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Original article

Development and Food Applications of Sunflower Oils in Argentina

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Abstract

Sunflower is the fourth-largest global source of vegetable oil (after soybean, palm, and rapeseed) that is primarily used for human consumption. Argentina ranks as the third-largest producer of sunflower oil in the world. Breeders have developed genotypes with varying fatty acid compositions to provide alternatives to conventional sunflower oil and to replace trans fatty acids. High oleic and high stearic-high oleic genotypes have expanded the range of sunflower oil compositions available. High oleic oil presents greater oxidative stability than conventional sunflower oil, due to its lower content of polyunsaturated fatty acids. High stearic-high oleic oil and its fractions exhibit even greater stability and plasticity, making them suitable alternatives to high-melting animal fats, tropical oils, or hydrogenated lipids. Additionally, sunflower oil can modify its fatty acid composition based on the environmental conditions during grain filling, mainly conditioned by the temperature. This aspect is crucial for sunflower cultivation in Argentina, given the country's extensive production area. The oxidative stability and technical functionality of these oils are mainly determined by their fatty acid composition; thus, different food applications of sunflower oils are described based on their specific characteristics.

Keyword: Breeding; environmental variability; frying; high oleic; high stearic-high oleic; margarines; trans fat

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a crop native to North America, where it was used by human pre-Columbian populations for food, medicine, handicrafts, and rituals. Its ornamental appeal led to its introduction in Europe during the 16th century colonization of the Americas, and it later spread to Russia. By the late 19th century, sunflower was introduced in Argentina as valuable oilseed source. This marked the beginning of agrarian settlements dedicated to sunflower cultivation, particularly in the provinces of Entre Ríos, Chaco, and Buenos Aires. A comprehensive history of sunflower in Argentina can be found in Melgarejo (2003).

Sunflower is the fourth-largest global source of vegetable oil, following soybean, palm, and rapeseed (USDA 2019). Argentina ranks as the third largest producer worldwide after Ukraine and Russia, contributing around 7% of global production. Sunflower oil is principally used for human consumption and is valued as a high-quality commodity in the global oil market. It is composed of more than ten fatty acids, with the four main ones being the saturated palmitic (C16:0) and stearic (C18:0) acids, the monounsaturated oleic acid (C18:1), and the diunsaturated linoleic acid (C18:2). Clinical and animal studies have reported that both the monounsaturated fatty acids (MUFA) oleic acid and polyunsaturated FA (PUFA) from the n-6 family, linoleic acid, can decrease serum cholesterol level (Crupkin and Zambelli 2008, and references therein). Additionally, sunflower oil presents a favorable level and composition of antioxidants compounds such as alfa-tocopherol (Vitamin E) and phytosterols, which are beneficial in preventing of several pathologies (Velasco et al. 2002; Nolasco et al. 2004, 2006; Izquierdo et al. 2011; González Belo et al. 2017, 2018, 2019). This work aims to address the development of sunflower genotypes in Argentina and the influence of environmental conditions on fatty acid composition. We will also discuss how the new genotypes have been used to replace *trans* fats resulting from industrial partial hydrogenation of seed oils in many leading food industries.

Trans fatty acids and regulatory aspects

Except for direct consumption, such as salad dressing, or other applications where seed oils can be used as-is, oils intended for deep frying or margarine production requires prior hydrogenation to improve functional properties and stability. Partially hydrogenated oils can contain up to 50 % of TFA.

Until 1990, TFA were considered neutral regarding their impact on cholesterol and cardiovascular diseases. However, over the last three decades, accumulated scientific data has demonstrated that the dietary intake of industrially produced TFA is associated with an increased risk of cardiovascular disease, dyslipidemia, inflammation, diabetes, and cancer (Dawczynski and Lorkowski 2016, de Souza et al. 2015, Kiage et al. 2013, Kwon 2016). This growing concern led to the establishment of the first food labeling standards at the beginning of the century. Consequently, one of the current options to improve the functional properties and stability of oils is full hydrogenation followed by interesterification.

