Comparative analysis of the properties of cookies containing oleogel based on beeswax and its fractions

Yu V Frolova¹, R V Sobolev¹, and A A Kochetkova¹

¹Federal Research Centre of Nutrition and Biotechnology, Moscow, Russia

E-mail: Y.operarius@yandex.ru

Abstract. The article presents a comparative analysis of the properties of dough and cookies based on oleogels structured with various substances. Oleogels based on beeswax and its fractions were used as an alternative to solid fat in cookies. We found out that the use of separate beeswax fractions in oleogels makes it possible to obtain dough with different rheological characteristics. It was revealed that there is no regularity in the change in the rheological properties of cookies from the properties of the dough and oleogels. Analysis of the organoleptic profile of the cookie samples showed high values. This fact indicates the acceptability of using oleogels based on individual wax fractions in the biscuits cookies. The results obtained indicate the potential of using oleogels based on beeswax fractions in cookies as an alternative to solid fats.

1. Introduction

The use of oleogels in food products as substitutes for solid fats to reduce the content of saturated and trans-isomeric fatty acids in final products is attracting more and more attention from researchers and developers [1, 2]. The advantages of oleogels include ease of production, the possibility of varying the fatty acid composition of the final product containing oleogel; depending on the type of structuring agent and concentration its possible to change the rheological characteristics of both oleogels and final products [3].

The use of waxes, in particular beeswax, for structuring edible oils is due to their gel-forming properties at low concentrations and high oil-binding capacity [4]. Beeswax is a complex mixture more than 300 components [5], characterized by the main classes: hydrocarbons, free fatty acids, wax esters, fatty alcohols, and exogenous impurities [5, 6].

At the same time, the composition and ratio of components (fractions) in wax can vary depending on the breed and family of bees, their diet and geographical location [5]. Currently, the literature presents studies on the use of oleogels based on various waxes [7, 8] and their combinations [9-11] in the composition of food products. Due to the different content of hydrocarbons, wax esters, free fatty acids, and alcohols, using a combination of waxes allows the production of oleogels with a wide variety of properties. Therefore, there is interest in studying the role of individual wax fractions in the structuring of edible oils and their effect on the properties of final products containing oleogels. Currently in the literature there are separate studies of groups of compounds extracted from wax to obtain oleogels [12-14].

This work aimed to study the changes in the rheological and organoleptic properties of cookies with a modified fat component, depending on the oleogel structuring agent.
2. Materials and methods

2.1. Materials
Refined sunflower oil (SO) (Russia); beeswax (BW) (Russia); beeswax fractions: fraction 1 - F1 (hydrocarbons), fraction 2 - F2 (monoesters), fraction 3 - F3 (mono-, di- and triesters), fraction 4 - F4 (wax esters, free fatty acids and alcohols) obtained by the method [15].

2.1.1. Preparation of oleogels. Oleogel samples were prepared immediately before use according to the procedure [4]. The concentration of the structure-forming agent in all oleogels was 6 wt.%

2.1.2. Preparation samples of cookies. The cookies consisted of the following ingredients: wheat flour, fat component (sunflower oil or oleogel), white sugar, chicken egg, dough loosener. The fat content in the dough was 26.75 %. Cookie-making technology corresponded to the method [4] with modifications. The dough samples were cooled at a temperature of 8 ± 2 °C for 20 minutes, followed by rolling and cutting out “shaped cookies”. Cookies were baked at 180 °C for 8 minutes.

2.2. Methods

2.2.1. Study of rheological parameters of dough and cookies. Rheological parameters of dough and cookies were determined on a universal testing machine Shimadzu EZ Test SX (Shimadzu, Japan), to characterize the samples recorded values of Young’s modulus (N/mm²) and Hardness (N) at room temperature. The dough and cookie samples were tested using cylindrical probe (diameter 6 mm) at a test speed of 3 mm/s, a penetration depth of 10 mm, and a test speed of 0.5 mm/s, a penetration depth of 7 mm, respectively. Data processing was carried out using the Trapezium X software (Shimadzu, Japan) and the SPSS Statistics 23 software package.

