Oleogels as alternatives for frying fats and oils

Deep-fat frying is one of the most popular applications for the preparation of food. It is fast, simple to handle, and results in highly accepted products due to the typical smell, taste, and palatability of fried food. One pivotal aspect in the production of high-quality fried food is the selection of an appropriate frying medium. During the frying process, oil or fat serves as a medium that transfers heat from the heating source to the food [1]. Another important task of the frying medium is to enhance food's flavor, which is responsible for the typical smell and taste of fried products. The selection of a suitable frying medium is also crucial for the quality of the final product. This is because a lot of fat or oil is taken up by the food, and the high amounts of fat in fried food influence its shelf life, aroma, texture, and surface properties.

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- Oleogels are structured vegetable oils that behave like solid fats but have the same nutritional properties of liquid vegetable oils.
- Our research group recently did the first promising experiments to evaluate the use of oleogels in deep-fat frying.
- This article describes the first initial results.

Over the last 50 years, the trends for using fats and oils in food processing have changed several times, driven especially by consumer awareness about nutritional quality. Fifty years ago, animal fats were very popular due to their technological properties and high storage stability. Later, animal fats were replaced by partially hydrogenated oils (PHO) due to concerns about the high cholesterol contents of animal fats. Then, PHO was banned in many countries because they contain trans-fatty acids, which are suspected to cause cardiovascular heart diseases [2].

Palm oil or modified fats became the replacement, but this has prompted strong discussion about environmental impacts and the high content of saturated fatty acids. Today, the use of highly stable liquid high-oleic oils or blends of different vegetable oils are preferred as a frying medium. They display some advantages with respect to nutritional aspects due to low amounts of saturated fatty acids, high contents of monounsaturated fatty acids, and an oxidative stability that is comparable with solid fats. On the other side, the application of liquid oils gives fried food a greasy surface and causes oil leakage during long-term storage.

WHAT ARE OLEOGELS?

Thus, the search for alternative fats or oils for food processing is an ongoing story. One promising alternative to conventional frying media are oleogels. Oleogels have technological properties that are similar to those of solid triacylglycerol structured fats, but they display the nutritional properties of liquid vegetable oils. While the structure of solid fats results from saturated fatty acids, which have a more-or-less linear structure and therefore allow a compact assembly of fatty acids, oleogels mainly consist of liquid oil and a small amount of a structuring agent known as an organogelator.

Therefore, oleogels contain a high amount of unsaturated triacylglycerols, but the solid structure is provided by the organogelator, which forms a 3-dimensional network in which the liquid oil is incorporated. Since the unsaturated fatty acids in the oleogel are not changed, the nutritional value of the liquid oil is preserved [3]. Many different structuring agents are applicable, such as ethyl cellulose, monoacylglycerols, fatty acids, phytosterols, alcohols, or waxes. Ethyl cellulose and monoacylglycerols, for example, are already approved as food additives, waxes, such as sunflower wax (SFW), have not been approved yet. The preparation of oleogels is a simple process that includes heating and stirring of the liquid oil in combination with the organogelator, just above its melting point. Finally, the mixture is cooled down to allow the formation of a gel-like structure, in which the liquid phase is embedded [4].

OLEOGELS AS PROMISING ALTERNATIVES FOR CONVENTIONAL FRYING MEDIA

The application of oleogels for food processing has been presented in the literature for some products [5-7], especially for bakery goods [8-10]. Only one scientific study has been published on the application of oleogels as an alternative to high saturated-fat frying media [11]. In this work, soybean oil-based oleogels with carnauba wax as organogelator, were used to prepare instant fried noodles. The resulting products had a similar texture and more favorable fatty acid composition than noodles fried in saturated fat.

An alternative to carnauba wax obtained from leaves of the palm Copernicia prunifera, SFW is a natural constituent of sunflower seeds. This wax forms a protective layer on the seed surface, and noticeable levels are extracted with the oil during oil processing. These high-melting waxes solidify at room temperature, causing a visible white precipitation that is unappealing to consumers. Therefore, waxes are removed from the oil during oil processing by winterization, leading to a large quantity of SFW that is readily available. SFW has not been approved as food additive yet, but since its molecular structure is similar to that of carnauba wax, SFW is likely to pass through the digestive tract unaltered as well—and to be approved in the coming years.