A decade after the convening of the World Health Organization (WHO) to discuss the consequences of TFA on human health (Uauy et al. 2009), the fields of food security and nutrition continue to face a significant challenge: reducing or eliminating TFA in the human diet in a cost-effective manner, while maintaining food quality and avoiding detrimental health effects. Two modeling studies, one conducted in Argentina (Rubinstein et al. 2015) and another in Denmark (Restrepo and Rieger 2016), assessed the impact of each country's TFA policies, both showing positive outcomes in reducing CVD rates. Argentina adopted and implemented legislation to reduce industrially produced TFA, which includes mandatory labelling of TFA content in food since 2006 and limitation of industrially produced TFA to 2% of total fats in vegetable oils and below 5% of total fats in other foods (Rubinstein et al. 2015). The limit of 2% TFA for all foods was ruled following the recommendations of the REPLACE program of WHO and Pan American Health Organization (WHO 2018; PAHO 2020) has this guideline has recently been incorporated into a new amendment to the Argentine Food Codex, which also bans the partial hydrogenation process for food products. In recognition of the association between TFA and an increased risk of CVD, most countries worldwide have implemented policies to reduce TFA levels in the food supply (Downs et al. 2017, Parziale and Ooms 2019).

Oil oxidation is a complex process occurring in food (*in vitro*) or within the consumer's body (*in vivo*), with PUFA being the primary targets. *In vitro* lipid oxidation not only alters the taste of foodstuff (leading to rancidification) but also diminishes its nutritional quality, producing highly reactive and toxic compounds that can be harmful to consumers (Laguerre et al. 2007, Manzocco et al. 2016, Redondo-Cuevas et al. 2018). Increasing oxidative stability by decreasing PUFA content in oils is a valuable objective in the food industry but needs to avoid the introduction of TFA through partial hydrogenation. To address this demand, various technological strategies were developed to eliminate or reduce TFA in food, such as enzymatic interesterification, modified hydrogenation, fractionation, and oil blending (Tarrago-Trani et al. 2006). Among these methods, one of the most effective ways to reduce PUFA content is by introducing high oleic (HO) varieties of sunflower oil as a food ingredient (Zambelli 2021).

Cellular oxidation of PUFA can be catalyzed by lipoxygenases, leading to the production of excessive amounts of aldehydic end products that promote apoptosis or necrotic cell death. Furthermore, the *in vivo* involvement of lipid oxidation products in the etiology of atherosclerosis was clearly established, along with their roles in various human pathologies including Alzheimer's disease, cancers, inflammation, and aging (Ayala et al. 2014, Laguerre et al. 2007, Sottero et al. 2019). The

FDA concluded that consuming oleic acid from edible oils, such as HO sunflower oil, may reduce the risk of coronary heart disease. After conducting a systematic review of the available scientific evidence, the FDA characterized the relationship between the consumption of oleic acid in edible oils (containing at least 70% of oleic acid per serving) and a reduced risk of coronary heart disease (FDA 2018).

Sunflower oils as functional and healthy options

In recent decades, considerable attention has been directed toward genetically engineering sunflower oil to modify its content of fatty acids, thereby developing products with enhanced nutritional and functional properties requiring little, if any, processing for specific end-use markets. The ability to introduce novel fatty acid compositions was based on a solid understanding of the metabolic pathways involved in fatty acids synthesis. Seed fatty acids are synthesized in the plastids, then exported into the cytosol, where oil (triacylglycerol) is ultimately synthesized in the endoplasmic reticulum (ER). The multiple enzymatic reactions occurring in the stroma of plastids produce 16- and 18-carbon fatty acids, of which around 75% are unsaturated. Desaturation implies the formation of a double bond at a specific position in a fatty acid chain to produce an unsaturated fatty acid. This process is catalyzed by desaturases found in both the ER and plastids. The desaturation of stearic acid (18:0) to oleic acid (18:1) is catalyzed by stearoyl-acyl carrier protein desaturase (SAD) in the plastid. Further desaturation of oleic acid to linoleic acid (18:2) is catalyzed by fatty acid desaturase 2 (FAD2, also known as oleate desaturase) in the ER (Dar et al. 2017, Ohlrogge and Browse 1995, Pleite et al. 2006, Somerville et al. 2000).

