Technical Report

Project title: Development of Expeller-Pressed Regular and High Oleic Soybean Oil Oleogels for Edible Applications

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1. Introduction

Under the new rule (80 FR 34650) from the FDA, partially hydrogenated oils (PHOs), the core source to manufacture shortening, are no longer "Generally Recognized as Safe" (GRAS) and cannot be added to foods after June 18, 2018. However, it is difficult to find an ideal product to fully replace PHO in the food industry, so FDA is extending the compliance date to January 1, 2020 to allow for an orderly transition of the majority of PHO-contained products made before Jun 18, 2018. In order to comply with the new regulation, the baking industry starts to replace PHOs with palm oil and coconut oil. However, Dietary Guidelines for Americans (2015-2020) and the new Scientific Report of the Dietary Guidelines committee (2015) both recommend that consumers increase consumption of polyunsaturated fats and decrease consumption of saturated fats to decrease risk for coronary heart disease (CHD). The association of high dietary saturated fat with increased risk of CHD suggests that improving the nutritional profiles of foods by substituting their saturated fat with unsaturated fat could have an important and positive impact on consumer health. Certainly, palm or coconut oil is not a promising answer for PHO replacement since both oils contain extremely high amounts of saturated fats. In general, palm oil contains about 50% saturated fatty acids while coconut oil usually is composed of 90% saturated fat. As a matter of course, food manufacturers and scientists are seeking alternative approaches that can replace PHOs and produce shortening that can mimic the physical properties of PHOs-based shortening while maintaining the balanced fatty acid profile.

The overarching goal of this research is to develop premium semisolid oleogels using expeller-pressed soybean oil (regular and high oleic soybean oil). Such oleogels can be used to replace other shortenings for edible applications. Three objectives were pursued during the funding year: (i) quantifying the minor constituents in expeller-pressed soybean oil and understanding the role of minor constituents on the physical, chemical, and rheological properties of soybean oleogels prepared with different gelators; (ii) oxidative stability of oleogels prepared from EP soybean oil; and (iii) optimizing the gelators with minimal concentrations in preparing soybean oleogels for cookie making

2. Research methods

Preparation of EP soybean oil oleogels: We prepared oleogel by using expeller-pressed high oleic soybean oil (EPS) and sunflower wax (SFX) at different concentrations (3, 5, 7, and 9 wt

Characterization of EP soybean oleogels: Colorimeter, differential scanning calorimetry (DSC), rheometer, X-ray diffraction (XRD), polarized light microscopy (PLM), and texture analyzer were used to measure the physical characteristics of all the soybean oil oleogels.

Oxidation of EP high oleic soybean oil oleogel: The oleogel was incubated at 55°C to accelerate the oxidation process. Lipid hydroperoxide content in high oleic soybean oil oleogels was measured as the indicator of the primary oxidation process. Moreover, the secondary oxidation process was studied by measuring the content of propanal using gas chromatography.

Preparation of cookies: Cookies were prepared using the official AACC method. EPS oleogels were used to replace shortening in cookies, and the physical properties of oleogel based cookies were compared with commercial shortening-based cookies.

Characterization of cookies: Colorimeter and texture analyzer were used to measure the color and texture of cookies. The width, thickness, and spread ratio of cookies were also measured. The microstructures of those cookies were investigated by confocal laser scanning microscopy.

3. Research results

The properties of oleogel and the corresponding cookies, including thermal, rheological and mechanical properties, as well as polymorphism and crystal morphology were systematically investigated. This part of research has been published in ***Food & Function*** journal and the detailed results can be found at (https://pubs.rsc.org/en/Content/ArticleLanding/2020/FO/D0FO02451A#!divAbstract). Meanwhile, the lipid oxidation results will be discussed in the following.

1). Lipid hydroperoxide content in high oleic soybean oil oleogel

Oleogels were prepared by mixing high oleic soybean oil with monoacylglycerol (MAG) or rice bran wax (RBX) at a concentration of 10 wt%. To accelerate the oxidation process of oleogels, all the oleogel samples were incubated at 55°C. The formation of lipid hydroperoxides (LOOH, primary oxidation marker) and headspace propanal (secondary oxidation marker) during storage was determined.