Compared to frying with conventional fats, the application of rapeseed oil-based oleogels with SFW as an organogelator for the preparation of potato crisps or French fries offers several advantages: optimized surface properties, improved multi-sensory perception, and a more healthful fatty acid profile that is lower in saturated fat and higher in unsaturated fatty acids but has comparable technological properties. Another important aspect in this context is that oleogels become solid again after deep-frying, when the fried food cools down. This should result in a significantly less oily surface and, possibly, a lower fat uptake. In a first experiment, these aspects were proven by using a SFW-based oleogel as a frying medium for commercially available par-fried French fries.

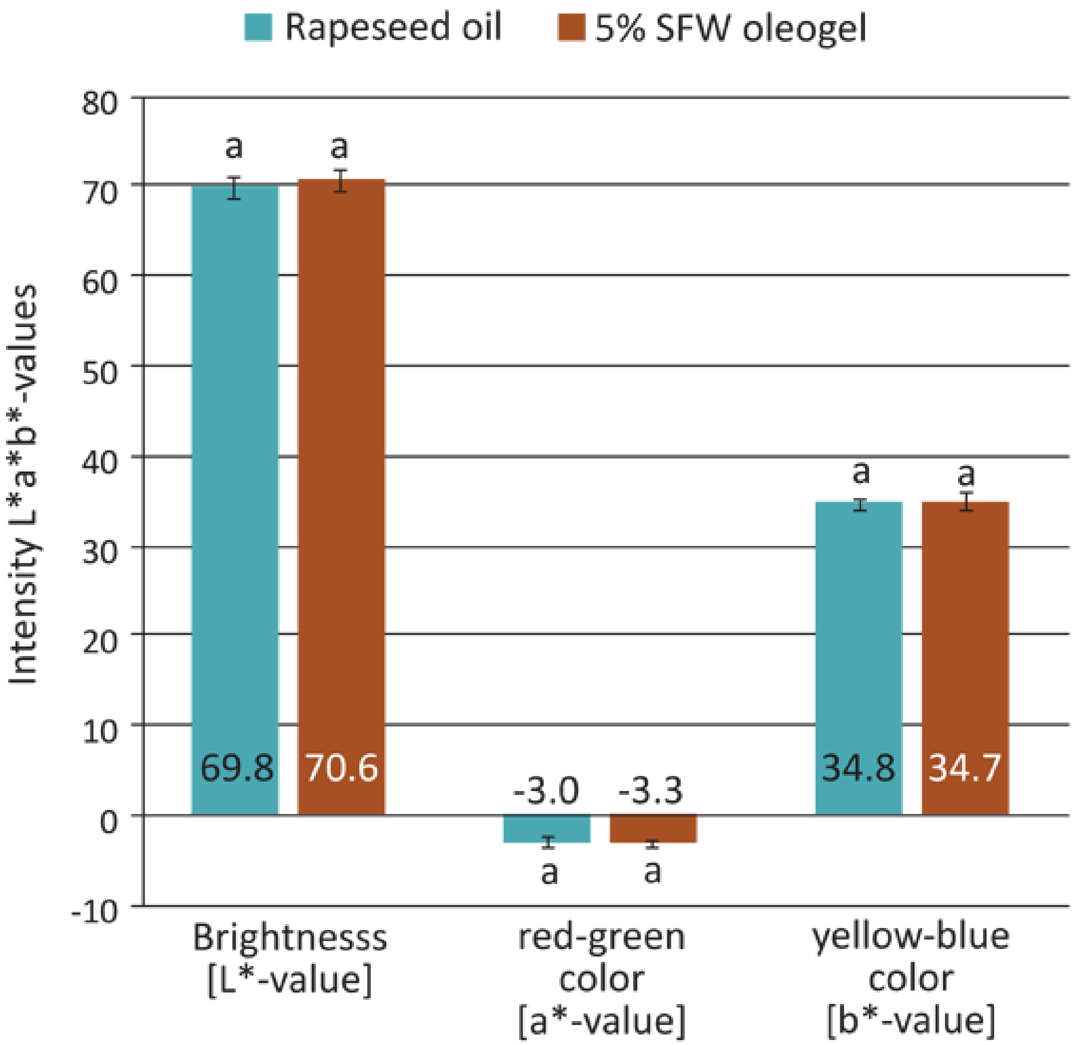

FIG. 1. Color of French fries fried in rapeseed oil and 5% SFW oleogel in the CIELAB color room