2.2.2. Organoleptic analysis of cookies. Revealing of characteristics capable of influencing the perception of cookie samples was carried out by the method of “free-choice sensory profile” by GOST ISO 13299-2015. The following were chosen as the descriptors: taste, odor, texture, surface condition, shape, fracture view, sweet taste, creamy flavor, vanilla flavor, floral flavor, waxy flavor, rancid flavor, fatty flavor, soapy flavor, foreign flavor. The results were processed using the SPSS Statistics 23 software package.

3. Results and Discussion
The rheological properties of oleogels structured with beeswax depend on their component composition. The use of oleogels with different rheological characteristics makes it possible to vary the properties of a food product based on them. The influence of the studied oleogels on the rheological properties of the dough is shown in figure 1. A dough containing sunflower oil was used as a comparison sample to reveal the contribution of the structuring of the oil to the rheological properties of the dough and, subsequently, the final product.
As a result of the studies, it was found that the structuring of sunflower oil in all the cases studied leads to a significant (p < 0.01) decrease in the hardness of the dough formed. In earlier studies [4], it was shown that the use of beeswax-based oleogel results in a dough with rheological parameters identical to those of butter-based dough, in connection with which oleogels can potentially be used as an alternative to solid fat in cookies. Replacing the structural agent beeswax with its fractions resulted in dough samples with higher rheological indices, except for samples containing F4.

The studied oleogels differ in rheological parameters [15]. This fact is due to their component composition since individual classes of substances that make up beeswax have different structuring abilities. Analysis of the data revealed that the pattern "the harder the oleogel, the harder the product on its basis" is not confirmed. For example, a sample-based on 4 fractions has the highest hardness values compared to other oleogels [15]. At the same time, the dough on its basis was more plastic and less solid. Obtaining such results is probably due to the complex action of wax esters, free fatty acids, and alcohols included in the fourth fraction on the components in the dough.

The cookie samples made from the dough are shown in figure 2.
According to the results of a preliminary visual assessment of the final cookies, it was revealed that after baking, all the samples under study retain their shape; the fracture view has a uniform porous structure, without voids and traces of undermixing.

The results of rheological studies of final cookies are shown in figure 3.

![Figure 2](image1.png)

**Figure 2.** Appearance of final cookies: (a) - based on sunflower oil; (b) - based on oleogel structured with beeswax; (c) - based on oleogel structured with the F1 fraction; (d) - based on an oleogel structured with the F2 fraction; (e) - based on oleogel structured with the F3 fraction; (f) - based on oleogel structured with F4 fraction.

![Figure 3](image2.png)

**Figure 3.** Rheological parameters of the studied samples of cookies: (a) – Young’s Modulus (N/mm²), (b) – Hardness (N).
In the process of baking, there is a transformation of the component composition of the dough. Thanks to this, the rheological characteristics of the finished cookies are forming. Based on the obtained data, it was revealed that there is no regularity in the change in the rheological properties of cookies from the properties of the dough and oleogels. In this regard, it becomes clear that the formation of cookie properties depends on the structuring component that is part of the oleogels. At the same time, in terms of hardness, the samples of BW cookies had the lowest values. This sample was more crumbly than other samples. This was also noted by panelists in the sensory evaluation of the cookie (figure 4).

![Figure 4. Petal diagram of the mean values of descriptor expression of the studied samples of cookies.](image)

