



UDC 663.86.054.1

## Development of craft drinks with oat milk and fruit and berry powders

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**Abstract.** Consumption of plant-based milk is growing every year, especially among allergy sufferers and lactose intolerant people. The development of beverages based on it with the addition of nutrients and improved taste properties is a trend among soft drink manufacturers. The purpose of the article is to develop recipes for craft drinks with oat milk and powders from freeze-dried fruits and berries, as well as to determine their sensory and physicochemical characteristics. The research was conducted using the method of expert evaluation of the sensory characteristics of drink compositions, the calculation method for calculating the nutritional and energy value of drinks, qualimetry methods for calculating a comprehensive indicator of drink quality, methods for determining the physicochemical characteristics of drinks, the Color Detector & Catcher mobile application for determining the colour of drinks using the RGB additive colour model, and methods of statistical data processing using Mathcad 14 software. For drinks based on plant-based milk, it is proposed to use powders from freeze-dried fruits and berries as a recipe components. Freeze-dried plant powders preserve the colour, smell and taste of natural raw materials, as well as their nutrients. Model compositions of drinks with oat milk and powders made from freeze-dried mango, blueberries, strawberries, bilberries and raspberries were developed. The best drink compositions with high sensory properties (taste and smell, colour, appearance and consistency) were identified by an expert evaluation method. The density and active acidity of the developed drink compositions were investigated and their nutritional and energy values were calculated. It was found that the density of drinks increases with the increase in the content of fruit and berry powders, and the pH of drinks decreases. It has also been found that an increase in the content of freeze-dried fruit and berry powders in a drink leads to an increase in the content of protein and carbohydrates. Fruit and berry powders fortify drinks with nutrients and diversify their taste and aroma. The proposed drinks can be recommended for implementation in food industry enterprises, craft food production facilities and restaurants

**Keywords:** plant-based milk; drink recipe; drink properties; freeze-dried fruit; freeze-dried berries

### Introduction

The consumption of plant-based milk is increasing globally, driven by its health benefits and the growing number of people with milk protein allergies and lactose intolerance, as well as consumer awareness of the environmental impact of cow's milk production. According to J. Mylan *et al.* (2018), the raw materials for plant-based milk include legumes (soybeans, peanuts, peas, lupins, cowpeas), nuts (almonds, coconut, hazelnuts, pistachios, walnuts, cashews), cereals (oats, rice, corn, spelt), pseudo-cereals (quinoa, teff, amaranth), as well as sesame,

flax, hemp and sunflower seeds. Almond, soy and coconut milk are the market leaders (Craig & Fresán, 2021), but oat milk is becoming increasingly popular in this beverage category, with an average annual sales increase of 131.9%. Oat milk is low in sugar and fat, and contains calcium, potassium, phosphorus, iron, vitamins A, B<sub>12</sub>, and D (Collard & McCormick, 2021). An important area for improving plant-based milk is to improve the sensory properties of these drinks and fortify them with nutrients, which will help increase demand for these products.

### Suggested Citation:

Dudarev, I. (2024). Development of craft drinks with oat milk and fruit and berry powders. *Commodity Bulletin*, 17(1), 105-115. doi: 10.62763/ef/1.2024.105.



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Plant-based milk mimics the physicochemical and sensory properties of animal milk. This product should be safe, healthy, tasty and affordable for consumers (Nawaz *et al.*, 2022). The ingredients of plant-based milk are plant raw materials, water, emulsifiers and other additives (flavours, colours, preservatives, stabilisers, thickeners) that ensure the formation of the required functional properties of the final product. The main technological operations for the production of plant-based milk are soaking and wet grinding or dry grinding and extraction, separation of insoluble substances, product formation (addition of other ingredients), homogenisation, heat treatment, nutrient enrichment and packaging. F. Reyes-Jurado *et al.* (2023) found that vitamins, minerals, sweeteners, flavours, colourants, salt, oil, and stabilisers are added during product formulation. The most common stabilisers are carrageenan, rice starch, gelatin, corn dextrin, xanthan gum, guar gum and tapioca starch. Citric acid is used as an antioxidant in the drinks. To improve and diversify the taste of beverages and fortify them with nutrients, various natural raw materials, mainly of plant origin, are used (Saleba *et al.*, 2020).

A promising product on the market is a powder made from freeze-dried fruits, berries and vegetables that retains the colour, aroma and taste of fresh raw materials (Liu *et al.*, 2022). Freeze drying is the preferred method of drying foods containing compounds

that are temperature-sensitive and prone to oxidation, as it takes place at low temperatures and high vacuum. Therefore, freeze-drying is the best way to dehydrate fruits, berries and vegetables in order to maintain an optimised content of bio-compounds in the final product (Fructuoso *et al.*, 2021). Fruits and vegetables in powder form are used in the confectionery, bakery, alcoholic beverage, and other food industries to make a variety of sauces, teas, puddings, natural colours, additives, etc. Freeze-dried fruit powders fortify foods with nutrients and improve flavour and aroma properties and colour. It is important to enrich drinks based on plant-based milk with nutrients and to give these products new flavours, including fruit and berry flavours. Therefore, the aim of the study was to develop recipes for craft drinks based on oat milk and powders obtained from freeze-dried fruits and berries, and to evaluate their sensory, physicochemical characteristics.