The results showed that the concentration of LOOH in MAG-based oleogels started to increase on day 4 and increased dramatically from day 6 (**Fig. 1**). For RBX-based oleogel, the concentration of LOOH started to grow from day 2 and increased dramatically from day 4. Although the LOOH seemed to be grown earlier in RBX-based oleogel, the total concentration of LOOH was higher in MAG-based oleogel than that in RBX-based ones. For example, the total concentration of LOOH in MAG-based oleogel on day 18 was 9.53 mmol/g while it was 7.21 mmol/g in RBX-based oleogel on the same day.

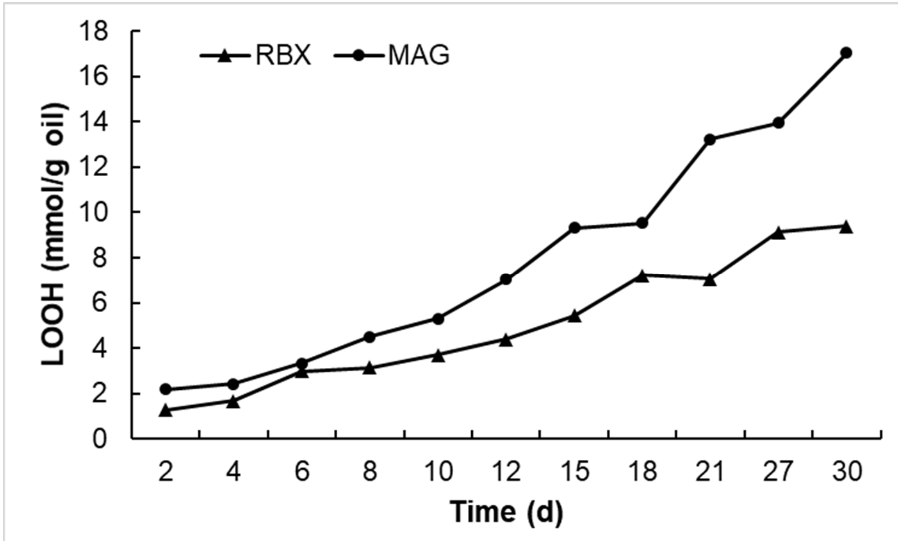

Fig. 1. The concentration of lipid hydroperoxide (LOOH) in monoacylglycerol (MAG) based oleogel and rice bran wax (RBX) based oleogel.

2). Propanal content in high oleic soybean oil oleogel

The content of propanal in high oleic soybean oil oleogel was measured by gas chromatography as the indicator of the secondary oxidation process. The results showed that the concentration of propanal in both oleogels started to grow around day 2 and kept growing slightly until day 12 (**Fig. 2**). The content of propanal increased dramatically from day 12 for both oleogels. In terms of gelator type, RBX-based oleogel produced more amount of propanal than MAG-based oleogel. For example, the area of propanal in RBX-based oleogel was about 223 pA*s while in MAG-based oleogel was 174 pA*s on day 18. The results indicated that RBX-based oleogel oxidized faster than MAG-based oleogel during the secondary oxidation process.

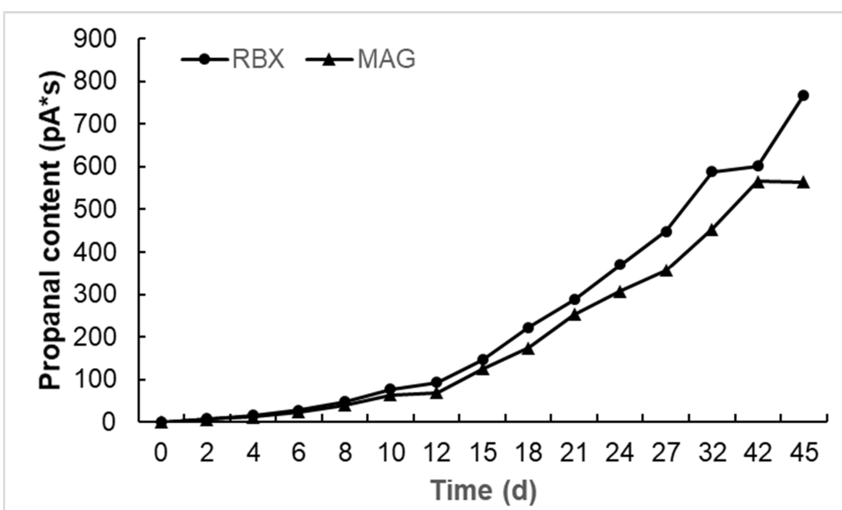

Fig. 2. The content of propanal in monoacylglycerol (MAG) based oleogel and rice bran wax (RBX) based oleogel.

