ESTIMATION OF TECHNOLOGICAL PROPERTIES OF NUT MEALS AND THEIR EFFECT ON THE QUALITY OF EMULSION FOR BUTTER BISCUITS WITH LIQUID OILS

E. Shydakova-Kameniuka
PhD, Associate Professor*
E-mail: shidakovaee@gmail.com

A. Novik
Postgraduate student**

Y. Zhukov
PhD, Associate Professor
Department of Tourism and Hotel Business***

Y. Matsuk
PhD, Associate Professor**

A. Zaparenko
PhD, Associate Professor
Department of Food Technologies and Restaurant Business***

P. Babich
PhD, Associate Professor
Department of Food Technologies and Restaurant Business***

S. Oliinyk
PhD, Associate Professor*

*Department of Bakery, Confectionary, Pasta and Food Concentrates Technology
Kharkiv State University of Food Technology and Trade
Klochkivska str., 333, Kharkiv, Ukraine, 61051

**Department of Food Technologies
Oles Honchar Dnipro National University
Gagarin ave., 72, Dnipro, Ukraine, 49010

***Kharkiv Institute of Economics and Trade of Kyiv National University of Economics and Trade
Otakara Yarosha lane, 8, Kharkiv, Ukraine, 61045

UDC 664.682 : 664.696.3 : 664.34
DOI: 10.15587/1729-4061.2019.159983

1. Introduction

A significant segment of the global confectionery market accounts for flour-based products. Specifically, according to statistical data for 2013–2017, the sales of bakery and pastry products in the world grew by 3.9 % [1]. The largest specific weight in the production of the specified products (about 45 %) belongs to cookies [2], including butter biscuits. However, the peculiarity of the chemical composition of butter biscuits is low content of vital nutrients (protein, dietary fiber, vitamins, minerals, etc.). It is predetermined by the fact that mostly refined raw materials are used in its technologies (modified fats, sugar, wheat flour of the highest grade, etc.).

One of the main raw components of butter biscuits (up to 35 %) is fats – butter, solid natural vegetable oils (palm, coconut, etc.), modified hardened vegetable oils (margarine,
pastry and culinary fats, spreads, etc.). Fatty raw material should be solid in consistency. Such fats are characterized by plasticity and the capability to crystallize to the finely-crystalline form. It is the fat crystals that are largely responsible for stabilizing the structure of a whipped emulsion [3]. Specifically, fat crystals are kept on air bubbles during emulsifying by capillary forces [4, 5]. This provides for the formation of porous and loose structure of finished products and their respective quality [6].

The use of butter in the technology of butter biscuits is restricted due to its high cost and low microbiological stability. When making the specified products, the advantage is given to hardened vegetable oils that acquired solid consistency as a result of certain modifications – hydrogenation, transesterification, etc. However, these fats are characterized by low biological value, by the high content of saturated fatty acids (FA) and the presence of trans-isomers of FA that can adversely affect the human body [7, 8].

Given this, it is a relevant task to search for possibilities to completely or partially replace the hydrogenated and re-esterified fats in the technologies of butter biscuits with more biologically valuable (due to the presence of significant amounts of polyunsaturated fatty acids, fat soluble vitamins, the absence of trans-isomers of FA) and cheap liquid vegetable oils. However, the use of liquid vegetable oils in the technology of butter biscuits is limited due to the emergence of certain technological problems.

First, fats in the technologies of butter biscuits must be applied in the form of finely-dispersed emulsions. That contributes to better distribution of fat particles in the form of thin films among flour particles, which prevents the swelling of flour colloids. As a result, the bond between components of the solid phase of dough is weakened, the dough acquires plastic properties. The smaller the thickness of the fat films, the looser the structure of ready biscuits [9]. Liquid oils are bad at emulsifying, which is why emulsions on their base, when compared with emulsions on solid fats, are characterized by lower stability. That predetermines the deterioration of quality of the baked biscuits. Second, liquid oils are easily separated from dough during baking and poor at keeping the bubbles of gas, released during the disintegration of looseners. The result is the reduced porosity and worsened organoleptic properties of finished products. Third, they are poorly retained by biscuits during storage. As a result, there is the migration of fat to packing materials with the deterioration of physical appearance and taste characteristics of products [9].

