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Extended Abstract

Changes in Thermal, Textural, Color and Microstructure Properties of Oleogel Made from Beeswax with Grape Seed Oil under the Effect of Cooling Rate and Oleogelator Concentration

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Abstract

In this study, the crystallization behavior of beeswax in grape seed oil in a wide range of cooling rates of 0.04, 0.08, 0.16, 0.33 and 0.66 (°C/min), from 85 to 25 °C and wax concentrations of 10, 15 and 20% were examined. Thermal behavior characteristics, texture, color and the crystal shapes of the samples were evaluated. The results showed that with increasing the percentage of wax in oleogel, the onset and melting temperatures increased in different treatments, so that the greatest increase was shown in the cooling rate of 0.16 °C/min. Temperatures of 45.90±0.46 and 46.8±0.30 for 10 wax concentration up to 62.70±0.2 and 65.80±0.17 for 20% wax concentration for onset and melting temperatures, respectively were measured. With increasing wax concentration, the factors of stiffness and adhesiveness also increased and this increase was more evident in the cooling rate of 0.66 °C/min, so that the stiffness and adhesiveness parameters increased the most at concentrations of 10% to 20%, respectively. Also, with slow cooling rate, samples with larger crystals were obtained. Color evaluation revealed that with increasing wax concentration, all color parameters except parameter a*, which did not show a significant difference, increased in all cooling rate treatments. The fat crystal engineering approach followed here offers the prospect of obtaining stronger structures at oleogelator concentrations and creating oleogel with desirable properties.

Keywords: Beeswax, Cooling rate, Grape seed oil, Oleogel

Introduction

As a proper vegetable oil, grape seed oil has a variety of food applications (Movahed & Ghavami, 2007). It contains substantial amounts of unsaturated and essential fatty acids as well as natural antioxidants (Emmons *et al.*, 1999; Movahed & Ghavami, 2007). Oleogel is a gel network comprised of a gelator molecules which entrap edible oils in the network through interchain reactions and can structure to the oils during cooling (Dassanayake *et al.*, 2011).

The ability to form gel from edible oils using very small amounts of oleogelators such as beeswax (BW), is one of the most important functions of oleogels (Cerqueira *et al.*, 2017; Martins *et al.*, 2016; Öğütcü & Yılmaz, 2014). BW, as an edible wax, has been frequently applied in the production of edible oleogels (Lim *et al.*, 2017; Toro-Vazquez *et al.*, 2013; Toro-Vazquez *et al.*, 2010; Toro-Vazquez *et al.*, 2007) . Waxes have high melting points;

thus, they rapidly crystallize at room temperature. A limited number of studies have been conducted on the effect of the wide range of cooling rates on the crystallization behavior of oleogels. Moghtadaei *et al.* (2019) investigated the impact of cooling rate at 4 and 25 °C on sesame oil oleogels containing BW and ethyl cellulose. The influence of cooling rate (0.1, 1 and 10 °C/min) was examined on the crystallization behavior of BW in five edible oils (Jana & Martini, 2014). Giacomozzi *et al.* (2019) modified the physical properties of the oleogels containing monoglyceride using the monoglyceride concentration, cooling rate and the application of ultrasound. The purpose of the present research is to investigate the crystallization behavior of BW in grape seed oil influenced by a variety of cooling rates (0.04, 0.08, 0.16, 0.33 and 0.66 °C/min from 85 to 25 °C) and the BW concentration (10, 15 and 20%).

Materials and methods

BW concentrations of 10, 15 and 20% were used in grape seed oil. 5 cooling rates (0.04, 0.08, 0.16, 0.33 and 0.66 °C/min) were used for the various ratios of BW to the oil. In each step, the oil was heated up to 140 °C, and then the wax was added. The resulting sample was divided into four equal portions which were further incubated at the predefined cooling rate. Afterwards, they were stored in the incubator at 25 °C for further analyses. The crystals morphology (Martini *et al.*, 2002), differential scanning calorimetry (Jana & Martini, 2014), texture analysis (Afoakwa *et al.*, 2008) and color assessment (Yi *et al.*, 2017) were carried out.

Results and discussion

At all the three concentrations, larger crystals were obtained from the samples which had been crystallized at slower cooling rates (longer times), because crystals had more time to grow at longer durations. Therefore, a smaller number of crystals with larger dimensions were formed; in contrast to what occured at shorter times of cooling.

With an increase in the cooling rate (shorter cooling durations), since more crystals with smaller sizes are formed, they can entrap more oil in their network, thus forming a more homogenous substance macroscopically. Application of slower cooling rates (longer times) showed a reverse phenomenon. On the other hand, the rise in the wax concentration in the oleogel at lower cooling rates could give the final product a relatively homogenous appearance, due to the increase in the number of the wax molecules in the mixture.

