benecol® a margarine containing plant stanol ester was launched in 1995 by Raisio group, Finland. It is an example of a functional food that has been shown to effectively lower total serum and low-density lipoprotein cholesterol (LDL-C) levels [20,21].

A soyabean oil containing fat spread with a daily recommended dose of 30 g/day contains 3 grams of PS. This concentration is shown to effectively lower LDL-C level without impacting the high-density lipoprotein cholesterol (HDL-C) levels [22]. In Europe, the average consumption of butter or margarine is about 25 g/person/day. The sterol-enriched margarines may contain up to 2 gram of PS or stanols per daily portion. These values are in accordance with the previous opinion of the committee on the safety for the use of phytosterol esters in yellow-fat spreads [23]. So far, several studies have been reported on investigation of the effect of PS enriched margarine/fat spread and its impact in significantly reducing the levels of LDL-C. Patch and co-worker showed that the PS enriched spread, when consumed for a period of 4 weeks, lowered the total serum cholesterol and LDL-C by 7 percent and 9 - 10 percent, respectively [24]. A 25 g/day of spread intake would ensure the recommended daily dose of 2 - 3 gram of PS, which can help achieve an optimal cholesterol lowering effect. The results are in line with previous studies reported by other scientists [25-28].

According to Rouyanne., *et al*. INVEST (Investigating Vascular Function Effects) results of PS showed that a regular intake of 20 grams low-fat spread with added 2 g/day PS for 12 weeks, significantly reduced LDL-C by ~ 6.7 percent, without improving nor worsening the vascular function [29].

Fat phase modifications

The major health risks are perceived to be associated with saturated fatty acid (SFA), cholesterol and TFA. Milk Fat is the primary source of SFA and cholesterol whereas hydrogenated vegetable fat is the primary course of TFA. Therefore, substituting saturated fat with monounsaturated fat, reducing or removing cholesterol levels and eliminating TFA generation processes are promoted to improve fat spreads' dietary benefits.

Monounsaturated fatty acids (MUFA)

Earlier, PUFA was considered good for heart health because of its lowering effects on harmful LDL (bad cholesterol), total cholesterol and triacylglycerols in blood. This benefit was achieved without compromising the levels of HDL/good cholesterol. Interestingly, it is now believed that a balance between saturated and unsaturated fatty acids can yield better health benefits including reduced risk of heart disease [30]. According to FAO (Food and Agriculture Organization)/WHO recommendations, there is convincing evidence that replacing (a) carbohydrates with MUFAs increases good HDL-C and (b) SFAs with MUFAs reduces bad LDL-C [31]. In recent survey, spreads sold in the US marketplace showed that 14 gram serving of spread contained on an average 50 percent of fat, of which 1.42 percent is TFA, 12.8 percent is SFA, 12.8 percent is MUFA and 20.71 percent is PUFA [32].

Oils rich in MUFA (e.g. peanut, canola, rice bran) and high-oleic acid (e.g. safflower and sesame oils) [33] have become particularly desirable in fat blends for low-fat spreads. Excellent examples include safflower and sesame oils which contain a high percentage of MUFA (41.2 - 79.7 percent) and a lower percentage of SFA (16 percent or less). Similar to these, canola oil (low-erucic acid rapeseed oil), olive oil and rice bran oil is approved by Food and Drug Administration (FDA) for usage in fat spreads and are placed in the 'healthy products' category [34]. Olive oil containing spreads are popular in European and Canadian market, whereas rice bran oil is widely used for margarine preparation in India [35].

An appropriate emulsification process of peanut butter (obtained from roasted peanuts) yields a low-fat spread which contains ~40 percent fat, 24 percent MUFA, 14 percent PUFA and 16 percent protein. It has been reported to reduce the total blood serum levels and LDL cholesterol by 11 and 14 percent, respectively, within a month. [36] It also reduces triacylglycerol by 13 percent without adversely affecting the HDL-C level, thereby decreasing the risk of CVD by 21 percent.

Trans fatty acid-free spreads

Partial hydrogenation of vegetable oils is a common practice in the preparation of fat blends for fat spreads. The process provides desired consistency and mouth feel characteristics along with improved shelf life. TFA have also been found to increase the risk of CHD by aggravating the deficiencies of essential fatty acids, such as *cis* alpha-linoleic acid [37]. It is obvious, therefore, that oil processing technologies which can yield fats with the desired physical properties without producing TFA have been sought to improve the health value of spreads. Interesterification is another technological alternative, which allows for random distribution of different ester groups over the triacylglycerols in the mixture. The mixture resulting from random interesterification may have the desired plasticity.