## Materials and methods

The study was conducted at Lutsk National Technical University (Lutsk, Ukraine) in 2023. The developed model compositions (MCs) of drinks (Tables 1-5) containing ultra-pasteurised oat beverage (hereinafter oat milk), powders (Fig. 1) from freeze-dried fruits and berries (mango, bilberry, strawberry, blueberry, raspberry) were studied.



**Figure 1.** Freeze-dried plant powders

**Note:** a – mango (M); b – bilberry (B); c – strawberry (S); d – blueberry (Bl); e – raspberry (R)

**Source:** compiled by the author

**Table 1.** Model drink compositions with oat milk and mango powder

| Recipe component of the drink | The content of components in the model compositions of the drink with oat milk and mango powder, wt. % |        |        |        |
|-------------------------------|--|--------|--------|--------|
|                               | MC1  | MC2(M) | MC3(M) | MC4(M) |
| Oat milk                      | 100.0  | 99.0   | 94.0   | 89.0   |
| Mango powder                  | –  | 1.0    | 6.0    | 11.0   |
| Total                         | 100.0  | 100.0  | 100.0  | 100.0  |

**Source:** compiled by the author

**Table 2.** Model drink compositions with oat milk and bilberry powder

| Recipe component of the drink | The content of components in the model compositions of the drink with oat milk and bilberry powder, wt. % |        |        |        |
|-------------------------------|---|--------|--------|--------|
|                               | MC1   | MC2(B) | MC3(B) | MC4(B) |
| Oat milk                      | 100.0   | 99.0   | 94.0   | 89.0   |
| Bilberry powder               | –   | 1.0    | 6.0    | 11.0   |
| Total                         | 100.0   | 100.0  | 100.0  | 100.0  |

**Source:** compiled by the author

**Table 3.** Model drink compositions with oat milk and strawberry powder

| Recipe component of the drink | The content of components in the model compositions of the drink with oat milk and strawberry powder, wt. % |        |        |        |
|-------------------------------|---|--------|--------|--------|
|                               | MC1   | MC2(S) | MC3(S) | MC4(S) |
| Oat milk                      | 100.0   | 99.0   | 94.0   | 89.0   |
| Strawberry powder             | –   | 1.0    | 6.0    | 11.0   |
| Total                         | 100.0   | 100.0  | 100.0  | 100.0  |

Source: compiled by the author

**Table 4.** Model drink compositions with oat milk and blueberry powder

| Recipe component of the drink | The content of components in the model compositions of the drink with oat milk and blueberry powder, wt. % |         |         |         |
|-------------------------------|--|---------|---------|---------|
|                               | MC1  | MC2(BI) | MC3(BI) | MC4(BI) |
| Oat milk                      | 100.0  | 99.0    | 94.0    | 89.0    |
| Blueberry powder              | –  | 1.0     | 6.0     | 11.0    |
| Total                         | 100.0  | 100.0   | 100.0   | 100.0   |

Source: compiled by the author

**Table 5.** Model drink compositions with oat milk and raspberry powder

| Recipe component of the drink | The content of components in the model compositions of the drink with oat milk and raspberry powder, wt. % |        |        |        |
|-------------------------------|--|--------|--------|--------|
|                               | MC1  | MC2(R) | MC3(R) | MC4(R) |
| Oat milk                      | 100.0  | 99.0   | 94.0   | 89.0   |
| Raspberry powder              | –  | 1.0    | 6.0    | 11.0   |
| Total                         | 100.0  | 100.0  | 100.0  | 100.0  |

Source: compiled by the author

Characteristics of the nutritional value and calorie content of the components of the drink compositions are presented in Table 6. The recipe components of the drink compositions were purchased at a local supermarket (Lutsk, Ukraine).

**Table 6.** Nutrient content and calorie content of drink composition components

| Component of drink compositions | Nutrient content and calorie content of drink composition components (per 100 g of component)* |        |                  |                       |
|---------------------------------|--|--------|------------------|-----------------------|
|                                 | Protein, g   | Fat, g | Carbohydrates, g | Calorie content, kcal |
| Oat milk                        | 1.0  | 2.5    | 6.5              | 52.5                  |
| Mango powder                    | 4.7  | 2.2    | 86.0             | 382.0                 |
| Bilberry powder                 | 7.7  | 2.1    | 87.0             | 398.0                 |
| Strawberry powder               | 4.9  | 2.5    | 84.9             | 381.0                 |
| Blueberry powder                | 8.1  | 0.8    | 56.4             | 265.0                 |
| Raspberry powder                | 8.0  | 4.3    | 79.6             | 389.0                 |

Note: \*according to manufacturers

Source: developed by the author

Manufacturers of components of drink compositions:

- oat milk (ultra-pasteurized oat beverage fortified with calcium) – produced by Lustdorf LLC, Illintsi, Vinnytsia region, Ukraine;
- freeze-dried mango, bilberry and blueberry powders – produced by Gulfrost LLC, Byshkiv, Lviv region, Ukraine;
- freeze-dried strawberry and raspberry powders – produced by Ledova LLC, Chornomorsk, Odesa region, Ukraine.