In order to ensure the required structural-mechanical properties of dough and the high quality indicators of finished biscuits when using liquid oils, an additional application of stabilizing additives is required, which should simultaneously possess high fat-emulsifying, fat-retention, and water-retaining properties [9]. Such supplements make use of macromolecular compounds (proteins, starches, gums, dietary fiber, etc.) or natural raw materials, which contain the specified substances. In this regard, it is a relevant task to undertake a research aimed at finding the natural raw ingredients which would exert a stabilizing influence on emulsions for biscuits with liquid oils.

2. Literature review and problem statement

In order to stabilize the emulsion systems for biscuits on liquid oils, it is promising to use supplements of plant origin. Their advantage is the presence in their composition of a set of nutrients, useful for human organism (vitamins, minerals, phenolic compounds, etc.), in the most accessible and digestible form.

It was proposed to replace 13.5 % of margarine in the technology of sugar biscuits with pumpkin oil, or 20 % – with sea buckthorn oil [10]. The stabilizing supplement that was used in the technology of biscuits with pumpkin oil was the powder made from dried apples (6.3 % of the mass of finished biscuits), from leaves of Calendula officinalis (0.3 %). When making biscuits with sea buckthorn oil, authors propose to additionally introduce powder made from dried apricots (4.9 %) and lungwort (0.3 %). The use of pumpkin and sea buckthorn oils can improve the content of polyunsaturated fatty acids in biscuits (by 2.5 and 3.3 times, respectively), while the introduction of plant powders made from fruit and medicinal raw materials can enrich products with pectin substances, food fibers, mineral substances, and vitamins.

Introducing sea buckthorn meal in the amount of 7 % by weight of flour makes it possible to replace 20 % of fat in the technology of shortcrust biscuits with flax oil [11]. In this case, the authors noted not only the enrichment of biscuits with useful nutrients, but also the improvement of organoleptic and structural-mechanical properties of products – color becomes golden, friability increases, improving the ability of biscuits to soaking, its density reduces.

Paper [12] proposed a complete replacement of margarine in shortcrust biscuits with deodorized refined sunflower oil. However, a given technology implies significant changes to formulation composition – wheat flour is completely replaced with corn flour, which is characterized by high fat-retention properties [13]. In addition, formulation components with high moisture content (condensed milk with sugar, whole eggs, honey) are replaced with dry powdered ingredients (dried fat-free milk, egg powder, glucose). In addition, the formulation is supplemented (1 % by weight of flour) with the citrus food fibers Herbacel AQ Plus – the type N [14]. The technological process becomes more complicated – the dough is made by brewing in hot water (90...100 °C) a mixture of dry formulation components with sunflower oil followed by the introduction of chemical looseners and flavorings. The advantage of the specified technology is obtaining a product for gluten-free diet. However, when compared with the sample based on margarine, in the process of storing there is a slight migration of fat to packing materials.

Paper [15] reported a technology of shortcake butter biscuits with the replacement of 29 % of margarine with a liquid oil with the addition of a 2.1-% mixture (by the weight of oil) of natural plant additives with a stabilizing action (xanthan and guar gum, wheat fiber, and soy protein isolate). The biscuits, made in line with a given technology, are characterized by the stability of quality indicators in the process of storage – the degree of fat migration to packing materials is almost the same as in the control sample.

The authors of [16] examined a possibility to replace 60 % of a fat component in the technology of shortcake dough with corn oil. Such a high concentration of liquid oil becomes possible owing to two factors. The stabilizer used was the Althea root powder (2.3 % by weight of flour). There is also an additional operation to pretreat corn oil in a specialized unit in a vortex layer of ferromagnetic particles.