Research efforts in the sunflower oil field focus on developing more stable oils and healthy substitutes for high-melting animal, tropical oils, or hydrogenated fats (Zambelli et al. 2015). Increased stability of sunflower oil was achieved by raising the content of oleic acid and decreasing the content of PUFA (linoleic acid). This type of oil is also suitable for producing biolubricants. The food industry requires healthy substitutes for high-melting fats which can be obtained by increasing the content of saturated fatty acids (SFA), mostly stearic acid, as its intake does not modify serum cholesterol levels in humans (Crupkin and Zambelli 2008; Garcés et al. 2009).

In Argentina, breeders have made significant efforts to develop varieties with modified fatty acid composition, as illustrated in Figure 1. Thus, breeding programs have pointed to produce HO and HSHO commercial hybrids.

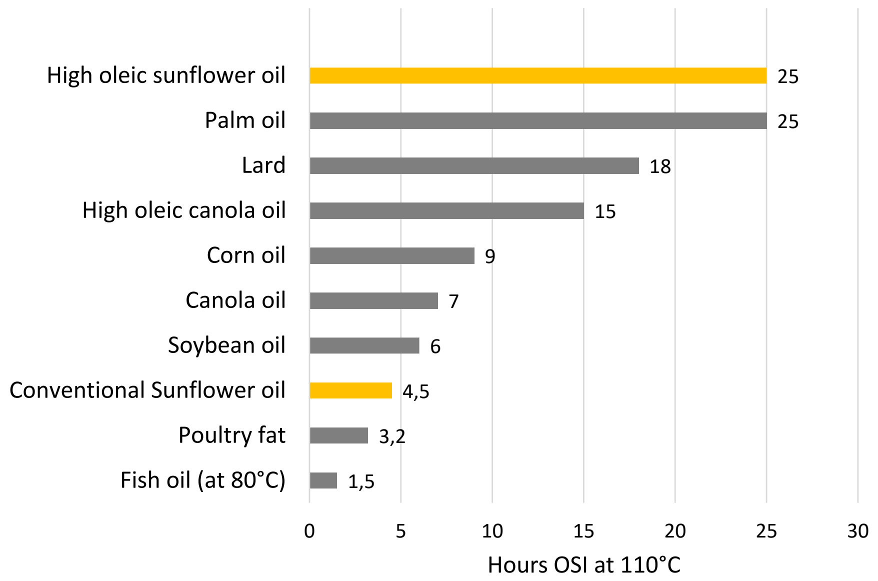

Figure 1. Oil fatty acid composition of sunflower genotypes in Argentina. HO: high oleic; UHO: ultra-high oleic; HSHO: high stearic-high oleic; HSHL: high stearic-high linoleic.

High oleic cultivars

The first sunflower cultivar with a HO content, named Pervenets, was generated through chemical mutagenesis becoming the primary source of HO in sunflower breeding programs (Soldatov 1976). The mutagenic treatment induced a partial duplication of the FAD2-1 gene, inhibiting its transcription (Lacombe et al. 2001, Schuppert et al. 2006). The Agricultural Research Service of the USDA in Fargo, North Dakota, received seeds with this mutation and subsequently developed inbred lines that were released for public use worldwide in 1986. The first HO varieties arrived in Argentina in the mid-90s, and the area cultivated with HO sunflower rapidly increased, reaching 10% of the total sunflower area, a level that has been maintained today.

