Technical Brief

Food Reformulation for Fats

Cattaruzza, A. and French, S. (2024)

Introduction

As scientific opinion has developed concerning the health impact of fats during the past 60 years, regulatory and voluntary efforts to alter the fat composition of foods and the diet have ensued (1).

What are fats?

Fats and oils are macronutrients required by the body, as part of a healthy diet, and about a third of our daily energy source. They comprise saturated, monounsaturated and polyunsaturated fatty acids, linked together in groups of three (triglycerides) (2). Saturated fats contain a high percentage of saturated fatty acids (SAFA), usually more than 50% (e.g. palm oil); unsaturated fats contain less saturated fatty acids, for instance 16% in soya bean oil. Trans fatty acids (trans fats; TFA) are unsaturated fatty acids with the functional properties of saturated fats and are naturally occurring in milk, dairy products and meats, but are also produced industrially by hydrogenation, where oils are converted into solid fats.

The functions of fats in the body are:

- energy release
- transportation of fat soluble vitamins (A, D, E, K) to where needed
- provision of essential fatty acids (important nutrients the body cannot produce) e.g. long-chain omega-3 (2)
- important structural components of all cell membranes
- providing a protective layer around vital organs, to give a cushioning effect
- helping regulate temperature and keeping the body warm, when necessary.

Where do fats in the diet come from?

Saturated fats are mostly found in meats, meat products and dairy products, such as butter, milk and cheese. However, some fats derived from plants are high in SAFA, such as cocoa butter, coconut, palm and palm kernel oil (referred to as tropical oils). They are widely used in foods such as cakes, biscuits and pastries. Vegetable oils (e.g. rapeseed, olive, peanut) contain high amounts of mono-unsaturated fatty acids. Soya bean, sunflower and maize oil contain considerable amounts of omega-6 polyunsaturated fatty acids (PUFA), while flaxseed and fish oils are particularly rich in omega-3 PUFA. Trans fats are used in the same products as saturated fats. They are used in margarine and can prevent separation in peanut butter.

Why are fats a concern for health?

Fats are the most calorie dense macronutrients, delivering 9 kcal/g, compared to 4 kcal/g from carbohydrates and proteins. They contribute disproportionately to the energy density of a product; hence the overconsumption of high fat foods can be a major contributor to overweight and obesity. The effects of the dietary intake of different types of fats on health have been the subject of a huge amount of research in the last 60 years. Mensink and Katan (3) showed a cause/effect relationship between trans, saturated and unsaturated fatty acids on blood cholesterol, a key indicator of cardiovascular health. Despite recent controversial positions, there is extensive evidence that replacing some saturated fats with polyunsaturated fats reduces the risk of coronary heart disease. The negative effects of trans fats on cholesterol levels are more pronounced, leading to limits or bans for use in food in some legislations. Replacement of saturated fats with carbohydrates, e.g. in a low-fat diet, does not deliver benefits in controlling blood cholesterol, as saturated fats must be replaced by unsaturated fats to have a positive effect (4). Specific fatty acids, e.g. alpha-linolenic acid, and long chain omega-3 PUFA, have recognised health benefits on cardiovascular and brain health.

Acrylamide, a chemical formed when some foods, such as bread, potatoes and cookies are cooked (e.g. toasted, fried, grilled, baked) above 120ºC, has the potential to cause cancer in humans and so should be prevented (5). Although Maillard reaction is the major pathway for its formation, lipid oxidation also contributes to fried products, since breakdown products can react with asparagine to form acrylamide, despite the absence of reducing sugars (6).

Details of their functional role in food

Depends on the recipe and fat specification. At room temperature, a fat low in saturated fatty acids (e.g. sunflower, rapeseed) is in a liquid state and provides lubrication, flavour release and efficient heat transfer, hence can be used in condiments, mayonnaise and emulsions. Conversely one high in saturated fatty acids, typically over 45-50% (e.g. palm oil, milk fat, cocoa butter), crystallises at room temperature in a solid state influencing texture, mouthfeel and melting behaviour of food products. Textural functionality is crucial in baking, chocolate confectionery components, aerated products, ice cream, and cheese. Both low saturated oils and high saturated fats can be used for frying, but their stability to oxidation and exposure to high temperatures determines their suitability. Fats high in saturates are more stable in terms of oxidation compared to mono- and poly-unsaturated fats.

Technical strategies for reformulation of fats in food products

The science is clear on the directions to take to improve the nutritional impact of food, when considering their fat composition, in terms of amount and quality of ingredients:

i. reduce energy density of a product by acting on all macronutrients, e.g. replacing fats with fibres as opposed to simple carbohydrates. In cases where low fat foods, such as yogurt, merely have fat replaced with sugar, they will be less healthy than perceived (7)

ii. reduce to minimum trans fats, by avoiding the use of partially hydrogenated fats, and controlling fat processing (e.g. deodorisation) to produce trans fats below 1-2% in the fat (see EU Regulation 2019/649)

iii. increase the amount of omega-3 fatty acids, considering recommended dietary allowances (RDA) and oxidation risks in the food

iv. replace saturated with unsaturated fats to improve fat quality for cardiovascular health, e.g. use more sunflower and rapeseed oil, instead of palm, milk fat or cocoa butter. This is the most challenging, depending on required functionality, as it implies using liquid oils instead of solid fats. Saturated fats crystallise (are solid), at 10–50ºC, which is an essential property in some products but complementary or redundant in others. See table 1.