Drink compositions were prepared by mixing oat milk with powders from freeze-dried fruits and berries according to the recipe. The sensory properties (taste and smell, colour, appearance, consistency) of the drink compositions were evaluated by experts according to the methodology (Lawless & Heymann, 2010;

Pudovkin, 2021) on a five-point scale. The study was conducted in accordance with the standards set out in the Declaration of Helsinki (1979). The weighting coefficients of these indicators were also calculated based on the results of the expert survey. Statistical processing of the survey results was performed using Mathcad 14 software, which was used to build sensory profiles of drink compositions. In addition to scoring the sensory properties of drink compositions, experts gave their verbal description. The colour of the drink compositions was determined using the camera of the Xiaomi Redmi Note 8 Pro smartphone (China) and the Color Detector & Catcher mobile application, using the RGB additive colour model. Oat milk (MC1) was chosen as the control variant.

The quality indicator of the of drink compositions was calculated by Equation:

$$Q = \frac{m_1 P_1}{P_{b1}} + \frac{m_2 P_2}{P_{b2}} + \frac{m_3 P_3}{P_{b3}} + \frac{m_4 P_4}{P_{b4}}, \quad (1)$$

where  $m_1, m_2, m_3, m_4$  – weighting coefficients of drink sensory indicators, respectively, taste and smell, colour, appearance and consistency;  $P_1, P_2, P_3, P_4$  – sensory indicators of the drink, respectively, taste and smell, colour, appearance and consistency;  $P_{b1}, P_{b2}, P_{b3}, P_{b4}$  – basic values of sensory indicators of the drink, respectively, taste and smell, colour, appearance and consistency (5 points).

The nutritional value and calorie content of model compositions of drinks was calculated by Equation:

$$P = \sum_{i=1}^n \frac{a_i m_{pi}}{100} \quad F = \sum_{i=1}^n \frac{a_i m_{fi}}{100} \quad C = \sum_{i=1}^n \frac{a_i m_{ci}}{100}, \quad (2)$$

$$E = 4 \cdot P + 9 \cdot F + 4 \cdot C, \quad (3)$$

where  $P, F, C$  – the content of protein, fat and carbohydrates per 100 g of soft drink, g;  $a_i$  – the content of the  $i$ -th recipe component per 100 g of soft drink, %;  $m_{pi}, m_{fi}, m_{ci}$  – the weight, respectively, of protein, fat and carbohydrates per 100 g of the  $i$ -th recipe component, g; 4, 9, 4 – the calorie content of 1 g, respectively, of protein, fat and carbohydrates (Capuano *et al.*, 2018), kcal g<sup>-1</sup>;

$n$  – the number of components of the drink composition;  $E$  – the calorie content of 100 g of the soft drink, kcal.

The density of drink compositions with oat milk and freeze-dried plant powders was determined by the pycnometric method (Yohannes *et al.*, 2013). The active acidity of the developed drink compositions was determined using a pH-meter (Yohannes *et al.*, 2013). The statistical processing of the study results involved determining the arithmetic mean and standard deviation using Mathcad 14 software.

## Results and discussion

The results of the expert verbal characterization of the developed model drink compositions with oat milk and freeze-dried fruit and berry powders are presented in Tables 7-11. The developed drink compositions with a weight content of fruit and berry powders of 1% have a liquid consistency and the appearance of an opaque homogeneous liquid. Drink compositions with a weight content of freeze-dried plant powders of 6% and 11% have, respectively, a liquid sour cream-like and sour cream-like consistency and an appearance of an opaque homogeneous mass.

**Table 7.** Sensory characteristics of model compositions of drink with oat milk and mango powder

| Sensory characteristics | Characteristics of indicators for drink compositions |                               |  |  |
|-------------------------|--|-------------------------------|--|--|
|                         | MC1  | MC2(M)                        | MC3(M)   | MC4(M)   |
| Taste and smell         | pleasant oat taste; oat aroma                        | pleasant oat taste; oat aroma | sweet-sour taste, oat-mango flavour; oat aroma | sweet-sour taste, oat-mango flavour; oat aroma |
| Colour                  | RGB (243, 239, 231)                                  | RGB (238, 225, 200)           | RGB (245, 218, 161)                            | RGB (236, 205, 127)                            |
| Consistency             | liquid   | liquid                        | liquid sour cream-like                         | sour cream-like                                |
| Appearance              | opaque, homogeneous liquid                           | opaque, homogeneous liquid    | opaque, homogeneous mass                       | opaque, homogeneous mass                       |