The negative health image of TFA among the consumers has led to the development of several low or no trans fat blends, most of which contain a high level of liquid oil. Non-dairy spreads low in TFA can be obtained by using tropical oils, such as, palm oil, palm kernel oil and coconut oil; however, the high levels of SFA in these oils make them as such less desirable from the health point of view [34]. Interesterification of completely hydrogenated mixture of palm oil and Babassu oil (American palm kernel oil, rich in lauric acid) has been reported by Ward [38] to yield hard fat that can be used to prepare fat blends for a highly unsaturated fatty acid (USFA) margarine. Soft margarine has also been formulated from fully hydrogenated interesterified palm oil and palm kernel oil [39]. Interesterified mixture of coconut oil, palm oil and palm stearin (the last obtained as a solid fat upon fractionation of palm oil) has been prepared into soft margarines [40]. Spreads prepared from blends containing liquid oil, 3-10 percent a fully hydrogenated palmitic fat and less than 3 percent trans acids have been

developed by Schijf and Muller (1992) [41]. Enzymatic interesterification has also been reported by Yayashi., *et al*. [42] to yield a fat blend suitable for low-TFA spreads. Similarly, zero-TFA spreads have also been produced employing interesterification approach.

Omega-3 fatty acid

Food fortified with long chain omega-3 PUFA could play an important role in meeting the demands for optimal health. Developments in food technology allow fortification of omega-3 fatty acids into foods, which can be achieved without imparting the undesirable fishy odour/taste throughout the shelf life of product [43]. Food products, such as, bread, dairy products, eggs, pasta, biscuits, margarines and other spreads are now enriched with omega-3. There is need to increase the amount of long chain omega-3 PUFA consumed per serve and optimize their bioavailability.

In 1992, spreads from oils containing long-chain omega-3 fatty acids were reported in United States [32]. A reduced-fat margarine (Pact) based on rapeseed oil with a low SFA level, high MUFA level, and omega-3 fatty acids was commercially introduced in Denmark in 1995 [44,45]. It also contained a small amount of unhydrogenated fish oil (giving 0.2 gram long-chain omega-3 fatty acids per 15 gram of the spread) and the spread was claimed to be stable and free from fishy flavour. A study which employed a long chain omega-3 spread together with a range of products enriched with microencapsulated fish oils (milk shake, orange drink, pasta, bread, biscuits, cakes) was able to achieve a daily intake of 1.4 gram eicosapentaenoic acid (EPA)/docosahexaenoic acid (DHA) [45]. Unlike Pact, which is a low-fat spread containing unhydrogenated fish oil free from TFA, Blue Gaio is a dairy blend (produced using butter technology) enriched with long chain omega-3 fatty acids from fish oil. Both products are produced by MD foods [46]. To achieve a more desirable ratio of dietary omega-3 to omega-6 PUFAs (ω–6:ω–3 PUFAs = 1:1), the consumption of fish and omega-3-rich seed oils and spreads, such as canola, soy and flaxseed are promoted [47]. In the Lyon Heart Study, which tested the "Mediterranean diet," an increase in alpha-linolenic acid (ALA) plant source of omega-3 from about 500 mg/day to 1,600 mg/day (from a canola-based margarine) was just one of several dietary changes that resulted in reduced risk for heart attacks [48]. Omega-3 fatty acids enriched chocolate spreads developed using soybean and coconut oils contained 19.8 percent lauric acid, a medium chain fatty acid, which is a source of disease fighting fatty acid derivative [49]. Chocolate spread developed by Jeyarani and co-workers had good amount of omega-6 (22.3 percent) and omega-3 fatty acid (2.1 percent). Optimized chocolate spread formulations can provide consumers with an alternative flavored product while maintaining optimized omega-6/omega-3 fatty acids levels [50].