Thus, the stabilization of emulsion systems for biscuits with the addition of liquid oils is achieved both by the use of sub-
stances-stabilizers and by applying non-traditional technological techniques. However, the latter technique implies changing the hardware implementation of the technology, which is economically impractical. More promising is to use additional natural raw materials, which includes stabilizing substances and biologically active components useful for human body.

Stabilizing effect on the emulsion systems is exerted by protein substances, soluble (specifically, pectin) and insoluble (for instance, cellulose) food fibers, phospholipids, lecithin, and others. That is, it can be assumed that the raw materials containing these compounds would have a positive impact on the properties of emulsions for butter biscuits and, as a consequence, the structural and mechanical properties of the finished product.

It is recommended that the biscuit formulations should be supplemented with components that contain the following substances. Specifically, it is proposed to use cryopowders made from grape pomace (5 % by weight of flour) [17] and a powder from grape seeds (15 % by weight of flour) [18]. There are suggestions to use apple pectin (8 % by weight of flour) [19] or fiber from pumpkin seeds with pineapple (20 % by weight of flour) [20]. A possibility was considered to introduce pumpkin puree (25 % by weight of sugar), Jerusalem artichoke powder (6 % by weight of dry matter in the finished product) [21], microbial polysaccharides [22].

This contributes to improving the structure and consistency of finished products, which could be a prerequisite for the development of biscuit technology with their use by replacing part of the fat component with a liquid oil.

A significant number of substances with high functional and technological properties are included in products from nut processing, namely cedar nut meal (CNM) and walnut meal (WNM). Specifically, these products are characterized by the high content of high-molecular compounds [23, 24], Table 1.

Table 1

<table>
<thead>
<tr>
<th>Substance</th>
<th>Content of biopolymers in CNM and WNM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CNM</td>
</tr>
<tr>
<td>Proteins:</td>
<td>38.59</td>
</tr>
<tr>
<td>Including Albumins</td>
<td>2.86</td>
</tr>
<tr>
<td>Globulins</td>
<td>10.91</td>
</tr>
<tr>
<td>Prolamins</td>
<td>8.27</td>
</tr>
<tr>
<td>Glutenin</td>
<td>16.55</td>
</tr>
<tr>
<td>Starch:</td>
<td>15.84</td>
</tr>
<tr>
<td>Including amylose</td>
<td>11.76</td>
</tr>
<tr>
<td>Amylopectin</td>
<td>4.08</td>
</tr>
<tr>
<td>Food fiber</td>
<td>18.79</td>
</tr>
<tr>
<td>Including hemicellulose</td>
<td>12.65</td>
</tr>
<tr>
<td>Cellulose</td>
<td>0.90</td>
</tr>
<tr>
<td>Lignin</td>
<td>0.04</td>
</tr>
<tr>
<td>Pectin substances</td>
<td>5.2</td>
</tr>
</tbody>
</table>

In addition, nut meals are characterized by the high content of physiologically beneficial nutrients – polyunsaturated fatty acids, minerals (iron, silicon, potassium, manganese, copper, zinc, etc.) and some phenolic compounds [22]. This will promote the improvement of biological value of food products that use them.

Features in the chemical composition of nut processing products predetermine their manifestation of excellent stabilizing properties in emulsion systems – in the technologies of ice cream [25], sauces and mayonnaises [26], cottage cheese products [27], and meat semi-finished foods [28].

An analysis of information sources for the last 10 years reveals that no study into a possibility to stabilize emulsion systems for biscuits with liquid oils using nut meals has been undertaken. There is an unresolved issue related to examining the functional and technological (water-retaining, fat-retention, and fat-emulsifying) properties of walnut and cedar nut meals. There is the lack of systemic realization of the effect of nut meals on the quality of emulsions for butter biscuits with the addition of liquid oils. The above is a prerequisite for conducting the research in this field.

3. The aim and objectives of the study

The aim of this study is to estimate the technological properties of nut meals (CNM and WNM) and the prospects of their use in order to stabilize the emulsion for butter biscuits with the addition of liquid oils.