As the wax concentration was elevated in the oleogels, the onset and melting temperatures were raised in different samples, which could be attributed to the rise in the number of crystals caused by the increase in the surface area of the wax molecules in the mixture.

It was also revealed that as the wax concentration rose, stiffness and adhesiveness were elevated. The textural parameters of the different concentrations of the oleogel at various cooling rates are depicted in Fig. (1). With a rise in the wax concentration in the grape seed oil, stiffness and adhesiveness were raised which happened at all the cooling rates, equal durations and different wax concentrations. Only the wax concentration of 20% showed a rise in stiffness and adhesiveness as the cooling rate increased, because this concentration provided a sufficient number of molecules in the oleogel network, Hence, crystallization was only affected by different cooling rates at this concentration, and stiffness and adhesiveness were only impacted by the cooling rate of the gel system. The textural parameters could not be measured for the samples with 10% of the wax at 0.04 and 0.08 °C. Owing to the small number of the wax molecules in the gel network at 10%, they formed large crystals at low cooling rates and could not retain the oil phase in the crystalline network. Consequently, the two samples had a semi-solid appearance, whose textural parameters could not be quantified through the penetration test. At the cooling rates of 0.16, 0.33 and 0.66 °C/min, the textural parameters decreased at 10% of the wax, which was in contrast to what expected at 20%. This could also be justified by the rise in the wax concentration at various cooling rates, because the wax concentration was so low that the crystalline network did not have enough time to be formed and entrap the oil phase at low cooling durations, and the system had a lower compressibility. At the wax concentration of 15%, it seems that the crystallization was partly dependent on the wax concentration at 15%, similar to what occurred at 10% but to a lesser extent, and the results more tended towards those obtained at 20%.

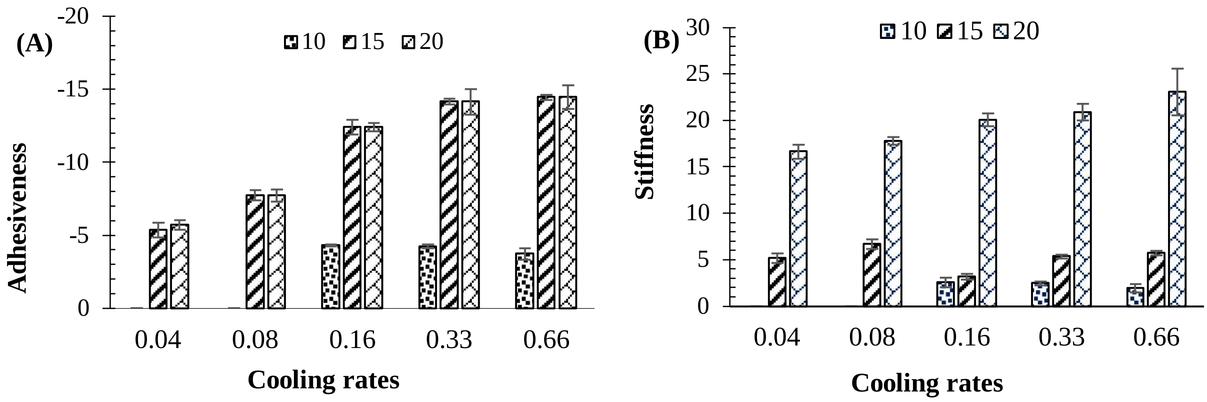

Fig. 1. Textural parameters of oleogels of grape seed oil and beeswax at 10, 15 and 20% and different cooling rates

The lightness (L*) of the control sample was more than that of the oleogels containing BW, and as the wax concentration increased, lightness increased, too; even though they had lower L* values than the control. The yellowness (b*) of the oleogels was also elevated with a rise in the wax concentration, while redness (a*) showed no significant change as the wax concentration rose.

Conclusions

Application of different cooling rates along with various concentrations of beeswax showed significant effects on the oleogel properties. As the oleogelator concentration and cooling rate were increased, the oleogels showed a more uniform appearance. The thermal properties of the oleogels were more influenced by the oleogelator concentration rather than the cooling rate. The correlation between the cooling rate and the wax concentration was significantly positive in the case of the textural properties. Among the color indices, only the redness value did not significantly increase as the wax concentration increased. The promising results of this study demonstrated that by changing the oleogelator concentration and cooling rate, it would be possible to configure oleogels with different textures and potential functions.

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