A reduced fat spread formulated by Kolanowski and co-workers [51] contained fish oil omega-3 PUFA. A daily portion of this enriched spread (30g) would provide 0.25 gram of EPA and DHA, significantly increasing long-chain omega-3 levels in the average diet. AP Foods (Seafood Chain) omega-3 spread contains 600 mg of long chain omega-3 PUFA per 100 gram. Approximately 35 g/day of this spread must be consumed for healthy heart and 175 g/day would need to be consumed to obtain sufficient long chain omega-3 PUFA to benefit those at high risk of CVD [52]. Flora Omega-3 Plus spread, launched in UK, is a novel spread with long-chain omega-3 fatty acids. 20 gram serving of this spread contains 135 mg of fish source omega-3 fatty acids and 600 mg of plant source (from linseed and rapeseed oil) omega-3 fatty acids [53].

The Promise Light Buttery Spread is fortified with 15 percent or more of vitamins D, E, B_6 and B_{12}. It also contains omega-3 fatty acids that have been shown to help lower the risk for heart disease and boost immune system. Promise Spread is marketed as 65 percent (omega-6 = 3.4 gm; omega-3 = 0.4 gm) and 35 percent (omega-6=2 gm; omega-3 = 25) gm vegetable oil. In both cases a ratio of 8-8.5 for ω-6/ω-3 is maintained in one tablespoon (14 gram) of serving [54].

St Ivel Gold is a low-fat spread that now has a new look and a new range. The range consists of St Ivel Gold Low Fat, St Ivel Gold Lightest and St Ivel Gold Omega-3. Long chain omega-3 fatty acids is about 10 times more effective than short chain forms. St Ivel Gold Omega-3 spreads consists of long chain omega-3 fatty acids (DHA and EPA) in which 100 gram of the product has 0.275 gram of omega-3 and is equivalent to 61 percent of the recommended daily intake (RDI) [55].

Prebiotics

Both inulin and oligofructose have been demonstrated to be effective prebiotics. Owing of their recognized prebiotic properties, principally the selective stimulation of colonic bifidobacteria, both inulin and oligofructose are increasingly used in new food product developments [56]. Inulin also possesses gel-forming capabilities. The sensorial and rheological properties of inulin gel allow to mimic fat's texture and macroscopic properties [57]. Replacement of fat by inulin results in unaltered mouth feel and structure. Basically, all of these properties are present in foodstuffs with inulin. However, food manufacturers usually decide to use inulin for either nutritional or technological properties [58]. In last few years, inulin containing products has gathered a lot of media attention, leading to novel product innovations. This is particularly true in products, such as, fat spreads, butter-like products, dairy spreads, cream cheese and processed cheese [59]. It allows for the replacement of significant amount of fat and the stabilization of the emulsion, while providing a short spreadable texture [60]. A low-fat spread formulation is reported which uses inulin in the water phase as a structuring agent, thereby improving spreadability, mouth feel, flavour release and process stability [61]. The use of high-performance inulin would prove to be the method of choice when formulating a low-fat table spread that has a creamy, fat-like mouth feel with no added sweetness **[62**]. Excellent stability and performance results are obtained in w/o emulsion spreads with a fat content ranging from 20 to 60 percent, as well as in water-continuous formulations containing 15 percent fat or less [59]. In low-fat cheese spread milk protein is replaced by 5 percent inulin which dramatically enhances the physicochemical, rheological and sensory characteristics of the cheese spread [63].

The attempt was made to incorporate the dietary fibre in the form of inulin and oat in the formulation of fat spread. Kharb and Thompkinson study indicated that the higher the level of oat fibre adversely affected sensory attributes of resultant fat spread. Addition of inulin cream gave better body to formulation and improved the texture and spreadability scores [64]. Inulin containing spread (Actiline) manufactured by Belgium company Vamdermoortele is available in European market [65]. Apart from inulin and oat fibre, sunfibre is used as a prebiotic in the formulation of soy-based fat/table spread. Sunfibre is a galactomannan based soluble dietary fibre made from hydrolyzed Guar gum. Soy spread developed by using soy protein isolate (7 percent) and sunfibre (4 percent) imparted good body, texture and spreadability to the final formulation [66].