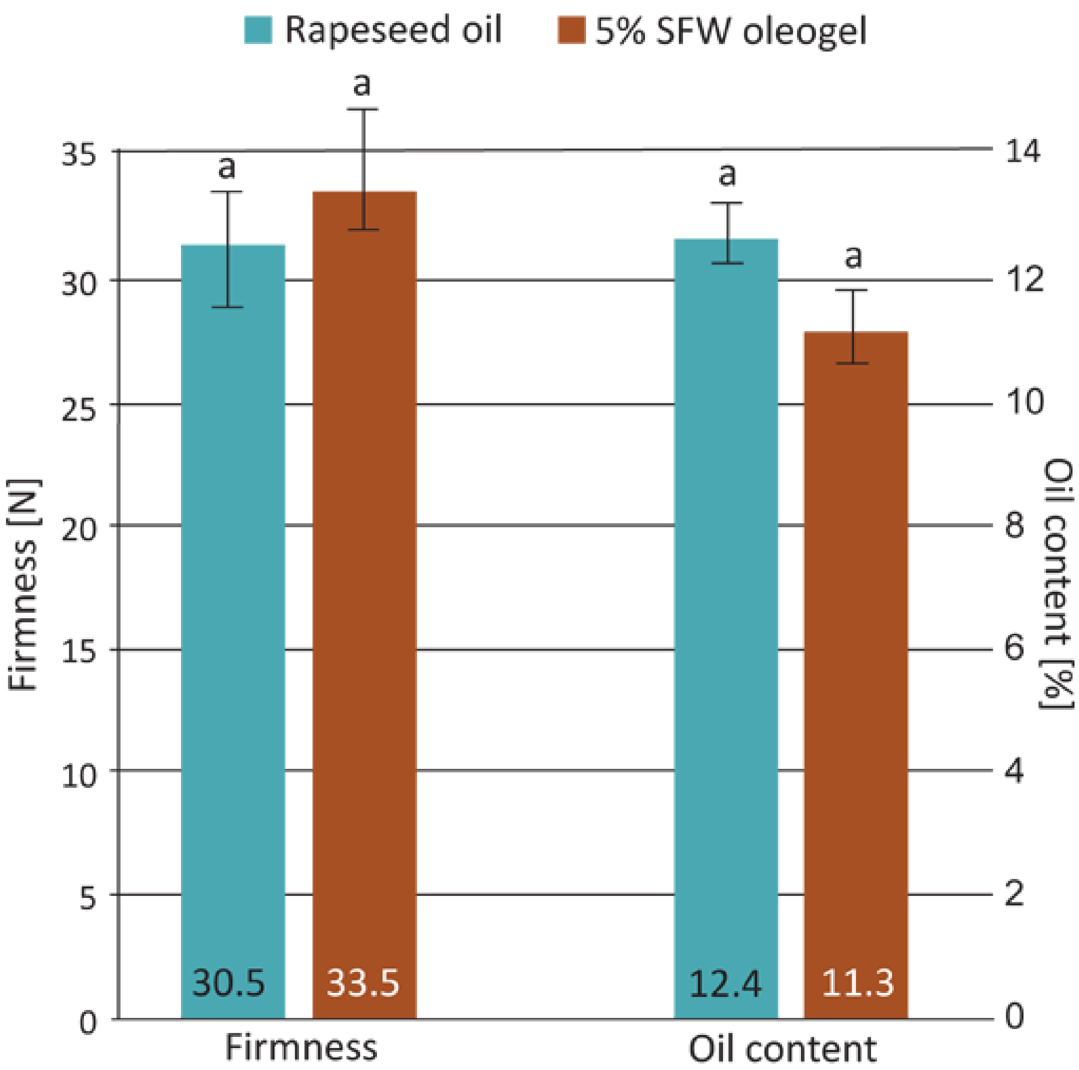

FIG. 2. Comparison of the firmness and oil content of French fries fried in rapeseed oil with those fried in 5% SFW oleogel