3). *Propanal content in cookies prepared with oleogel and commercial shortening*

RBX-based oleogels were used to replace commercial shortening in the preparation of cookies. The content of propanal in oleogel-based cookies was measured by gas chromatography as the indicator of the secondary oxidation process, and the results were compared to shortening-based cookies. The results showed that cookies prepared with shortening and oleogel shared similar oxidation behavior. Cookies prepared with shortening and oleogel both started to produce propanal on day 4 and the total propanal grew dramatically from day 12 (**Fig. 3**). When comparing the content of propanal based on the type of fat, it was obvious that the content of propanal in shortening-based cookies was much higher than the one prepared with oleogel. This result indicated that the replacement of shortening with oleogel could delay the secondary oxidation process of cookies, thus, improving the shelf-life of cookies.

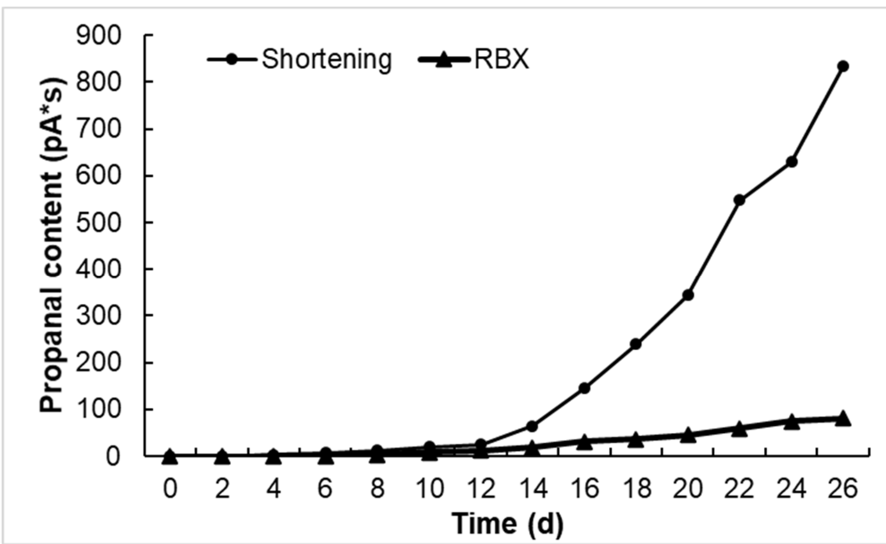

Fig. 3. The content of propanal in cookies prepared with commercial and rice bran wax (RBX) based oleogel.

4. Conclusion

Oleogel was prepared by mixing high oleic soybean oil with either monoacylglycerol or rice bran wax at a concentration of 10wt%. The oxidation of oleogels was studied by measuring both primary and secondary oxidation products. The results showed that the primary oxidation starts from day 2 and 4 for RBX and MAG-based oleogels, respectively. However, the total concentration of LOOH was higher in oleogel prepared with MAG than RBX. To study the secondary oxidation process of oleogel, propanal was measured. The results showed that the content of propanal started to grow from day 2 and increased dramatically from day 12 for both oleogels. When comparing the total propanal in both oleogels, RBX produced more propanal than MAG which indicated RBX-based oleogel oxidized faster than MAG-based oleogel during the oxidation process. RBX-based oleogel was used to prepare cookies and the oxidation behavior of cookies was studied and compared to cookies prepared with commercial shortening. The results showed that both oleogel-based cookies and shortening-based cookies started to be oxidized from day 4 and the content of propanal increased dramatically from day 12. However, shortening-based cookies produced much higher total propanal than oleogel-based cookies, which indicated that oleogel could delay the oxidation process of cookies, thus, improving the shelf-life of cookies.