Number of health benefits are associated with these prebiotics e.g., improved gut microbiota, increased mineral absorption, stimulation of immune functions, reduced risks of irritable bowel diseases and constipation [67-69]. Besides, they also possess the potential to lower the cholesterol and colorectal cancer [70]. The effect of prebiotics in humans have found variable results [71,72]. Van Dokkum., *et al*. and Pedersen., *et al*. [73,74] reported two separate controlled studies with normal versus type 2 diabetes patients [75]. No significant effects were found on blood triglyceride, blood cholesterol, or blood glucose with 14 or 15 g/day doses of oligofructose administered for 3 or 4 weeks. In contrast, Causey and co-workers [76] observed a significant decrease of blood triglyceride levels after 3 weeks of 20 grams inulin/day dosage. In addition, he observed cholesterol reduction in hypercholesterolemic men. Further research in humans is required to determine if some of these benefits exist when prebiotic-containing foods are consumed as a part of normal diet.

Probiotics

Probiotic bacteria are live microorganisms which confer a health benefit to the host when administered in adequate amounts [77]. Therefore, probiotic strains should remain alive in the product and should survive passage through the human gastrointestinal (GI) tract. The low-fat spread is a suitable carrier for probiotic strains, such as *L. reuteri* DSM 17938 and *L. rhamnosus* GG. A double-blind, placebo-controlled human intervention study demonstrated that both *L. reuteri* DSM 17938 and *L. rhamnosus* GG, when administered in low fat spread, can survive the passage through the human GI tract. A significant increase in the recovery of viable probiotic bacteria in fecal samples was observed after 3 weeks of daily consumption of this low-fat probiotic spread [78]. A reduced fat 60 percent (w/o) edible bio-spread was developed by Charteris., *et al* [79]. In this bio-spread, viable, non-growing, mixed-strain and potentially probiotic culture was added. *Lactobacillus casei* ACA-DC 212.3 and *Bifidobacterium infantis* ATCC 25962 were added as probiotics in a hydrocolloid-stabilized

aqueous phase and the spread was processed through pre-emulsification pasteurization, emulsification, processing and packaging under nitrogen atmosphere, to achieve acceptable strain viability (with a viable count of 10^5 cfu/ml). The spread contained a lipid phase of anhydrous milk fat, a hard milk fat fraction and soybean oil (66:26:8) combined with an emulsifier at 0.4 percent (w/w), of aqueous phase [79].

In a separate study, functional cheese spread containing omega-3 fatty acids was prepared with probiotic *Lactobacillus fermentum* ME-3 strain which also served as an antioxidant [67]. A clinical study on animals further demonstrated that *Lactobacillus fermentum* ME-3 benefits the general health status, prevents the carrier state of *Salmonella,* and improves the mucosal antioxidative parameters [80].

Fortified with micronutrients and antioxidants

In most developed countries foods fortified with minor essential food ingredients are constantly developed and marketed. In developing countries, > 200 million children aged < 5yr are affected by retarded linear growth, or stunting, and > 40 percent are estimated to have iron deficiency and anemia [81]. Hence, there is an urgent nutritional need for vulnerable populations in developing Asian and African countries to combat severe malnutrition. This can be addressed through the use of highly fortified foods.

Vitamin and mineral

Fat spreads has been used as vehicles for fat-soluble vitamin fortification. The low-fat spread is fortified with folic acid (FA) with the aim of determining the acute absorption of FA from the fortified spread (FS). A double blind, crossover study was conducted to test each of the following treatments administered at weekly intervals: (A) 20 gram low-fat (40 percent) spread fortified with 200 µg FA and a placebo tablet; (B) 20 gram low-fat placebo spread and a 200 µg FA tablet; (C) 20 gram low-fat placebo spread and a placebo tablet. The absorption of FA from fortified low-fat spread is lower than that of a placebo tablet. Despite lower levels as well as absorption FA's bioavailability is more effective through low-fat spreads. These results suggest that low-fat spreads typically associated with fat-soluble vitamin fortification, can also be considered as vehicles for FA fortification [82]. Low-fat spreads are formulated to deliver fat-soluble vitamins (A, D and E) wherein the concentration of vitamins is similar to or higher than those supplied by butter and their absorption is likely improved. Low-fat spreads might be viewed positively as vehicles for lipolytic nutrients without excessive lipid and can contribute to the fulfilment of the recommended daily intake of A, D and E vitamins [12]. Fat-based spreads/margarine are routinely fortified with vitamin D. This has already been introduced by countries such as the US, Canada, India, and Finland. Finland recommends addition of vitamin D at a dose of 10 µg/100g to all fat spreads and at a dose of 0.5 µg/100g to all fluid milk products. In 2010, these fortification recommendations were doubled to 20 µg/100 g in all fat spreads. It is also worth mentioning that fat spreads were already a substantial source of vitamin D [83]. A number of calcium-supplemented foods, including spreads, came on the market. A spread enriched in vitamin D and calcium is on market in the Netherlands which claims to supply 15 percent of recommended dietary allowances (RDA) calcium intake with a dose of 25 gram spread/day [84]. Kharb and Thompkinson formulated fat spread with three different sources of calcium salts at different concentration of 16, 20 and 25 percent of RDA per 30 gram of spread serving. They investigated fat spread with added calcium salts for sensory evaluation and rheological attributes. The spread fortified with tricalcium citrate at 16 percent RDA was adjusted the best in terms of sensory and rheological attributes [64].