Most sunflower seed companies have included competitive HO hybrids in their portfolios, making this crop a leader in the current global HO oil market. Oil from HO sunflowers carrying Pervenets mutation exhibits a fatty acid profile characterized by 80–90% oleic acid, 1–10% linoleic acid, and nearly undetectable levels of linolenic acid (less than 0.3%). High oleic sunflower hybrids show no significant difference in grain yield, oil content, and seed productivity compared to conventional hybrids (Angeloni et al. 2017; Carvalho et al. 2019; Fick 1984; Gouzy et al. 2016; National Sunflower Association 2018; Van der Merwe et al. 2013). In sunflower, HO can be considered a semi-qualitative trait since it depends not only on environment but also on the genetic background of the recurrent line (Ferfuia et al. 2015; Neto et al. 2016; Alberio et al. 2018). In this sense, it has been proposed that certain genes may interact with the Pervenets mutation influencing the expression of the HO trait because of the epistatic interaction of three loci: the FAD2-1 gene, a suppressor of the Pervenets mutation (referred to as “supole”), and modifier genes. Thus, some allelic combinations would mask the HO phenotype, making the presence of the Pervenets mutation insufficient to reach higher oleic levels (Lacombe et al. 2001, 2009).

A new sunflower mutation, called NM1, was created in Argentina through X-ray mutagenesis and has emerged as a promising alternative to Pervenets. NM1 mutants show a DNA insertion in the FAD2-1 gene, resulting in a premature stop codon (Alberio et al. 2016, Zambelli et al. 2015). Comparison of near-isogenic lines with NM1 and Pervenets mutations indicate that lines bearing NM1 demonstrate superior performance evidenced by a higher percentage of oleic acid (up to 92%), a lower percentage of linoleic acid (as low as 1%), and nearly undetectable level of linolenic acid (less than 0.3%). Additionally, NM1 shows a more stable fatty acid profile across environments and exhibits low or even no dependence on the genetic background (Alberio et al. 2018). While NM1 affects the coding region of the FAD2-1 gene, Pervenets interferes with its transcription to an extent that does not solely rely on the presence of this mutation. This difference in their inhibitory mechanisms means that epistatic genes do not significantly impact the expression of the HO trait when the materials possess the NM1 mutation, resulting in a much more stable fatty acid profile that is less influenced by external factors (Alberio et al., 2018). The development of sunflower hybrids with NM1 has enabled the release of ultra-high oleic materials, making their production more efficient and predictable (Pan 2015).

High stearic-high oleic cultivars

Partially hydrogenated vegetable oils were industrially valued for their ability to provide solid or semisolid fats. Therefore, there is a need to find suitable solid fat substitutes that do not increase the risk of cardiovascular disease. For solid fat applications, stearic acid–rich fats emerge as excellent substitutes for *trans* fats and cholesterol-raising SFA such as myristic and palmitic acids (Crupkin and Zambelli 2008, Hunter et al. 2010). High stearic (HS) sunflower oil, which contains high levels of stearic acid (greater than 25%) has been obtained through induced mutagenesis with both EMS and sodium azide (Fernández-Moya et al. 2002; Osorio et al. 1995; Zambelli et al. 2015). HS sunflowers can reach such stearic content due to a reduction in SAD activity, which increases the proportion of stearic acid at the expense of oleic acid (Cantisán et al. 2000). Although the HS phenotype exhibits a higher solid fat content, its elevated linoleic level makes it thermo-oxidatively unstable (high stearic–high linoleic oil, HSHL). To increase thermal and oxidative stability, HS and HO mutations were combined by crossing, giving rise to the high stearic-high oleic (HSHO) sunflower oil (Pleite et al. 2006). Of the total global vegetable oil production, more than 75% accounts for liquid oils and fractions used for cooking, frying, and the production of emulsions or margarine. The remaining 25% comprises solid fats such as palm and palm kernel stearins, coconut fat, and cocoa butter, which are mainly used in various food formulations and confectionary products (Gunstone 2002; Salas et al., 2009). The uneven distribution of the production of solid fats versus liquid oils highlights the need for alternatives to solid tropical fats that are compatible with a healthy diet (Garcés et al. 2012, Salas et al. 2021). In the late 1990s, aiming to reach this objective, HS and HO sunflower mutants were included into breeding programs to develop HSHO sunflower hybrids. HSHO sunflower oil contains levels of stearic acid of 15-20%, oleic acid of 65-70%, and linoleic acid of less than 8%. This composition makes it an attractive option that combines nutritional health with stability, positioning it as an ideal substitute for animal fats, partially hydrogenated oils, and palm oil fractions (Garcés et al. 2012, Sanyal et al. 2018). Fractionation by crystallization (whether through dry or wet method), produces fractions with different levels of solids (stearins) making them suitable for a wide range of food formulations, including fillings, coatings, and confectionery products (Botello et al. 2011, Dubinsky and Garces 2011, Salas et al. 2021).