To accomplish the aim, the following tasks have been set:
- to examine the functional and technological properties of CNM and WNM (dispersity, water-retaining, fat-retention, and fat-emulsifying capacities);
- to explore CNM and WNM in terms of properties of the emulsion for biscuits with liquid oils (dispersity, stability, viscosity).

4. Materials and methods to study the functional and technological properties of nut meals and the quality of emulsion for butter biscuits with liquid oils

The examined materials used in the study included wheat flour of highest grade; CNM and WNM (made by PP “NVF “Elite phyto”) and samples of emulsions for butter biscuits. Controls were the samples of emulsions on margarine (formula No. 160, “Formulations for biscuits and waffles”) (control No. 1) and with the replacement of 30 % of margarine with a liquid oil (control No. 2). The examined ones were the emulsions for butter biscuits with the replacement of 30 % of margarine with a liquid oil and with the addition of CNM or WNM (20, 40, 50 % by weight of emulsion). The liquid oil used was sunflower refined deodorized oil.

The granulometric composition of flour and nut meals was determined by microscopy at magnification ×120 times.

The water-retaining capacity (WRC) of samples was determined by centrifuging the sample suspension with water (1:5) at the ratio of difference between the amount of water used and the weight of the resulting centrifugate to the mass of the batch [29].

The fat-retention capacity (FRC) was estimated by the amount of fat that was retained by the sample following the infusion and centrifugation [29]. The fat-emulsifying capacity (FEC) was determined based on the ratio of the volume of the emulsified layer to the overall volume of the system following the centrifugation for 5 min at a speed of 2,000 rpm [29].

Dispersion of the emulsions was determined at magnification ×400 times at the microscope Bresser Biolux FA 50x-2000x based on the distribution of fatty balls (%) by size. Stability of the emulsions was determined in line with [30], effective (dynamic) viscosity of the emulsions – by applying the rotational viscosimeter Brookfield DV-II+PRO under autonomous mode over the range of spindle rotation speed 0.3...100 rpm.
Statistical processing of results from the experimental study was carried out using the standard software package Microsoft Office for a series of parallel measurements (n=4–5, p<0.05).

5. Results of studying the functionally-technological properties of nut meals and their impact on the quality of emulsion for butter biscuits with liquid oils

5.1. Results of studying the functional and technological properties of nut meals

Functional and technological properties of powder-like raw materials largely depend on the degree of their shredding [31]. Therefore, we considered it proper to estimate the grain composition of CNM and WNM compared with wheat flour of the highest grade (Table 2).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Granulometric composition of additives (%)</th>
<th>µm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grainalometric composition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>of CNM and WNM compared with</td>
<td></td>
</tr>
<tr>
<td></td>
<td>wheat flour of the highest grade (n=4, p=0.04)</td>
<td></td>
</tr>
<tr>
<td>10...20</td>
<td>20...40</td>
<td>40...60</td>
</tr>
<tr>
<td>Flour</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>CNM</td>
<td>14</td>
<td>55</td>
</tr>
<tr>
<td>WNM</td>
<td>12</td>
<td>60</td>
</tr>
</tbody>
</table>

Experimental data indicate that the examined supplements represent highly-disperse powders with close granulometric composition. Thus, the size of 60 % of CNM is up to 40 µm, 72 % of WNM, and only 35 % of flour. The maximum size of CNM and WNM particles does not exceed 100 µm, whereas wheat flour contains particles the size of up to 160 µm.

The main functional-technological properties that make it possible to estimate the influence of additives on the structural-mechanical properties of emulsions for butter biscuits are water-retaining, fat-retention, and fat-emulsifying capacities.

The water-retaining capacity (WRC) characterizes the hydrophilic properties of additives and reflects the intensity of intramolecular interaction between water and the surface of their particles. WRC depends on the type of polymers, which are part of the additives, size, density, their particles' surface condition. Given the fact that the main water-retaining component in the formulation of butter biscuits is flour, we estimated the WRC of supplements compared with wheat flour of the highest grade. We investigated WRC of the samples under conditions of exposure to different temperatures (20 to 90 °C), which is predetermined by the presence of a baking stage in the technology of biscuits. Average values for measurement results are shown in Fig. 1, relative error did not exceed 3.2 % (for n=4).