Highly nutrient-dense (HND) spread was used to deliver multiple micronutrients to high-risk groups [85]. The spread was obtained by blending skim milk powder with peanut butter and powdered lactoserum and comprised of 10 percent protein, 57 percent fat along with mineral and vitamins in concentrated forms. This spread was found to serve as highly effective supplement to the local diet and was found superior to the liquid formulation F100 developed by WHO in energy intake. The sensorials of this spread was particularly preferred by children. The amount of HND spread, which need to deliver a daily dose of micronutrients, can vary from 10 gram to 100 g/day [86]. A new approach is to develop a fortified food with lower nutrient density and use of an additional, separate supplement to reach the higher levels needed by younger infants (e.g., a sprinkles product or a fat-based spread fortified with iron and zinc or liquid iron and zinc supplements administered separately) [87].

Supplementation with zinc and possibly iron and vitamin B_{12} was shown to improve linear growth of children in deficient populations [88,89]. The supplementation consisted of 50 g/day of fat spread that provided high energy and high levels of proteins. For most vitamins and minerals, fortification amounts were 1.5 - 3 times higher than the RDI. Ratios were then adjusted for known interactions between micronutrients. For example, zinc has no identified storage compartment in the body but has been shown to affect linear growth when deficient in the diet. Hence, zinc was supplemented at 43 mg/day, an amount > 3 times than the RDI, to adjust for the zinc-to-iron ratio [90]. Micronutrient adjustments were also made to prevent any potential absorption issues and to avoid toxic concentrations. Inclusion of electrolytes, such as, potassium, phosphorus, and magnesium were regarded as important, given their central role in diarrhoea management. A HND spread fortified with vitamin and minerals, was developed by Lopriore and co-workers [91] for treatment of retarded linear growth and reduction of anemia in stunted children. Linear growth of children who were fed fortified spread (FS) was 30 percent faster at 3 months than in children who were fed unfortified spread (UFS). The height-for-age *z* scores increased only slightly in the FS group and remained unchanged in the other groups. In addition, an increase in hemoglobin concentrations in the FS group at 6 months was two-fold higher than that in the UFS and control groups (37 ± 40, 19 ± 15, and 16 ± 17 g/L, respectively). Importantly, anemia was reduced by nearly 90 percent in the FS group.

In another study, three amino acid-balanced, vitamin- and mineral-fortified peanut spreads were stored at 4ºC, 23ºC, and 40ºC for 3 months. Compositions were a) 69.6 percent peanut, 19 percent soybean, 40.5 percent fat; (b) 61.9 percent peanut, 19 percent soybean, 44.5 percent fat; and (c) 74.1 percent peanut, 14 percent non-fat dry milk (NFDM), 40 percent fat. The peanut spreads were fortified with vitamin A, thiamine, riboflavin, vitamin B_6, vitamin C, calcium (calcium carbonate), and iron (ferric orthophosphate) to provide 33.3 percent of the RDA for children. Water-soluble vitamins were quite stable in deaerated peanut spreads. The antioxidant activity of phytochemicals in soybean prevented vitamin A degradation in soy-containing spreads, whereas the NFDM spread lost 70 percent of the initial content of Vitamin A [92].

Antioxidant

Spread and antioxidants work synergistically. On one hand, spreads serve as a good vehicle for fat-soluble antioxidants, while, on the other hand, antioxidants are needed for efficient absorption.

Vitamin E

The principal source of vitamin E is vegetable oils and spreads made from vegetable oils. Hence, these vehicles serve as the main dietary sources of vitamin E. The prepared spread contains 0.6 gram of vitamin E per gram of linoleic acid and contributes towards lowering the risk of CHD [84]. The contribution of spreads, dressing and oil to vitamin E intake is approximately 50 percent. Spreads enriched in vitamin E (31 mg/day) and α and β-carotene (3 - 5 mg/day) helps increase their levels in plasma and LDL [93].