Influence of environmental growing conditions on fatty acid composition of sunflower oils

The environment, encompassing growing locations and crop management practices, can affect the fatty acid composition of sunflower oil. This effect is particularly pronounced in regions where sunflower production spans a wide latitudinal range, such as Argentina (26°-40° S). For instance, the difference in minimum night temperature during the grain filling period between two extreme Argentinian locations, such as Balcarce and Reconquista, can be as much as 7-8°C, inducing variations up to 30 percentage points in oleic acid. Therefore, the genotype, the environment, and their interaction largely determine the quality of the oil (Aguirrezábal et al. 2015, Alberio et al. 2015, Debaeke and Izquierdo 2020).

Temperature is one of the primary environmental factors influencing seed fatty acid composition. One survival mechanism for seeds is to decrease the unsaturated acid level: lower level of unsaturation correlates with lower base temperature for germination (Izquierdo et al. 2017). In sunflower, the temperature during the grain filling period impacts the fatty acid composition of the oil by modulating the activity of the oleate desaturase enzyme (FAD2-1). A sigmoid relationship has been reported between oleic acid concentration and minimum night temperature (Izquierdo and Aguirrezábal 2008). Differences of up to 25-30 percentage points in oleic acid can be observed in conventional hybrids between distant locations within Argentina sunflower-growing regions (Izquierdo and Aguirrezábal 2008). This effect is less pronounced in HO genotypes with the Pervenets mutation (resulting in a decrease of 8 to 10 percentage points in oleic acid content) and nearly negligible in HO cultivars carrying NM1 mutation (Izquierdo and Aguirrezábal 2008, Angeloni et al. 2017, Alberio et al. 2016, 2018). Generally, increases in oleic acid concentration due to higher temperatures mainly come at the expense of linoleic acid, with a smaller reduction in SFA levels.

In high stearic genotypes, temperature increases also affect fatty acid composition by raising the concentration of palmitic and oleic acids, while reducing stearic and linoleic acids. However, these changes are mild in HSHO because the high oleic mutation provides stability in composition, preventing marked variations in oleic acid (Izquierdo et al. 2013). Additionally, temperature affects triacylglycerol composition, an important functional feature for preparing margarine, spreads, or confectionery fats. Higher temperatures increase the symmetrical distribution of SFA in triacylglycerols (saturated-unsaturated-saturated), an effect that appears to be independent of the effect of fatty acid composition on triacylglycerol structure, likely mediated by differential expression of the glycerol-3-phosphate acyltransferase enzyme (Izquierdo et al. 2016).

Other environmental factors have also been reported to influence the fatty acid composition of sunflower oil, including radiation, water stress, nutrient availability, and thermal stress; among these, radiation interception was found to be the most significant factor. While radiation interception does influence fatty acid composition (in addition to temperature), its impact is generally lesser pronounced than that of temperature (Izquierdo et al. 2009, Echarte et al. 2010). In extreme cases, such as severe defoliation, reductions in oleic acid concentration may occur alongside decreases in seed oil content and crop yield (Izquierdo et al. 2009).