It was established in the course of experimental research that the examined supplements, when compared with wheat flour of the highest grade, are characterized by higher water-retaining properties. Specifically, at a temperature of 20 °C, CNM exceeds flour in terms of WRC by 3.2 times, and WNM by 3.9 times. In the case of increasing the temperature to 90 °C, a better pronounced tendency towards an increase in the value for WRC is observed in wheat flour – by 5.6 times, whereas for CNM this increase is 1.6 times, and for WNM – 1.4 times. It is noted that for WNM the dependence of WRC on temperature is nonlinear in character and slightly decreases in the temperature range 45...60 °C.

The fat-emulsifying capacity of the examined supplements was estimated based on the ratio to different types of fats: a liquid oil, margarine, and butter. Average data on research results are shown in Fig. 2, relative error of measurements did not exceed 3.5 % (for n=5).

It was established that CNM demonstrates almost the same fat-emulsifying properties in relation to butter and margarine – FEC is 32.7 and 32.1 %, respectively. For WNM, the capacity to emulsify butter is 16.1 % better than the capacity to emulsify margarine. FEC of the examined samples relative to liquid oil is much higher than that in relation to butter and margarine – for CNM, by 62.7 and 65.7 %, respectively; for WNM – 42.0 and 64.8 %. It is noted that WNM is 23.3 % better at emulsifying liquid oil than CNM.

Fat-retention capacity of the examined samples was assessed in relation to liquid oil in the temperature range from 20 to 140 °C. Average values for data obtained are shown in Fig. 3, relative error of measurements did not exceed 3.2 % (for n=4).

It was established that over the entire examined temperature range WNM shows better fat-retention properties than CNM. It was noted that the values of FRC for WNM and CNM in the temperature range from 20 to 60 °C grow by 1.9 times; in the range of 60...80 °C, FRC of the examined samples almost does not change, and under the influence of temperatures 100...140 °C it starts to decrease.
5.2. Results of studying the influence of nut meals on the quality of emulsion for butter biscuits with liquid oils

At the next stage, we investigated the stability of emulsions for butter biscuits in the case 30 % of margarine is replaced with a liquid oil with the addition of varying amounts of nut meals. Average data on results obtained are shown in Fig. 4, relative error of measurement did not exceed 3.0 % (for \( n = 4 \)).

It was established that the stability of emulsions in which 30 % of margarine was replaced with liquid oil (control No. 2) is 37.5 % less in comparison with the control on a margarine base (control No. 1). Introducing 20 % of CNM and WNM contributes to improving the stability of such an emulsion by 20.0 and 32.0 %; adding 40 % of nut meals – by 48 and 56 %, and 50 % – by 52 and 60 %, respectively. It was noted that the samples of emulsion with the addition of 40 % and 50 % of nut meals in terms of the value for the indicator of stability are maximally close to control sample whose fat base was margarine, which correlates with the results from studying the dispersity of emulsions (Table 3) and results from microscopy (Fig. 5, 6).

It was noted that for the case of introducing 50 % of nut meals the emulsion acquires high density. Technical possibilities of the instrument do not make it possible to obtain reliable data on the values for effective viscosity of such samples. Therefore, in this series of studies we assessed the samples of emulsions with a maximum dosage of nut meals, 40 %.

The results from microscopy (Fig. 5, 6) reveal that the introduction of CNM and WNM ensures the uniformity of the distribution of small fat balls, which are almost of the same size, throughout the entire structure.

An important rheological characteristic of emulsions, which defines their technological properties, is effective viscosity that characterizes the degree of resistance to flow (Table 4).

It was noted that for the case of introducing 50 % of nut meals the emulsion acquires high density. Technical possibilities of the instrument do not make it possible to obtain reliable data on the values for effective viscosity of such samples. Therefore, in this series of studies we assessed the samples of emulsions with a maximum dosage of nut meals, 40 %.