High doses of vitamin E have been shown to decrease lipid peroxidation in humans under oxidative stress. Halliwell., *et al*. studied the effect of moderate doses of a combination of vitamin E and carotenoids incorporated into food products like vegetable oils and fat spreads. Moderate doses can lead to measurable and significant improvements in plasma concentrations of antioxidants [84,94]. One hundred and five healthy adults were randomly, evenly assigned in this double-blind, placebo-controlled, parallel, 11-weeks intervention study. For the first 2 weeks, all subjects consumed a commercial UFS. After a 2-weeks stabilization period, the subjects consumed 25 g/day of one of the three categories of spread: Spread A contained 43 mg α -tocopherol (TE) and 0.45 mg carotenoids; Spread B contained 111 mg α -TE and 1.24 mg carotenoids; Spread C contained 1.3 mg α-tocopherol without carotenoids. Plasma α-TE concentrations increased significantly in subjects consuming spreads A (31 percent) and B (73 percent) but did not change significantly in those consuming spread C (2 percent). In contrast, larger increases in these variables were observed in subjects consuming spread B which indicate that the performance of product is dose dependent. Furthermore, consumption of spread B significantly reduced concentrations of the plasma lipid peroxidation (15 percent) [95].

Carotenoids

The major dietary carotenoids are α and β-carotene, β-cryptoxanthin, lycopene, lutein and zeaxanthin. These can be incorporated into spreads as they may be useful in the treatment of Vitamin A deficiency. A major drawback of these carotenoids is their ability to impart color to spread, which can be controlled through encapsulation technologies, such as, liposomes. Specifically, intake of lycopene is largely from tomatoes and it may have more promise as carotenoid source than β-carotene, due to its potent antioxidant properties. β-carotene and lycopene are fat-soluble compounds and can inhibit the oxidation of LDL when incorporated in spreads [96,97].

Ubiquinol/ubiquinone (coenzyme Q)

Ubiquinol is a fat-soluble antioxidant synthesised by the body. The ability to synthesize ubiquinol decreases with age. Dietary intake of ubiquinone is about 2 mg/day. Dietary supplements of ubiquinone are available in the market. The technology of Ubiquinol fortified spread was patented by Masayuki., *et al*. [98].

Fat replacers

Fat replacers are substances, which chemically resemble fats, protein or carbohydrates and possess certain desirable physical or organoleptic properties of fat. Fat replacers are categorized in two groups as Fat substitute and Fat mimetic. A few lipid-based fat substitutes have been developed which can be applied in low (zero) fat spreads [99]. Low-fat spreads can help in reducing fat energy intake in obese people. Obesity is a common risk factor in a number of diseases, including diabetes, cardiovascular disease [100] and cancer (e.g., breast and colon cancer). Reduced and low-fat spreads can help consumers make appropriate choice in food products for restricted dietary fat intake. Fat substitutes' compounds are completely broken down in the body and are useful in all edible compositions. These compounds thus achieve reduced caloric value and reduced problems associated with non-metabolizable fat molecules. Fat substitutes, such as, sucrose octanoate, sucrose polyesters of short and long chain fatty acids, Fat mimetic modified gums as well as modified whey protein concentrate (WPC) have been employed in fat spreads [33,101].

Coagel

A zero fat spread (less than 4 percent fat) has been on the American market since 1997. The spread is based on a coagel phase consisting of a network of saturated monoglyceride crystals. The crystalline coagel state has a fat like consistency, but interestingly it contains 95 percent water which makes it as a healthy alternative [102].

Sucrose polyester

Low-fat spreads are made by using sucrose polyester (SPE), which have fatty acyl ester of sucrose with six to eight fatty acid moieties. The hydrophilic and lipophilic properties of an SPE enable it to stabilize the interface tension between water and lipid/fat phase, thus, enabling it as a surface-active agent. As an emulsifier, it can replace up to 50 percent of the fat in a food formulation as well as provide aeration and foaming properties. It also helps control syneresis, encapsulate flavours, control rheology and provide lubricity to spreads [103]. Owing to the fat-like properties (physical and organoleptic), SPE can also be treated as a regular oil for frying. Unlike traditional oils/fats, SPE is not hydrolyzed in the GI by lipases due to steric hindrance and is completely excreted in the faeces [104,100]. It is already on the market as a non-energetic fat substitute and present in a number of low-fat snacks. At high intakes (30g SPE/ day), spreads can decrease plasma total cholesterol and triacylglycerol [105].