The analysis revealed that the descriptors of taste, texture, surface condition, shape, fracture view have high scores, without significant differences (p < 0.01). This fact indicates the acceptability of the use of oleogels as a fat component of cookies from an organoleptic viewpoint. The high intensity of the descriptor “Fatty Flavor” in the samples of sunflower oil-based cookies, oleogels BW, and F3 decreased the overall score of the descriptor “Flavor” for these samples. Differences in the descriptor “Odor” for the examined samples of cookies are associated with different profiles of volatile compounds of the fat component. Studies of the composition of volatile compounds of beeswax and its fractions are presented in [15]. It should be noted that the oleogels based on beeswax and fractions F1, F2 have a neutral odor with a characteristic weak odor of structurant, which may be because in the profile of volatile compounds of initial beeswax and fractions F1, F2 there is no predominant component. At the same time, the predominant components in the profile of volatile compounds were revealed for fractions F3 and F4 [15]. This led to a more intense odor of oleogels based on them. When baking cookies, as a result of a series of chemical reactions, the aromatic profile of the finished product is formed. In this case, the formation of individual profile can be both dominant and suppressed. Thanks to this, an individual aromatic profile of the final product is formed - the “Odor”
descriptor. As a result of the analysis, the highest severity of the “Odor” descriptor was found for cookies containing oleogel with fraction F1, the least for cookies containing oleogel with fraction F3 and BW. At the same time, according to [15], beeswax and fractions F3, F4 are characterized by the presence of volatile compounds perceived as “floral” and “aldehyde”, “sharp” and “solvent”, respectively, for fraction F1 - “fresh”, “waxy” and “soft”. However, despite the identical perception of the profiles of fragrances of fractions F3 and F4, final cookies containing oleogels based on them had significant differences in the Odor descriptor, which may be due to the different composition of these structure-forming agents and their interaction with the cookies components.

4. Conclusion
The work carried out a comparative analysis of the rheological and organoleptic properties of cookies with a modified fat component. Differences in rheological characteristics of dough and biscuits are shown depending on the composition of the fat component. It was revealed that there is no regularity in the change in the rheological properties of “oleogel-dough-cookie”. As a result of the organoleptic analysis of the cookie samples, it was found that all the studied samples containing the oleogel have high performance, which indicates the acceptability of the use of oleogels based on individual beeswax fractions in the composition of the cookie. Further optimization of oleogel formulations may lead to the creation of an alternative to solid fats containing saturated and trans-isomeric fatty acids.

Acknowledgements
The research was supported by a grant from the Russian Science Foundation (Project No 19-16-00113).

References
[1] Martins A J, Vicente A A, Pastrana L M and Cerqueira M A 2020 (J Food Science and Human Wellness vol 9(1)) pp 31–39
[2] Hwang H S 2020 J Biocatalysis and Agricultural Biotechnology p 101657
[3] Zhao W, Wei Z and Xue C 2021 J Critical Reviews in Food Science and Nutrition pp 1–18
[4] Frolova Yu V, Sobolev R V and Kochetkova A A 2021 J Food Industry vol 4 pp 8–11
[5] Fratini F, Cilia G, Turchi B and Felicioli A 2016 Asian Pacific Journal of Tropical Medicine vol 9 (9) pp 839–843
[6] Doan C D, To C M, De Vrieze M, Lynen F, Danthine S, Brown A, Dewettinck K and Patel A R 2017 J Food chemistry vol 214 pp 717–725
[7] Pușcaș A, Mureșan V, Socaciu C and Muste S 2020 J Foods vol 9 (1) p 70
[8] Li S, Wu G, Li X, Jin Q, Wang X and Zhang H 2021 J Food Chemistry vol 356 p 129667
[9] Hwang H S and Winkler-Moser J K 2020 Journal of Food Science vol 85 (10) pp 3293–3302
[10] Winkler-Moser J K, Anderson J, Felker F C and Hwang H S 2019 Journal of the American Oil Chemists' Society vol 96 (10) pp 1125–1142
[11] Fayaz G, Goli S A H, Kadivar M, Valoppi F, Barba L, Balducci C, Nicoli M C and et all 2017 European Journal of Lipid Science and Technology vol 119 (10) p 1700032
[12] Adulpadungsak K, Lilitchan S, Aryusuk K 2020 International Journal of Science vol 17 (1) pp 1–13
[13] Lupi F R, Greco V, Baldino N, de Cindio B, Fischer P and Gabriele D 2016 Journal of colloid and interface science vol 483 pp 154–164
[14] Pandolsook S and Kupongsak S 2020 Journal of Food Measurement and Characterization vol 14 pp 2078–2086
[15] Sarkisyan V, Sobolev R, Frolova Y, Malinkin A, Makarenko M and Kochetkova A 2021 Journal of the American Oil Chemists' Society vol 98 (3) pp 281–296