SUNFLOWER WAX-BASED OLEOGELS (5% SFW) IN THE FRYING PROCESS

Parameters for the evaluation of ready-to-eat French fries are texture, color, and oil content. In addition to sensory quality, these parameters determine the acceptance of products by consumers. Thus, when using an oleogel-based frying medium, it is paramount that these parameters are comparable with that of conventional frying media. Furthermore, the application of the organogelator should not impair frying performance of the frying medium.

Chemical results

No significant differences in the chemical parameters used to assess frying oil quality (such as polymer triacylglyerols or total polar compounds) were observed after 20 frying cycles with rapeseed oil-based oleogels versus rapeseed oil. Therefore, it can be concluded that the use of SFW does not significantly influence the frying performance of rapeseed oil.

Color

The color of fried French fries gives some indication of reactions in the context of the non-enzymatic browning (Maillard reaction), which takes place in the crust at higher temperatures when the moisture content of the product decreases in the presence of reducing sugars and asparagine as amino acid. When measuring the color of fried French fries, the amount of reflected light on the surface of the food is recorded, and the results are given in a color space. A common standard for a color space is the L*a*b* color space established by the International Commission for Eclairage (CIE) in 1976. The three parameters of this model represent the brightness of the color (L*), its position between red and green (a*), and its position between yellow and blue (b*) 13. The CIE-L*a*b* color system is based on the spectral range of the sensitivity of human vision. A comparison between French fries fried in rapeseed oil or in 5% SFW oleogel showed no significant difference between the three parameters of the CIELAB color room, so an influence of the frying medium on the color development can be excluded (Fig. 1). It can be assumed that the quality of the raw material and processing conditions have a stronger influence on the formation of Maillard reaction products and, therefore, on the color.

Firmness

The firmness of French fries strongly influences consumer acceptance. It is determined by chemical and physical changes that take place during the frying process in the product, e.g., release of intracellular materials, starch gelatinization, dehydration, crust formation, breakdown of adhesive forces between cells, water evaporation, and tissue expansion [12]. Firmness of French fries was measured by a texture analyzer and gives some impression of the crispness or hardness of the French fries with special consideration to the crust. Ten French fry sticks of nearly the same size were placed close together on the base platform of the texture analyzer, and the force needed to press a knife 5 mm deep into the sticks was measured. The results showed that the French fries fried with rapeseed oil were a little less firm than the French fries prepared with 5% SFW-based rapeseed oil oleogel. However, the difference was not significant (Fig. 2).

Fat content and fatty acid composition

Depending on the frying temperature, type of fryer, and quality of the raw material, fried French fries contain between 12 and 18% fat. From a nutritional point of view, a lower fat content is recommended to reduce fat intake. Frying with a 5% SFW oleogel resulted in 1% less fat intake (11.3%) compared to 12.4% fat intake for frying with rapeseed oil (Fig. 2). However, the difference between the two frying media was not significant.

Today, the fatty acid composition of food influences consumer purchasing decisions. The optimal fatty acid composition should have low levels of saturated fatty acids, a high level of monounsaturated oleic acid, and a ratio of linoleic to linolenic acid of 2:1. The proportion of trans-fatty acids should not exceed 2 grams per 100 g of fat [14]. Figure 3 shows the fatty acid compositions of rapeseed oil and 5% SFW oleogel compared to conventional frying media. There was no significant difference in fatty acid composition between rapeseed oil and 5% SFW oleogel. The content of trans-fatty acids was low for the different oils except for partially hydrogenated oil, which had more than 10% trans-fatty acids. In the other oils, transfatty acids are formed to a low-level during refining, which today should be below 1%. Palm oil is characterized by a high content of palmitic acid, while rapeseed oil shows the highest content of polyunsaturated fatty acids.