### Table 3

<table>
<thead>
<tr>
<th>Samples of emulsion</th>
<th>Distribution of fat balls (%) for size, μm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to 2</td>
</tr>
<tr>
<td>Control No. 1 (Fig. 5, a)</td>
<td>3</td>
</tr>
<tr>
<td>Control No. 2 (Fig. 5, b)</td>
<td>2</td>
</tr>
<tr>
<td>20 % CNM</td>
<td>13</td>
</tr>
<tr>
<td>20 % WNM</td>
<td>15</td>
</tr>
<tr>
<td>40 % CNM (Fig. 6, a)</td>
<td>19</td>
</tr>
<tr>
<td>40 % WNM (Fig. 6, b)</td>
<td>20</td>
</tr>
<tr>
<td>50 % CNM</td>
<td>21</td>
</tr>
<tr>
<td>50 % WNM</td>
<td>22</td>
</tr>
</tbody>
</table>

Fig. 3. Fat-retention capacity of nut meals under different temperature

Fig. 4. Stability of the examined samples of emulsions

Fig. 5. Microstructure of control samples of emulsions (at magnification ×300): a – control No. 1; b – control No. 2
Graphical interpretation of the results obtained is shown in Fig. 7. The shown curves for effective viscosity of the examined samples of emulsions take a typical form for non-Newtonian fluids [32]. These fluids are characterized by a decrease in the value for effective viscosity of the examined samples of emulsion at an increase in the rotation velocity of the measuring instrument’s spindle.

The effective (dynamic) viscosity of examined samples is typically described by equation of the following form:

\[ \eta = B \cdot \gamma^m, \]  

where \( \eta \) is the effective viscosity, Pa·s, \( B \) is the coefficient of consistency, proportional to viscosity, Pa·s, \( \gamma \) is the shear rate, m is the rate of destruction of a structure.

Table 4
<table>
<thead>
<tr>
<th>Velocity, rev-min(^{-1})</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>2.5</th>
<th>4</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>60</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control No. 1</td>
<td>1.090</td>
<td>850</td>
<td>750</td>
<td>610</td>
<td>550</td>
<td>450</td>
<td>380</td>
<td>250</td>
<td>180</td>
<td>140</td>
<td>90</td>
</tr>
<tr>
<td>Control No. 2</td>
<td>355</td>
<td>215</td>
<td>175</td>
<td>100</td>
<td>45</td>
<td>31</td>
<td>15</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>20 % CNM</td>
<td>394</td>
<td>348</td>
<td>221</td>
<td>183</td>
<td>117</td>
<td>91</td>
<td>35</td>
<td>17</td>
<td>10</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>20 % WNM</td>
<td>630</td>
<td>556</td>
<td>354</td>
<td>293</td>
<td>187</td>
<td>146</td>
<td>55</td>
<td>29</td>
<td>17</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>40 % CNM</td>
<td>400</td>
<td>399</td>
<td>367</td>
<td>322</td>
<td>261</td>
<td>213</td>
<td>72</td>
<td>31</td>
<td>26</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>40 % WNM</td>
<td>720</td>
<td>700</td>
<td>660</td>
<td>580</td>
<td>470</td>
<td>375</td>
<td>130</td>
<td>56</td>
<td>46</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

The results from mathematical treatment of experimental data from Table 4 are given in Table 5.

The estimated values for coefficients of determination (\( R^2 \)) indicate high reliability of analytical equations that describe the behavior of each of the examined samples.

The values from mathematical treatment of experimental data from Table 4 are given in Table 5.