Source: developed by the author

**Table 8.** Sensory characteristics of model compositions of a drink with oat milk and bilberry powder

| Sensory characteristics | Characteristics of indicators for drink compositions |                               |  |   |
|-------------------------|--|-------------------------------|--|---|
|                         | MC1  | MC2(B)                        | MC3(B)   | MC4(B)  |
| Taste and smell         | pleasant oat taste; oat aroma                        | pleasant oat taste; oat aroma | less sour taste, oat and bilberry flavour; oat aroma | sour taste, oat and bilberry flavour; oat aroma |
| Colour                  | RGB (243, 239, 231)                                  | RGB (187, 149, 135)           | RGB (68, 22, 22)                                     | RGB (29, 16, 16)                                |
| Consistency             | liquid   | liquid                        | liquid sour cream-like                               | sour cream-like                                 |
| Appearance              | opaque, homogeneous liquid                           | opaque, homogeneous liquid    | opaque, homogeneous liquid                           | opaque, homogeneous liquid                      |

Source: developed by the author

**Table 9.** Sensory characteristics of model compositions of a drink with oat milk and strawberry powder

| Sensory characteristics | Characteristics of indicators for drink compositions |                               |   |   |
|-------------------------|--|-------------------------------|---|---|
|                         | MC1  | MC2(S)                        | MC3(S)  | MC4(S)  |
| Taste and smell         | pleasant oat taste; oat aroma                        | pleasant oat taste; oat aroma | sour oat and strawberry flavour; oat and strawberry aroma | sour strawberry taste; oat and strawberry aroma |
| Colour                  | RGB (243, 239, 231)                                  | RGB (233, 211, 209)           | RGB (212, 100, 100)                                       | RGB (140, 24, 28)                               |
| Consistency             | liquid   | liquid                        | liquid sour cream-like                                    | sour cream-like                                 |
| Appearance              | opaque, homogeneous liquid                           | opaque, homogeneous liquid    | opaque, homogeneous liquid                                | opaque, homogeneous liquid                      |

Source: developed by the author

**Table 10.** Sensory characteristics of model compositions of a drink with oat milk and blueberry powder

| Sensory characteristics | Characteristics of indicators for drink compositions |                                  |  |  |
|-------------------------|--|----------------------------------|--|--|
|                         | MC1  | MC2(BI)                          | MC3(BI)                                | MC4(BI)                                |
| Taste and smell         | pleasant oat taste;<br>oat aroma                     | pleasant oat taste;<br>oat aroma | sour berry flavour;<br>light oat aroma | sour berry flavour;<br>light oat aroma |
| Colour                  | RGB<br>(243, 239, 231)                               | RGB<br>(175, 164, 186)           | RGB<br>(94, 56, 100)                   | RGB<br>(61, 39, 58)                    |
| Consistency             | liquid   | liquid                           | liquid sour cream-like                 | sour cream-like                        |
| Appearance              | opaque, homogeneous liquid                           | opaque, homogeneous liquid       | opaque, homogeneous liquid             | opaque, homogeneous liquid             |

Source: developed by the author

**Table 11.** Sensory characteristics of model compositions of a drink with oat milk and raspberry powder

| Sensory characteristics | Characteristics of indicators for drink compositions |   |  |  |
|-------------------------|--|---|--|--|
|                         | MC1  | MC2(R)  | MC3(R)   | MC4(R)   |
| Taste and smell         | pleasant oat taste;<br>oat aroma                     | oat-raspberry taste with<br>sourness; oat aroma | sour raspberry flavour; light<br>oat and raspberry aroma | sour raspberry flavour; light<br>oat and raspberry aroma |
| Colour                  | RGB<br>(243, 239, 231)                               | RGB<br>(240, 224, 224)                          | RGB<br>(231, 163, 172)                                   | RGB<br>(203, 96, 119)                                    |
| Consistency             | liquid   | liquid  | liquid sour cream-like                                   | sour cream-like  |
| Appearance              | opaque, homogeneous liquid                           | opaque, homogeneous liquid                      | opaque, homogeneous mass                                 | opaque, homogeneous mass                                 |

Source: developed by the author

Drink compositions with an increase in the content of fruit and berry powders develop a more intense taste and smell, which is typical of the raw materials used. The taste also becomes more sour, especially for compositions with berry powders. The colour of drink compositions with different fruit and berry powders is shown in Figures 2-6, and its characteristics using the additive RGB colour model are shown in Tables 7-11. The colour of the drinks depends on the colour of the raw material used (fruit or berry powder) and becomes more saturated with an increase in the content of this raw material.