Sensory evaluation

Another important factor that influences consumer purchasing decisions is the sensory quality of food. Products that do not meet consumer expectations will not have a chance on the market. A common method of comparing products is the pairwise comparison test with consumers known as DIN EN ISO 5495:2007. In this test method, the examiner is given two samples and asked to identify the sample with the most pronounced characteristic.

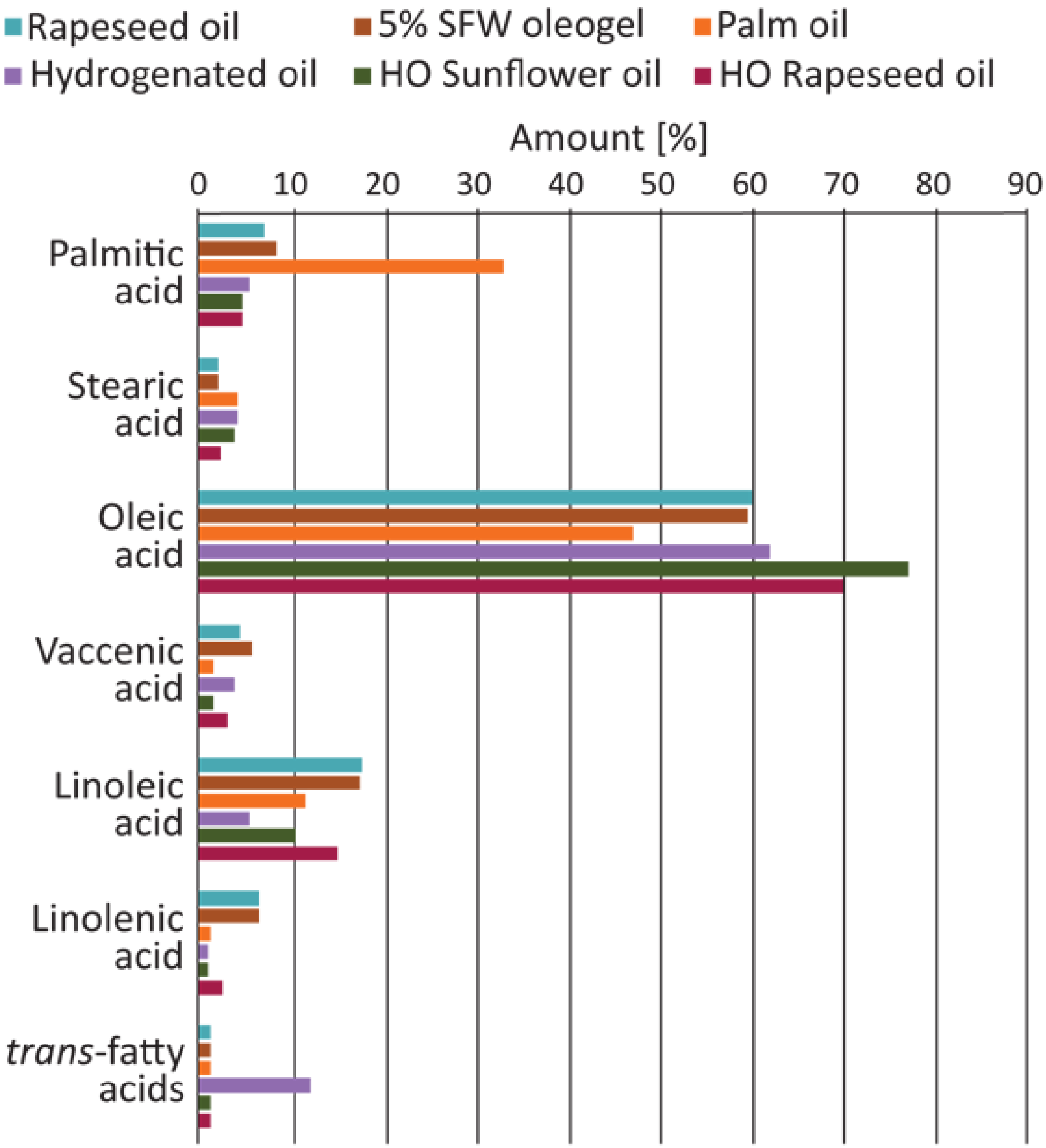

Fig. 3. Fatty acid composition of different conventional frying media and 5% SFW oleogel