6. Discussion of results of studying the functional and technological properties of nut meals and their impact on the quality of emulsion for butter biscuits with liquid oils

Study into the water-retaining properties of the examined supplements (Fig. 1) has established that at 20 °C they are characterized by the higher value for WRC than that of wheat flour. This can be explained by the smaller size of particles in additives (Table 2) and the peculiarities of the protein-poly-saccharide composition of the examined samples. Specifically, flour is represented to 70 % by starch, about 78 % of which are amylopectin. Compared with amylose, amylopectin is characterized by better hydrophilic properties due to the high susceptibility to hydrogen bond formation owing to the high molecular mass and branched structure. However, amylopec-
tin is inside a starch grain and can go beyond it only after a
destruction of the shell of the grain that occurs when a
temperature is above 60 °C (for wheat starch), which explains
a substantial increase in WRC of flour in the interval of tem-
perature 60...90 °C. The higher hydrophilic properties of CNM
and WNM at a temperature of 20 °C are predetermined by the
presence in their composition of a significant amount of food fiber
(18.79 and 10.99 %, respectively) and proteins (38.59 and
33.63 %) (Table 1). Even though the content of these biopoly-
mers is higher in CNM, it is slightly inferior in WNM in terms of
its capacity to retain water. This can be explained by the qual-
itative composition of hydrocolloids. Specifically, proteins
in CNM contain a significant amount of albumin and globulin
fractions (their total content is 13.77 g/100 g of meal, and for
WNM – 3.91 g/100 g of meal). In addition, even though the examined meals contain the same amount of starch (Table 1),
the starch in CNM is represented by amylose (the ratio amy-
lose:amylopectin is 11.76:4.08) while the starch in WNM – by
amylopectin (the ratio amylose:amylopectin is 1.03:14.42).
In addition, the examined supplements differ in the composi-
tion of food fiber – CNM contains a significant amount of wan-
ter-soluble hemicellulose and pectins (12.65 and 5.2 % against
5.16 and 3.95 % in WNM). As a result, the soluble nutritional
substances (albumins, globulins, amylose, hemicellulose, and
pectin), when dissolving in a liquid, increase its relative viscos-
ity and inhibit the swelling of insoluble polysaccharides, namely
cellulose. It is known that cellulose contains a large number of
hydroxyl groups and is characterized by a well-developed sys-
tem of thin sub-microscopic capillaries, which predetermines
its high water-retaining properties [33]. Given the fact that
the content of cellulose in WNM is 2 times higher than that in
CNM, it shows a higher water-retaining capacity.

At a temperature of 45 °C, there occurs the active swelling
of food fiber and starch grains, which causes an increase in
the WRC indicator in the examined samples. Since wheat
flour contains considerably more starch than the examined
additives, it is characterized by an intense increase in the val-
ues for a WAC indicator in a given temperature range. When
heated to 60 and 75 °C, there occurs the denaturation of pro-
teins the result being that the value of WRC for CNM almost
does not change, while decreasing for WNM. This may be
associated with a deeper denaturation of proteins in WNM.
One can also assume that the starch grains of nut meals are
smaller than the grains of wheat starch. As a result, they ge-
latinize at higher temperatures, consequently an indicator for
WRC of meals increases only at a temperature of 90 °C.

Our study into the fat-emulsifying capacity of examined
supplements (Fig. 2) has shown that they are better at emul-
sifying a liquid oil than solid fats that are traditionally used in
the technology of butter biscuits (margarine and butter). This
can be explained by the fact that margarine and butter are
essentially the emulsions in which the emulsifiers are their own
protein substances. The stabilizing effect of emulsifiers is pre-
determined by that their molecules contain the hydrophilic and
hydrophobic functional groups that are appropriately oriented
at the interphase boundary and reduce the surface tension. In
this case, hydrophilic substances bind part of the disperse me-
dium and form a protective solvate sheath around a fat drop. It
can be assumed that in the case when the examined nut meals
are introduced to the emulsion, the number of emulsifiers in
the system significantly increases. As a result, the second layer
of stabilizer’s molecules forms at the surface of fat droplets, its
functional groups are oriented in the opposite way. This fact
causes a decrease in the stability of the system [34].