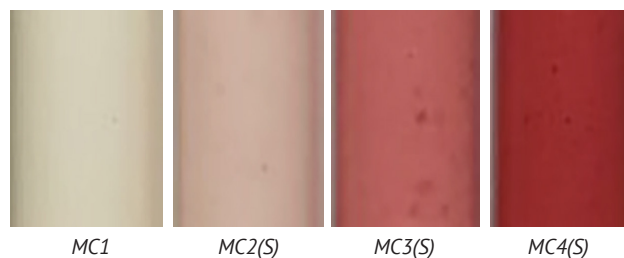


Figure 4. Colour of the drink compositions with oat milk and strawberry powder

Source: developed by the author

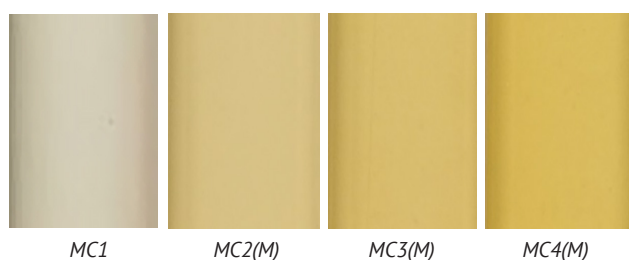


Figure 2. Colour of the drink compositions with oat milk and mango powder

Source: developed by the author

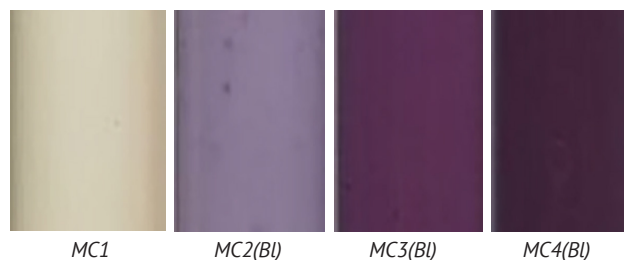


Figure 5. Colour of the drink compositions with oat milk and blueberry powder

Source: developed by the author

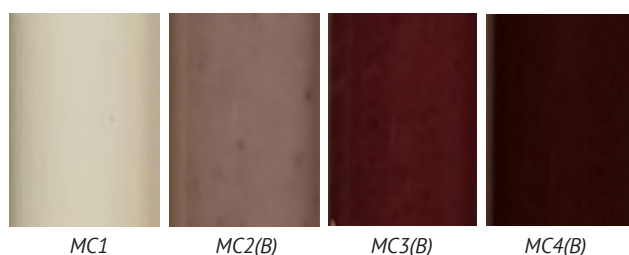


Figure 3. Colour of the drink compositions with oat milk and bilberry powder

Source: developed by the author

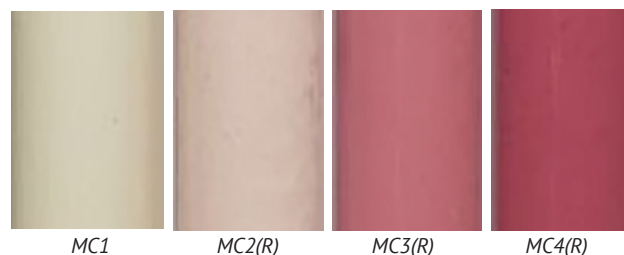
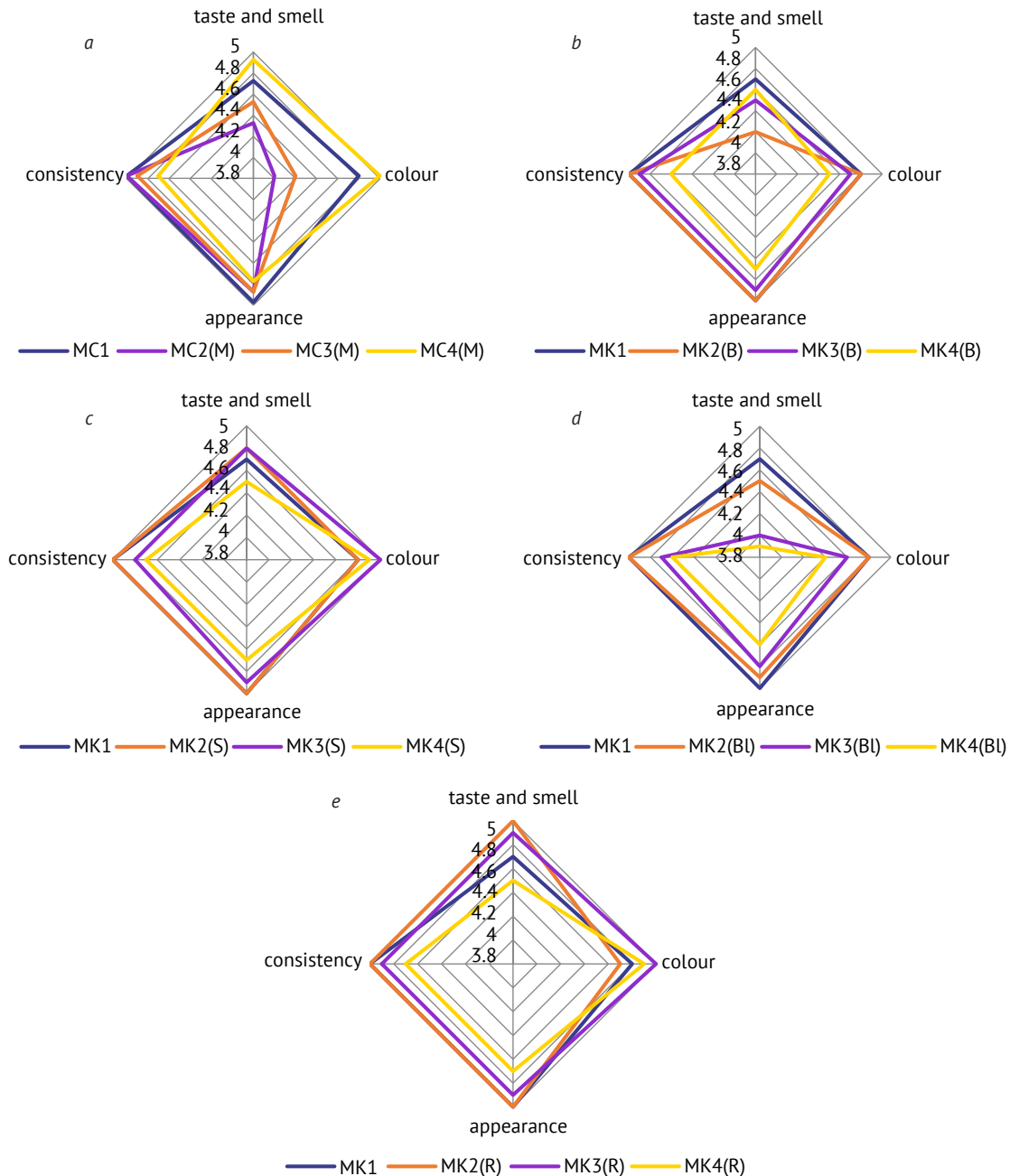