The significant impact environmental conditions on the fatty acid composition of sunflower oil prompted a request from the Argentine government to CODEX authorities to redefine conventional sunflower oils as mid-oleic and high-oleic varieties. This proposal was supported by experimental evidence collected from Argentina fields, demonstrating that conventional genotypes produce oils with higher concentrations of oleic acid than in other regions. Consequently, CODEX modified its definitions for these oils in 2022/2023, expanding the range of oleic acid content required to an oil to be classified as conventional sunflower oil.

Food applications of sunflower oils

The fatty acid composition of oils accounts for most of their key properties, which are associated with different dimensions of quality, including oxidative stability, aggregation state, and nutritional impact (Figure 2).

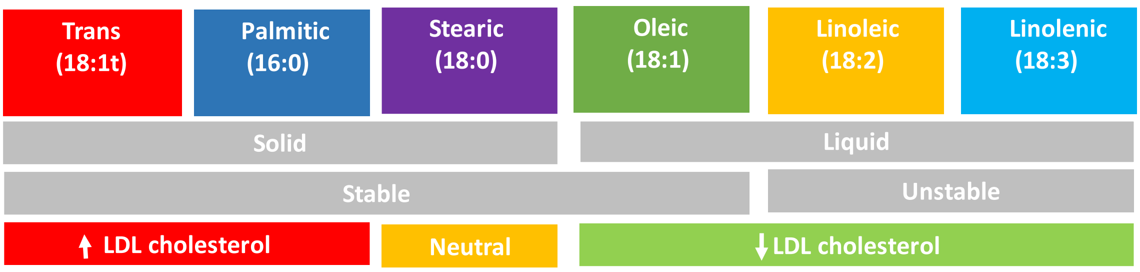

Figure 2. Relationship between fatty acid composition and quality of fats and oils.

Oxidative Stability: Conventional sunflower is rich in linoleic acid, a fatty acid with an oxidation rate that is 40 times higher than that of oleic acid (Frankel 2005). In this way, conventional sunflower oil is the most widely consumed bottled oil in Argentina, primarily used for household frying and salad dressings. However, its applications in the food industry are limited to products with short shelf life, such as certain snacks (90 days), industrial mayonnaise (6 months), and frying in restaurants, where it is often blended with other oils for cost savings.

The commercial development of HO sunflower in the first decade of this century expanded its use in the bakery industry, particularly for manufacturing biscuits and crackers, which have a higher consumption rate in Argentina (with shelf lifes ranging from 6 months to 1 year). HO sunflower oil is favored in fast-food shops, where oils with greater stability are required compared to conventional seed oils rich in polyunsaturated fatty acids (PUFA). Consequently, the fatty acid composition explains why the oxidative stability index (OSI) at 110°C of HO sunflower oil is five times higher than that of conventional sunflower (Figure 3).