Table 1: Implications of replacing saturated with unsaturated fats

Solid Fat Crystals	Application	Description
Redundant	Fried foods e.g. potato crisps	Reducing saturated fat is unrelated specifically to structure formation, however switching or blending oils to deliver healthier fatty acid profiles is common practice amongst producers
Beneficial	Margarine	A water-in-oil emulsion. The oil is saturated or unsaturated depending on the required consistency of the final product. Hard margarine contains saturated fat, e.g. palm oil; soft margarines contain sunflower or rapeseed oil. Blends of different fats, to achieve the right consistency and plasticity, are common
	Baked snacks	Made from a sheeted dough where fat crystals, in combination with the starch network, help with micro-lamination to deliver a lighter crispier texture. Replacing with liquid oil and maintaining desirable product design attributes, is possible through process and/or recipe modifications, e.g. increasing mechanical shear and use of modified starches
	Cake	Structure is formed by proteins, from eggs and wheat flour (gluten), which deliver an elastic, aerated 'scaffold' of air bubbles. Sugar and fat provide softness, lubrication and help the leavening process. For the creaming method, sugar is beaten with solid fat (e.g. butter, palm) to aerate the batter. Liquid oils can be used when all ingredients are added together equally, producing an aerated, fluffy texture. Hence, replacing fats with oils is straight forward, though process adaptations may be needed
Essential	Shortbread	Requires presence of fat crystals, in the mixture, to disrupt the gluten network and deliver a characteristic short, crumbly texture. Replacing solid fat with liquid oil dramatically changes texture. It is possible to disrupt the gluten network by creating an emulsion (oleogel) using liquid oil, to achieve a short texture

Essential	Puff pastry	Created by folding dough onto solid fat multiple times to form laminations. Solid fat crystals separate individual folds during baking to produce thin layers, hence difficult to find an alternative
	Chocolate	Blends of cocoa, sugar and fat. Solid fat crystals are essential to deliver texture and melting in the mouth (cocoa butter crystals melt quickly at body temperature i.e. 37°C) and characteristic snap. Hence it is difficult, or impossible, to replace saturated with unsaturated fats. Some suppliers offer low saturated fats suitable for achieving a reduction
	Fat-based creams (confectionery fillings & toppings)	Mixtures of milk, cocoa powder, sugar and fat. Solid fat crystals are essential as they deliver the texture and the melting behaviour in the mouth. It is difficult, or impossible, to replace saturated fats with unsaturated fats in these products. Nevertheless, some suppliers offer low saturated fats suitable for achieving a meaningful reduction

N.B. any reformulation needs to comply with regulations, including composition standards (e.g. EU Cocoa and Chocolate Products Directive), nutrition claims and labelling.

Sustainability implications

The food system uses 43% of ice and desert-free land, and emits 14 billion tonnes of Green House Gasses (GHG), or 26% of total emissions (8). Oils and fats are a substantial proportion of this: 19% of land use and 4 billion tonnes of GHG, or 7% of total emissions (9). Palm oil is the second main cause of global deforestation after cattle pasture; soya beans are third. However, palm is not the worst in terms of sustainable use of land as it is very productive. One hectare of palm trees produces 5-10 times more edible oil than any other oil crop (e.g. soya bean, sunflower, rapeseed) (10,11). It is difficult to substitute in many applications because of its composition and versatility. The Roundtable on Sustainable Palm Oil (RSPO) is a non-profit certification body used to guarantee sustainable practices from plantation to transformation. A promising innovation is the use of fermentation, from algae, bacteria, yeasts and fungi, to produce food ingredients. In the last decade, various companies have been attempting to apply this to oils and fats production, e.g. using microalgae and oleaginous yeasts. Fermentation of food waste, to produce fats, avoids use of agricultural land hence greatly reducing the environmental footprint.

Learning - where are we now?

Coronary Heart Disease and Cardiovascular Disease remain leading causes of premature death in United Kingdom (UK) and worldwide. Diet, physical activity and smoking are major lifestyle contributing factors to the risk of these diseases. Average intakes of saturated fat remain higher than maximum recommendations in all age groups surveyed in the latest UK National Diet and Nutrition Survey (12), although the percentage of the population meeting the recommendation was higher in the latest study than in previous assessments. Intake of trans fats is now well below the population recommendation of no more than 2% of food energy, at approximately 0.5%. In the UK, we typically eat enough omega-6 fatty acids but intake of omega-3 fatty acids, such as from oily fish, is low (13). Efforts, regulatory and voluntary industry initiatives have had positive impacts on overall and saturated fat intakes, and the UK Food and Drink Federation (FDF) estimated that, since 2015, their members' products are contributing 5% less total fat to the average shopping basket (14). Further efforts are required to address levels of obesity and associated diseases which remain too high. Currently, saturated fat is not specifically included in any of the reformulation programmes in the UK. The National Institute for Health and Care Excellence (NICE) recommends considering supportive legislation to reduce saturated fat levels in products, if necessary (15).

The future - where do we go from here?

Food scientists have been looking at strategies to reduce fat and reduce SAFA in foods. Oleogelation is a promising way to transform liquid oil into functional solid fat. Various ingredients act as oil gelators when incorporated into oil at levels below 5%, transforming liquid oil into solid fat without increasing levels of saturated or trans fats, with obvious health benefits. There has been quite a lot of work, and published literature, in the last 20 years accounting for the potential use of oleogels in food products (16). The actual commercial applications of these ingredients depend on factors such as the need for process changes, cost and effect on taste.

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Further reading

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