Oleogel: definition, possible applications and further developments

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Oleogelation is defined as the process able to convert a liquid oil into an anhydrous, viscoelastic self-standing material called oleogel [1]. In recent years, this topic has attracted an increasing interest and the research in this area is progressively growing. Different food applications have been proposed for oleogels. The most promising one is their use as fat substitute to obtain healthier foods with reduced content of sat/trans fatty acids. Currently, the fat substitution is highly demanded due to the health issues associated with the consumption of lipids rich in saturated/trans fatty acids, such as animal fats (e.g. butter and lard), tropical oils (e.g. palm oil, palm kernel oil and coconut oil), margarine and shortenings containing them. As extensively demonstrated, their excessive intake is closely related to the increase of the risk of incidence of many non-communicable diseases (e.g., coronary heart disease, Type II diabetes, obesity, stroke, metabolic syndrome and other cholesterol maladies) [2]. To complicate this matter, concerns over sustainability severely limit the use of some fats. This is the case of palm oil and other tropical oils, whose increased production has led to deforestation throughout the world's tropical regions with consequent environmental issues [3].
Oleogels and oleogelation methodologies were the topics of the webinar organized by the Società Italiana per lo Studio delle Sostanze Grasse (SISSG) on the 20th of October 2021. The contents of the webinar are here briefly summarized.

OLEOGELATION STRATEGIES

Up to now, numerous approaches for oil structuring exist. The most common method consists in the direct dispersion of one or more liposoluble gelators into liquid oil under proper physico-chemical conditions. The resulting solution is then cooled to induce the self-assembly of the oleogelator into a network entrapping oil [1]. This oleogelation methodology is called direct oleogelation and examples of gelators are i) saturated monoglycerides, fatty alcohols, or waxes forming a crystalline network in oil; ii) phytosterol-phytosterol ester mixtures entrapping oil by the generation of a network made of hollow double-walled tubules; and iii) ethylcellulose that is able to develop a polymeric structure in which oil remains embedded [1].
The second group of molecules exploitable for oleogelation is made of hydrophilic polymers, such as proteins and carbohydrates [4]. These molecules are widely used in the food industry as ingredients with many functionalities. However, their use to structure oil is quite recent and requires the development of multi-step methodologies, also called indirect oleogelation strategies. In these cases, the network is firstly formed in presence of water. Subsequently, water is removed leading to the formation of an oleogel or the generation of a porous material able to further absorb oil [4]. The most promising techniques belonging to these indirect methodologies are: a) emulsion-template approach, when the starting material is an emulsion, from which the water phase is removed by drying; b) solvent exchange procedure when the starting material is an hydrogel and the solvent is progressively removed by changing the solvent polarity; c) dried-template approach when the oleogel is obtain by oil absorption into a dried porous template (i.e. cryogel or aerogel) made of the hydrophilic polymer [4-5].
Figure 1 shows some examples of oleogels prepared in the laboratories of the Department of Agriculture, Food, Animal and Environmental Sciences of the University of Udine following the above reported methodologies.

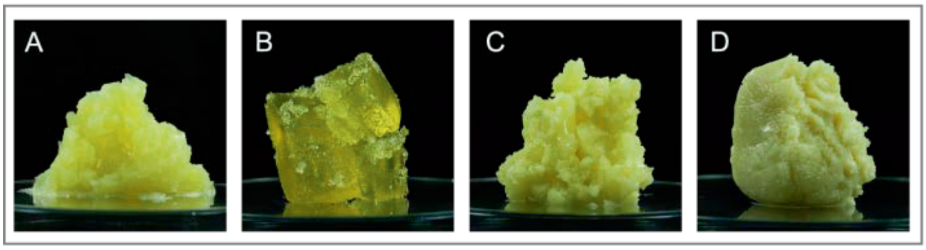

Figure 1 - Examples of oleogels prepared in the laboratories of the Department of Agriculture, Food, Animal and Environmental Sciences of the University of Udine and formulated with different gelators (saturated monoglycerides (A), mixture of phytosterol-phytosterol esters (B), rice bran wax (C), whey proteins (D)).

OLEOGEL FUNCTIONALITIES

As previously pointed out, oleogels have been studied and developed with the promise to become a feasible alternative of traditional fats, such as animal fats, tropical oils, margarine and shortenings. Their successful application as fat substitute goes through their capacity to mimic the technological functionalities of traditional fats. As well known, fats are multipurpose ingredients in many food formulations and their partial or total replacement is challenging due to their intrinsic properties impacting food processability and overall chemical, physical, and sensorial characteristics of the final product. The good capability of oleogels to replace fat characteristics (e.g., spreadability, texture, mouthfeel, emulsion stabilization) has been today demonstrated by many Authors in different food categories, such as meat and dairy derivatives, confectionaries or bakery products [6]. Depending on the expected oleogel application, the best performing oleogelator in combination with the oil to be delivered must be case by case identified.
Beside technological functionalities, oleogels demonstrated interesting health functionalities. For instance, oleogels resulted able to modulate lipid digestion by reducing the rate and extent of lipolysis during in vitro simulated digestion [7-8]. Moreover, they are claimed as efficient delivery and protection systems for lipophilic bioactive molecules in the human body [8-9].
Despite their excellent potentialities, it should be said that today the use of oleogels in foods is still in the early stages of development. This is also due to the presence of regulatory constraints associated with many of the proposed oleogelators. Among lipophilic oleogelators, only saturated monoglycerides can be used "*quantum satis*" as additive in a huge variety of foods. Other oleogelators, such as sunflower and rice bran waxes, are not allowed for food applications or can be used only under restrictions in specific product categories (e.g., ethylcellulose, bees and candelilla waxes, phytosterols) in EU [10]. Different is the case of hydrophilic molecules proposed to gel oils. In this case, the regulatory constrains are significantly reduced being these molecules classified as conventional food ingredients (e.g., proteins) or as additives widely used in many food categories (e.g., k-carrageenan, xanthan gum, methylcellulose). The drawback that is hindering food applications is the complexity of the oleogel preparation methodology.
In conclusion, oleogels represent a valuable solution to overcome some of the health-related concerns associated with the consumption of food lipids in the diet. Nevertheless, there is still the need of reinforcing research efforts on this topic to overcome the constraints in their application by food industry. Finally, being still limited the literature on oleogel health functionalities, there is the need to generate fundamental knowledge on the relationship between oleogel properties and their biological functions.

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