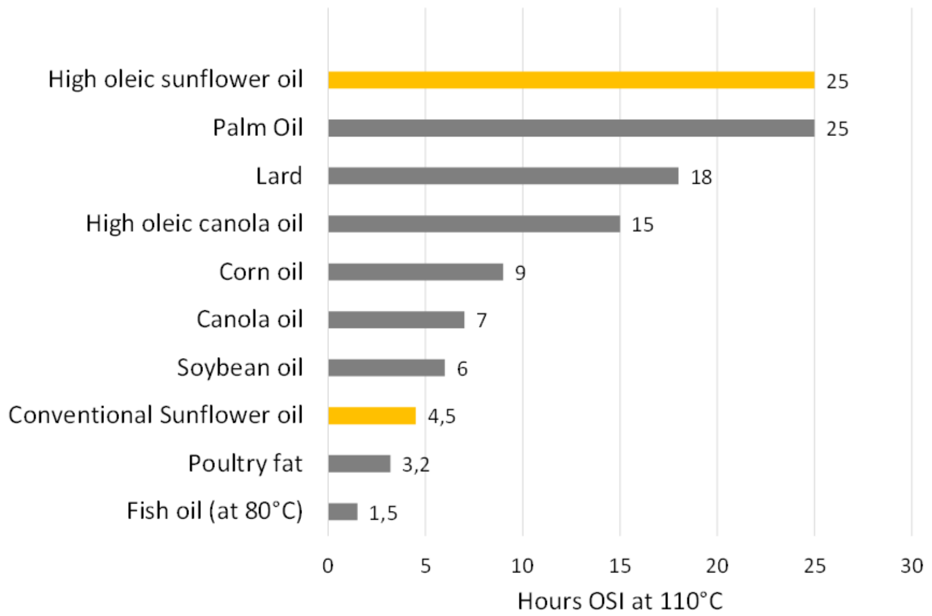

Figure 3. Comparison of oxidative stability index (OSI) measured by Rancimat at 110°C for different fats and oils.

Aggregation states and industrial functionality: When unsaturated fatty acids prevail, as in all seed oils, the material is classified as a vegetable oil (liquid at room temperature). Several food products, such as margarines, fillings, coatings and certain bakery items (e.g., puff pastry), require fats with different levels of SFA that are solid or semisolid at room temperature. These include palm oil and its fractions, lauric fats, animal fats, or butter fat.

Nutritional impacts: The fatty acid composition of oils and fats plays a crucial role in their impact on serum cholesterol level and on the risk of developing cardiovascular diseases and other pathologies, as previously explained in this review. To promote the use of HO sunflower oil, it was essential to clarify how fats and oils perform in baking and frying applications. This effort aimed to dispel two misconceptions that persisted during the first decade of this century regarding the use of fats and oils in these processes.

Use of fats and oils in bakery applications

The selection of fats (solid or semisolid) and oils (liquid) for bakery products is closely associated with their functionality and oxidative stability.

Functionality: The solid fat phase in a bakery shortening contributes to gas retention during proofing, increasing volume and providing the desired texture for baked goods.

Oxidative stability: Conventional seed oils can only be used in fresh products or those with very short shelf life. An alternative for achieving good sponginess in bakery products like muffins, cakes, sliced industrial bread is to use liquid oils combined with different types and proportions of surfactants. In products that require minimal or no gas retention, such as certain cookies, crackers, and cereal bars, the fat serves a lubricating function for gluten and starch chains (a shortening effect), yielding tender products while limiting the stailing. In snack crackers, stable fats are also necessary applying a very thin layer on the surface to enhance adhesion of salt or other seasonings for improved taste.

Misconception 1: Preparation of dough in all bakery products requires "solid fats”

The first liquid shortenings emerged in the USA in the 1960s and were prepared by blending various oils with mono- and diglycerides along with other emulsifiers. However, much of the literature on fats and oils emphasizes that liquid oils are unsuitable for baking because plastic fats are deemed necessary (Garcés et al. 2009). It has been suggested that liquid oils should be limited to frying and salad dressings (Bailey’s 1996), while some non-bread bakery goods -like cakes, crackers, and cookies- require a certain amount of solids to achieve an acceptable texture (Gupta 2006). Additionally, it has been argued that saturated fats are necessary to replace TFA (Berry 2005). Conventional seed oils rich in PUFA are associated with poor oxidative stability, which further contributed to the rejection of liquid oils for all bakery products, regardless of their predominant type of unsaturated fatty acid content (PUFA or MUFA). The rapid adoption of HO sunflower by leading food companies (particularly in biscuits, crackers, and industrial bread) clearly demonstrated that plastic fats are not necessary for many types of bakery products.

Use of fats and oils in frying

Food frying can be divided in two main groups such as industrial and fast food frying.