Figure 6. Colour of the drink compositions with oat milk and raspberry powder

Source: developed by the author

Sensory profilograms of drink compositions with oat milk and freeze-dried plant powders are shown in Figure 7. Among the developed drinks with mango powder (Fig. 7a),

composition MC4(M) has the highest scores for taste and smell and colour. Compositions MC2(M) and MC3(M) have the highest scores for appearance and consistency.



**Figure 7.** Sensory profiles of drink compositions with oat milk and freeze-dried plant powders

**Note:** a – mango powder; b – bilberry powder; c – strawberry powder; d – blueberry powder; e – raspberry powder

**Source:** developed by the author

The taste and smell of composition MC4(B) were rated by experts as the highest among drinks with bilberry powder (Fig. 7b). However, the highest scores for colour, appearance and consistency were given to composition MC2(B). Among the compositions of the drink with freeze-dried strawberry powder, the highest scores for all sensory indicators (Fig. 7c), except for colour,

were obtained by composition MC2(S), and for colour – by MC3(S). The highest scores for all sensory indicators of drinks with blueberry powder were obtained by composition MC2(BI) (Fig. 7d). Taste and smell, appearance and consistency of composition MC2(R) were rated by experts as the highest among the developed compositions with freeze-dried raspberry powder (Fig. 7d).

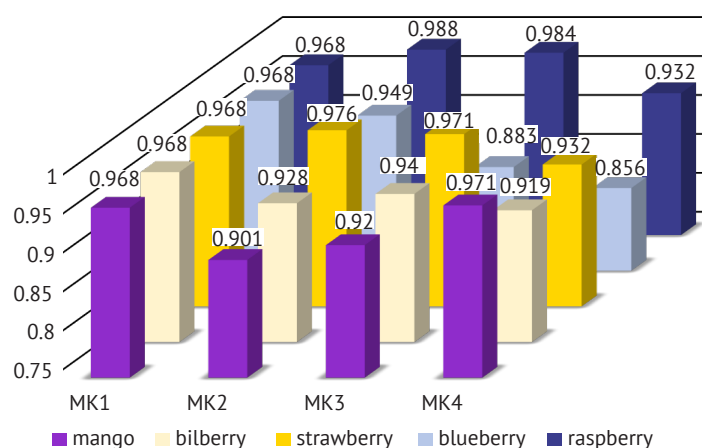
The highest score for the colour indicator was given to composition MC3(R).

Following an expert evaluation of the importance of sensory characteristics for drinks with oat milk and freeze-dried plant powders, sensory indicator weighting coefficients were calculated: taste and smell –  $m_1 = 0.4$ ; colour –  $m_2 = 0.2$ ; appearance –  $m_3 = 0.15$ ; consistency –  $m_4 = 0.25$ . According to experts, the most important indicators of drink quality are taste, smell and consistency.

