AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 02, Issue: 12 (December, 2025)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

The New Science of Trans-Free Fats

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Scientific evidence linking trans fatty acids to adverse health effects in humans has paved the way to the development of technologies that replace trans fats. The review explores scientific studies focusing trans free fats that maintain essential properties for the food industries. The discussion focuses on methods such as organogelation, interesterification and fractionation to replace trans fats and the development of food products. These technologies enable the production of fats with desirable characteristic, culinary properties, eliminate adverse health effects leading to a remarkable advancement in the field of food science and technology.

Introduction

Hydrogenation is a chemical reaction where fats and oils are treated with hydrogen gas in the presence of nickel catalyst. The hydrogen reacts with carbon-carbon double bond (C=C) making the fat or oil partially harder this results in conversion of oils to a semi-solid or plastic fat suitable for edible oil application (Puligundla *et al*., 2012). Hydrogenation enhances the degree of saturation leading to the increased melting point of fats/oils. The degree of unsaturation is reduced which further reduces auto oxidation thereby enhancing stability. Hydrogenation is always partial or marginal and the product is called partially hydrogenated oils (PHOs). The process also involves isomerization where a significant portion of *cis* double bonds are isomerized by *cis-trans* conversion and positional changes along the chain (Dijkstra, 2006). Hence these fats contain trans fatty acids (TFA) and are termed as trans fats.

Replacement of trans fats

World Health Organization (WHO) launched the **REPLACE** action framework in the year 2018 which provided the six-step strategic guide for the global elimination of industrially-produced trans fats. This initiative calls on governments to **re**view dietary sources of industrially-produced trans fats and the landscape for required policy change, **p**romote the replacement of industrially-produced trans fats with healthier fats and oils, **l**egislate or enact regulatory actions to eliminate industrially-produced trans fats, **a**ssess and monitor trans fat content in the food supply and changes in trans fat consumption in the population, **c**reate awareness of the negative health impact of trans fat among policy-makers, producers, suppliers, and the public and **e**nforce compliance with policies and regulations.

These guidelines aimed at a complete and sustainable elimination of industrially produced trans fatty acids from the food chain.

Technologies for trans-free fats

I. Structured oils/ organogelation

Structured oils represent a category where liquid oil is transformed into a gel-like solid. These methods include the creation of structured emulsions by organogelation. An organogel can be defined as a three- dimensional gel network containing an organic liquid entrapped

within a thermo-reversible, anhydrous and structured visco-elastic material, also referred to as oleogels if the organic phase is an edible oil. This gel network is formed by the self-assembly of organogelator molecules at a relatively low concentration; which are of low molecular weight compounds (e.g., plant waxes, monoacylglycerides, phytosterols etc.) that are able to gel organic solvents. Oleogelator compounds need to meet physicochemical properties like affinity for oil, surface activity and self-assembling properties, higher structural arrangement and preferably display thermo-reversible properties.

Applications

1. **Zetzl *et al.* (2012)** used an oleogel made from canola, soy bean and flaxseed oils and prepared frankfurters providing improved texture with very low TFA levels.
2. **Hwang *et al.* (2013)** created margarine with a high melting point but low saturated fat content using plant wax and soybean oil.
3. **Botega *et al.* (2013)** demonstrated that oleogels produced from sunflower oil and rice bran oil provided higher melt-down resistance and overrun in ice cream compared to high oleic acid sunflower oil.

II. Interesterification

Interesterification involves exchanging fatty acids between the triacylglycerols (TAGs) in a mixture. The reaction is catalyzed chemically or by enzymes. Interesterification is used to tailor the consistency of fats and oils which results in lowering the melting range of blends by eliminating the highest melting TAG present in the hard stock fats. Interesterification also changes the polymorphic behavior of blends, creating a β-crystal. This type of crystal provides a smooth consistency and desirable functionality in applications such as whipped toppings and cake batters.

Chemical interesterification (CIE) process is generally random and produces full positional randomization of the acyl groups on the glycerol backbone. CIE is relatively cheap and used in industrial applications to produce plastic saturated fats with a minimum level of TFAs. Enzymatic interesterification (EIE) comparatively offers more control over the reaction products. Enzymes are highly specific or selective to cleave specific ester bonds. EIE requires low temperature for processing, so lesser thermal degradation occurs.

Application

Mayamol *et al.* (2014) produced a zero trans fat by interesterifying pine nut oil and palm stearin, resulting in a fat with a suitable solid fat content (SFC) and β crystals.

III. Fractionation and blending

The controlled crystallization of triacylglycerol results in the separation of a solid phase (stearin) and a liquid phase (olein), and further fractionated. On the basis of crystallization temperature, cooling rate, and amount of pressure applied during the filtration, a number of palm fractions of different composition and functionality can be produced. Blends of oils and fats from different sources is often needed for a fat to achieve the desired characteristics for certain products. When mixed in the appropriate proportions, a fat exhibiting the necessary characteristics is produced. Palm oil is excellent for fractionation and fat blending due to its significant portion of high melting triglycerides. Palm oil fractions are used in production of the formulations such as cake shortenings, vanaspati, pastry margarines and low-fat spreads.

Application

1. **Sampoorna and Reddy (2011)** successfully created a zero trans-fat substitute for *vanaspati* by blending palm stearin with rice bran oil. This specialty fat successfully replicated the melting profile and functionality of traditional *vanaspati* in Indian sweets, producing products with superior sensory scores and no trans fats.
2. **Mayamol *et al.* (2014)** fractionated palm oil to obtain stearin. This was further blended in equal proportion with rice bran oil having high poly unsaturated fatty acids to prepare zero trans-fat shortening.
3. **Buitimea-Cantúa *et al.* (2018)** developed a fat blend of palm stearin and high-oleic safflower oil to prepare zero-trans tortillas. The reformulated tortillas maintained

excellent physical properties and achieved sensory acceptability compared to those with hydrogenated commercial shortening.

Conclusion

The technology for the development of trans free fats has gained prominence through advanced structuring methods, organogelation, interesterification, fractionation and specialized blending techniques. These technologies enable the development of zero-trans fats that mimic the functional and culinary properties of traditional hydrogenated fats while eliminating health concerns. The successful application of these fats across the diverse range of food products demonstrates their commercial viability and nutritional superiority, marking a significant advancement in food science towards efficient food processing and reduced health risks.

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