Industrial frying, can be further classified into two types: Frozen par-fried foods (e.g. French fries) and snack manufacturing (e.g., potato chips). In both cases, the frying process is continuous, with the frying oil constantly in contact with food. This interaction creates a steam-protecting layer between oil and air due to the evaporation of moisture from the food, which minimize the disposal of used oil. Additionally, there is a continuous renewal of the oil to replenish what is absorbed by the food. The percentage of oil in the final product is significantly higher in potato chips (around 30%) compared to frozen fries (around 6%). Thus, oil replenishment is greater in potato chips, leading to a more substantial impact on palatability, nutrition, and shelf life than is observed in frozen fries.

In fast food frying, the thermal stress on the oil is significantly higher than in industrial frying. The fryer is turn on in the morning and off in the evening, with the oil all remaining close to frying temperature throughout the day, whether in contact with food or not. The protective effect of the vapor layer depends on the demand; if demand is low, this protective layer may be absent for relatively long periods. For this reason, the oil should be discarded after several days of use, following specific control criteria such as measuring total polar compounds measured through rapid tests or conducting organoleptic evaluation (e.g., visual assessment for darkening, foaming, or tasting).

Misconception 2: A certain amount of linoleic acid is required for appealing flavor in fried products.

Much of the literature regarding frying applications emphasizes the need for a linoleic acid content in the oil that is higher than that found in HO sunflower oil to achieve an appealing flavor. Several studies on fries and chips have indicated ideal linoleic acid levels between 23% and 37% to achieve an optimum combination of stability and flavor (Rossel and Barry 2004; Warner et al. 1997; Warner 2006; Watkins 2005; Warner and Gupta 2005). Other authors have been more conservative, suggesting than even 3% linoleic acid levels are insufficient (Kochar 2000).

However, leading companies in frying have approved the use of HO sunflower oil in their products, challenging the common belief that consumers would reject HO oil due to a perceived lack of fried flavor. Commercial experience has demonstrated that this concern in unfounded.

Final Remarks

Since a diet high in TFA is associated with an increased risk of cardiovascular disease (CVD), it is highly recommended to eliminate daily intake of *trans* fats. This necessitates finding alternative fats that possess the functional properties required by the food industry.

When comparing different crops to select a HO source, particular attention should be paid to their fatty acid compositions. HO sunflower oil stands out as an excellent option in terms of oxidation stability, as its fatty acid profile features a higher level of oleic acid (up to 92%), lower linoleic acid (as low as 1%), and very low linolenic acid content (less than 0.3%). These values are not found in oils extracted from HO canola or HO soybean seeds. Reducing the percentage of polyunsaturated fatty acids positively impacts the stability of the oil, positioning HO sunflower as the optimal alternative to ensure the production of HO oil for the food industry. This is essential to meet the global demand for stable and healthy vegetable oils that can replace TFA and SFA in many food applications that traditionally relied on semisolid fats, which have negative effects for health and sustainability (Zambelli 2021).

A different challenge arise in applications where solid or semisolid fats are still needed, such as coatings, fillings, margarines, or certain bakery products puff pastry. In these cases, plastic fats with different solid fat content profiles —obtained from partially hydrogenated oils, animal fats, or unsustainable tropical fats— should be replaced. One of the best alternatives is stearic acid-enriched oil fractions due to their plasticity, stability, and minimal impact on consumer health. Although more research is needed, current evidence suggest that stearic acid must be differentiated from hypercholesterolemic saturated fatty acids such as lauric acid, myristic acid, and palmitic acid in terms of health impact. Multiple studies indicate that stearic acid may be beneficial or at least neutral regrading CVD risk factors —including serum cholesterol, thrombosis, systemic inflammation, and diabetes— stearic acid has not shown detrimental effects on human health compared to other fatty acids. Therefore, HSHO oils can be considered a functional and healthy alternative for replacing TFAs and other saturated fats in food manufacturing.

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