According to the sensory characteristics of drink compositions, the values of the quality indicator  $Q$  calculated by Equation (1) are shown in Figure 8. The highest values

of the  $Q$  indicator were found in the drink compositions with oat milk and freeze-dried plant powders (Fig. 8):

- among the compositions with mango powder: MC4(M) –  $Q = 0.971$ ;
- among the compositions with bilberry powder: MC3(B) –  $Q = 0.94$ ;
- among the compositions with strawberry powder: MC2(S) –  $Q = 0.976$ ;
- among the compositions with blueberry powder: MC2(BL) –  $Q = 0.949$ ;
- among the compositions with raspberry powder: MC2(R) –  $Q = 0.988$ .



**Figure 8.** Quality indicator  $Q$  for sensory characteristics of drink compositions with oat milk and freeze-dried plant powders

Source: developed by the author

The results of calculating the nutritional value and calorie content of the drink compositions with oat milk and freeze-dried plant powders are presented in Table 12. Regardless of the fruit and berry powders, increasing their content in the drink results in an increase in protein and carbohydrate content compared to the control. The protein content in the drink compositions varies within the following range (per 100 g of drink): with mango or strawberry powder – 1.0-1.4 g; with bilberry powder – 1.1-1.7 g; with blueberry or raspberry powder – 1.1-1.8 g. Thus, by adding fruit and berry powders, the protein content of the drinks increases by up to 80% compared to oat milk. The content of carbohydrates in the drink com-

positions varies within the following ranges (per 100 g of drink): with mango powder – 7.3-15.2 g; with bilberry powder – 7.3-15.4 g; with strawberry powder – 7.3-15.1 g; with blueberry powder – 7.0-12.0 g; with raspberry powder – 7.2-14.5 g. Due to the addition of fruit and berry powders, the content of carbohydrates in the drinks increases by 7.7-136.9% compared to oat milk. There are no significant changes in the fat content of drinks with mango, bilberry and strawberry powder compared to oat milk. In drinks with blueberry powder, compared to the control variant, the fat content with an increase in the powder content within 1-11% decreases from 2.5 to 2.3%, and in drinks with raspberry – increases from 2.5 to 2.7%.

**Table 12.** Nutritional value and calorie content of drink compositions with oat milk and freeze-dried plant powders

| Drink compositions | Nutritional value and calorie content of drink compositions (per 100 g of drink) |        |                  |                       |
|--------------------|--|--------|------------------|-----------------------|
|                    | Protein, g   | Fat, g | Carbohydrates, g | Calorie content, kcal |
| MC1                | 1.0  | 2.5    | 6.5              | 52.5                  |
| MC2(M)             | 1.0  | 2.5    | 7.3              | 54.0                  |
| MC3(M)             | 1.2  | 2.5    | 11.3             | 69.5                  |
| MC4(M)             | 1.4  | 2.5    | 15.2             | 85.0                  |
| MC2(B)             | 1.1  | 2.5    | 7.3              | 54.1                  |
| MC3(B)             | 1.4  | 2.5    | 11.3             | 70.4                  |
| MC4(B)             | 1.7  | 2.5    | 15.4             | 86.6                  |
| MC2(S)             | 1.0  | 2.5    | 7.3              | 54.0                  |
| MC3(S)             | 1.2  | 2.5    | 11.2             | 69.5                  |

Table 12. Continued

| Drink compositions | Nutritional value and calorie content of drink compositions (per 100 g of drink) |        |                  |                       |
|--------------------|--|--------|------------------|-----------------------|
|                    | Protein, g   | Fat, g | Carbohydrates, g | Calorie content, kcal |
| MC4(S)             | 1.4  | 2.5    | 15.1             | 84.9                  |
| MC2(BI)            | 1.1  | 2.5    | 7.0              | 52.9                  |
| MC3(BI)            | 1.4  | 2.4    | 9.5              | 62.9                  |
| MC4(BI)            | 1.8  | 2.3    | 12.0             | 72.9                  |
| MC2(R)             | 1.1  | 2.5    | 7.2              | 54.1                  |
| MC3(R)             | 1.4  | 2.6    | 10.9             | 70.0                  |
| MC4(R)             | 1.8  | 2.7    | 14.5             | 85.9                  |

Source: developed by the author

The calorie content of the developed drink compositions is higher than that of oat milk and ranges from 52.9-86.6 kcal 100 g<sup>-1</sup>, and it increases with the increase in the content of fruit and berry powders.

The results of determining the density and active acidity of the developed drink compositions with oat milk and freeze-dried plant powders are given in Table 13. The density of oat milk is 1031.4 ± 2.3 kg m<sup>-3</sup>. The density of

drinks with an increase in the content of fruit and berry powders within 1-11% increases and varies within the range: for compositions with mango powder – 1033.6-1052.4 kg m<sup>-3</sup>; for compositions with bilberry powder – 1033.9-1054.1 kg m<sup>-3</sup>; for compositions with strawberry powder – 1033.8-1052.8 kg m<sup>-3</sup>; for compositions with blueberry powder – 1032.9-1044.1 kg m<sup>-3</sup>; for compositions with raspberry powder – 1033.7-1048.5 kg m<sup>-3</sup>.