The results of the sensory evaluation (Fig. 4, page 26) show that the surface of French fries was assessed by testing the French fry sticks between the thumb and index finger. Those sticks fried in 5% SFW oleogel were determined to be less oily. The mouthfeel of French fries fried in 5% SFW oleogel was also characterized as less oily, demonstrating that the use of oleogel as frying medium resulted in the perception that the fried product was less oily. Finally, there was no significant difference in the taste of French fries fried in different types of frying media, indicating that the use of SFW-based oleogels did not impair the taste of the final product.

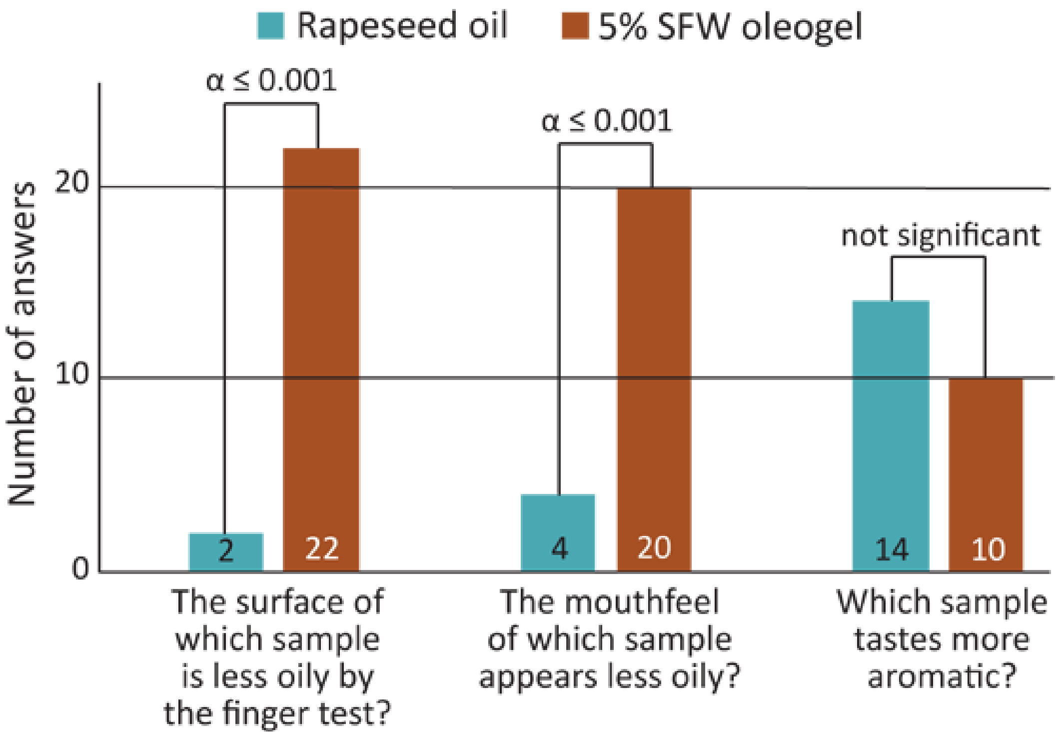

FIG. 4. Sensory evaluation of French fries fried in rapeseed oil and 5% SFW oleogel

These initial results of our frying experiment indicate that oleogels based on rapeseed oil with SFW as an organogelator are a promising alternative for solid fats rich in saturated fatty acids. The final products were comparable with respect to texture and color but had a slightly lower fat content, which is desirable from a nutritional point of view. Most important is that products fried in 5% SFW rapeseed oil-based oleogels were perceived to be less oily than French fries fried in liquid oil. This means that the solid structure of the oleogel improved the quality of the French fries. However, for the industrial application of SFW-based oleogels in food to move forward, it is essential to advance the approval of SWF. In addition, further work is necessary to evaluate different types and amounts of organogelators to optimize the frying process.

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