Carboxy/carboxylate esters

Lawrence and Finely described the carboxylate esters are fat mimetics which are employed in edible compositions or in food preparation processes where fat or oil is normally used in total or partial replacement [106,107]. In 1990, Jacklin., *et al*. [108] describes the preparation and properties of low-calorie fat mimetic comprising of carboxy/carboxylate esters. The application of these esters includes frozen desserts, pudding pie fillings, margarine, flavoured spreads, mayonnaise, etc.

Simplesse

Simplesse is an example of microencapsulated protein, which is manufactured from WPCs or milk and egg protein by micro-particulation process [109]. The protein-based fat replacer ingredients are used as thickeners or texturiser for frozen dessert type products. Its approved applications have been extended and Simplesse is in a variety of food products including low-fat cheese, low-fat spreads, margarine and dairy desserts [110]. It imparts creaminess in high moisture applications and tend to mask the flavour.

Polyglycerol esters (PGEs)

PGEs are prepared by polymerisation of glycerine under alkaline conditions wherein glycerol moieties are connected with ether groups. The PGEs are then esterified with varying moles of fatty acids. PGEs caloric value may be as low as 2 Kcal/g due to its partial absorption. It is used as emulsifiers in low-fat products, such as, margarine type spreads. It can also be used at high levels for total fat replacement; however, that would require changes in RDI [111]. The addition of PGEs improves the functional properties of the margarine (e.g. the organoleptic properties of spreads, stabilization or aeration of food products) in addition to the emulsification properties. They improve the organoleptic properties of a margarine or low-fat spread by reducing the graininess of the lipid phase, which imparts viscoelasticity corresponding to the natural butter [112].

Maltodextrin

Starch-based fat replacers are one kind of fat mimetic that can be produced either chemically as modified starch or enzymatically as maltodextrins. Several commercial maltodextrin-based fat replacers are available on the market, such as, Paselli SA2 from potato starch, Maltrin M040 from cornstarch, N-oil from tapioca starch, and Oatrim from oat starch [113]. The United State Department of Agriculture (USDA) has also approved Oatrim-5, which is a combination of oat beta-glucan and oat maltodextrins. This unique combination could deliver additional health benefits to the human body, such as cholesterol-lowering effects.

Paselli SA2 (Avebe America, Inc. Princeton, N.J) is a maltodextrin with a dextrose equivalent of less than 3. Gels made from Paselli SA2 are said to have a smooth, bland texture and is recommended for baked goods, spoonable dressing, mayonnaise type products, low-fat spread and ice creams [112].

Some disadvantages associated with potato-starch based maltodextrin fat replacers include low freeze–thaw, and low acid and heat stability [103]. This limitation is superseded by the use of native and cross-linked rice starch which significantly improved the freeze stability of mayonnaise [114]. Mayonnaise/spread is a commonly consumed food, but it contains a substantial amount of fat (20 percent). The replacement of mayonnaise fat with either native or cross-linked rice starch gels could yield superior sensory quality than the full-fat control [114]. Interestingly, rice starch modified by 4-α-glucanotransferase could be successfully used in the preparation of low-fat spreads, allowing the formulation of functional products for healthy diets [115].

Conclusion

With an increase in health consciousness, the consumption of butter is reducing due to higher fat content. Simultaneously, the perceived risk of saturated fat and cholesterol contents of milk fat has shifted scientific community towards the development of newer spreads, such as, butter blends and low-fat margarine. These substitutes have high polyunsaturated fatty acid content with reduced or no cholesterol. The growing awareness of the consumers towards the monounsaturated fatty acid, omega-3 fatty acid, plant sterol, etc. has set a trend towards low-fat spreads formulated with these functional ingredients. Several options of using protein and carbohydrate-based fat replacers have been successfully tried for improving the texture and mouth feel of very low-fat spreads. The use of probiotic culture to produce a biospread is another approach widely popular in increasing the health value of fat spreads. A highly nutrient dense spread fortified with minerals and vitamins is intended to serve as a rich source of nutrients supplements to the normal diet.

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