The high fat-retention capacity of nut meals (Fig. 3) is
predetermined by their finely-disperse state, which ensures
the high availability of hydrophobic groups. In addition, food fiber and protein substances in additives have a porous
structure. This makes it possible to physically bind and re-
tain free fat. An improvement in the supplements’ FRC in
the case of their warming at a temperature of 40 and 60 °C
can be explained by the thermal denaturation of proteins. As
a result, the conformation of its molecule changes with free-
ning the hydrophobic sections that were previously grouped
within the molecule. A decrease in FRC for nut meals at
heating from 100 to 140 °C can be predetermined by the
destruction of protein molecules. One can also assume that
this is accompanied by interactions between proteins and
other components. Consequently, there is the formation of
protein-carbohydrate and protein-lipid complexes, accompa-
nied by a general decrease in the functional groups within a
protein molecule.

The positive effect of nut meals on the stability (Fig. 4) and
dispersity (Table 3, Fig. 5, 6) of emulsion for butter
biscuits in which 30 % of margarine is replaced with a liquid
oil is explained by their high water-retaining properties and
good fat-retention and fat-emulsifying capacities in relation to
liquid oils. In addition, it is known that highly-disperse
powders can act as solid emulsifiers. In this case, the powder
particles are wetted by different places at the surface by the
respective phase of the emulsion, they concentrate at the
boundary surface and protect fat drops from coalescence by
the so-called armored shells [34].

Evaluation of viscous properties of the examined samples
(Table 4, Fig. 7) has shown that the replacement of 30 % of
margarine in the emulsion with a liquid oil leads to a signif-
icient decrease in its effective viscosity. The introduction of
nut meals to such an emulsion causes an increase in a coef-
ficient of consistency. A zone of the avalanche destruction
of structure in the samples with meals at the same shear
rate occurs at larger values for shear rate than in the sample
with a liquid oil. The resulting effect can be explained by the
presence in the composition of additives of food fiber, which
correlates with the results by other researchers [35 – 37] It
was noted that WNM, when compared with CNM, slows
down the rate of structure destruction of the emulsion with a
liquid oil to a larger degree. This confirms the results of ear-
er study into the stability of emulsions and it is explained
by peculiarities in the composition of biopolymers in addi-
tives. Thus, the use of nut meals (CNM, WNM) improves
the viscosity of emulsion for butter biscuits with liquid oils
and makes it more resistant to destruction.

It is noted that an increase in the concentration of nut
meals to 50 % led to that the values for effective viscosity
exceeded the permissible measurement range. This indicates
that due to the swelling of hydrocolloids in additional raw
materials there occurred an excessive compaction of the
emulsion. From the technological point of view, such a com-
paction will make it impossible to obtain the structure char-
acteristic of butter biscuits. That is, one can recommend, in
order to improve the properties of the emulsion for butter
biscuits with liquid oils, that up to 40 % of the cedar nut or
walnut meal should be introduced.

The results obtained suggest the feasibility of using up to
40 % of nut meals for improving the characteristics of emul-
sion for butter biscuits with liquid oils. However, the quality
of butter biscuits depends largely on the quality of dough.
That is, it is a promising task to further study the influence
of nut meals on the characteristics of dough for butter biscuits with liquid oils and on the quality of baked products.

7. Conclusions

1. Our study into the functional and technological properties of nut meals has revealed the following. In terms of the size of particles, the examined meals are the highly-disperse powders with a greater degree of dispersity than wheat flour. The size of 69% of CNM is up to 40 μm, 72% of WNM, and only 35% of flour. It was established that the supplements are characterized by high water-retaining and fat-retention capacity. It was noted that nut meals are better at emulsifying a liquid oil than solid fats that are traditionally used in the technology of butter biscuits (margarine and butter).

2. We have established the positive effect of nut meals on the quality of emulsion for butter biscuits with the replacement of 30% of margarine with a liquid oil. It was noted that the samples of emulsion with the addition of 40 and 50% of nut meals in terms of the value for an indicator of stability are maximally close to the margarine-based control sample. This fact correlates with the results from studying the dispersity, effective viscosity of emulsions, and the results from microscopy. It is noted that at an increase in the concentration of nut meals to 50%, due to the swelling of hydrocolloids in additives, there is an excessive compaction of the emulsion. From the technological point of view, such a compaction will not make it possible to obtain the structure characteristic of butter biscuits.

References