Table 13. Physicochemical characteristics of drink compositions

| Composition indicators                     | Value of the indicators |                |                |                |
|--|-------------------------|----------------|----------------|----------------|
| <b>Compositions with mango powder</b>      | <b>MC1</b>              | <b>MC2(M)</b>  | <b>MC3(M)</b>  | <b>MC4(M)</b>  |
| Density, kg m <sup>-3</sup>                | 1031.4 ± 2.3            | 1033.6 ± 1.8   | 1043.7 ± 2.5   | 1052.4 ± 2.8   |
| Active acidity (pH)                        | 7.1 ± 0.2               | 6.3 ± 0.1      | 5.0 ± 0.0      | 4.5 ± 0.1      |
| <b>Compositions with bilberry powder</b>   | <b>MC1</b>              | <b>MC2(B)</b>  | <b>MC3(B)</b>  | <b>MC4(B)</b>  |
| Density, kg m <sup>-3</sup>                | 1031.4 ± 2.3            | 1033.9 ± 1.6   | 1044.5 ± 2.9   | 1054.1 ± 2.5   |
| Active acidity (pH)                        | 7.1 ± 0.2               | 5.6 ± 0.0      | 4.0 ± 0.1      | 3.6 ± 0.0      |
| <b>Compositions with strawberry powder</b> | <b>MC1</b>              | <b>MC2(S)</b>  | <b>MC3(S)</b>  | <b>MC4(S)</b>  |
| Density, kg m <sup>-3</sup>                | 1031.4 ± 2.3            | 1033.8 ± 2.0   | 1043.9 ± 2.4   | 1052.8 ± 2.1   |
| Active acidity (pH)                        | 7.1 ± 0.2               | 5.4 ± 0.1      | 4.0 ± 0.0      | 3.6 ± 0.0      |
| <b>Compositions with blueberry powder</b>  | <b>MC1</b>              | <b>MC2(BI)</b> | <b>MC3(BI)</b> | <b>MC4(BI)</b> |
| Density, kg m <sup>-3</sup>                | 1031.4 ± 2.3            | 1032.9 ± 2.3   | 1038.4 ± 2.0   | 1044.1 ± 1.9   |
| Active acidity (pH)                        | 7.1 ± 0.2               | 5.2 ± 0.0      | 3.8 ± 0.0      | 3.4 ± 0.0      |
| <b>Compositions with raspberry powder</b>  | <b>MC1</b>              | <b>MC2(R)</b>  | <b>MC3(R)</b>  | <b>MC4(R)</b>  |
| Density, kg m <sup>-3</sup>                | 1031.4 ± 2.3            | 1033.7 ± 2.1   | 1040.2 ± 2.5   | 1048.5 ± 1.4   |
| Active acidity (pH)                        | 7.1 ± 0.2               | 5.0 ± 0.1      | 3.5 ± 0.0      | 3.3 ± 0.0      |

Source: developed by the author

The active acidity (pH) of oat milk is 7.1 ± 0.2. With an increase in the content of fruit and berry powders in the drink compositions, the pH of the drinks decreases. In particular, with the content of fruit and berry powders in the range from 1% to 11%, the pH of the drink compositions fluctuates: for compositions with mango powder – from 6.3 ± 0.1 to 4.5 ± 0.1; for compositions with bilberry powder – from 5.6 ± 0.0 to 3.6 ± 0.0; for compositions with strawberry powder – from 5.4 ± 0.1 to 3.6 ± 0.0; for compositions with blueberry powder – from 5.2 ± 0.0 to 3.4 ± 0.0; for compositions with raspberry powder – from 5.0 ± 0.1 to 3.3 ± 0.0.

Many scientists have conducted similar studies. For example, D.J. McClements *et al.* (2020) examined the scientific aspects of formulating the composition, production technology and quality assurance of milk

substitutes. Understanding the scientific principles of the development and production of plant-based milk products is important for increasing their usefulness and acceptance by consumers in the soft drinks market. A.R.A. Silva *et al.* (2020) found that alternatives to milk can have benefits, such as lower saturated fat and cholesterol, and supply of essential nutrients such as calcium and vitamin D. However, they can also pose challenges related to allergens and additives. From a technological point of view, the development and production of plant-based alternatives to milk requires careful selection of raw materials and processing methods to achieve the desired taste, texture and stability, making this an active area of research and development in the food industry. A. Sousa & K.A.K. Bolanz (2017) state that the composition of plant milk varies depending on

the raw material in terms of macro- and microelements, the presence of biologically active compounds and anti-nutrients. Plant-based beverages contain bioactive substances, in particular, soy-based beverages contain isoflavones and phytosterols, almond-based beverages contain  $\alpha$ -tocopherol and arabinose, and oat-based beverages contain  $\beta$ -glucan (Karam *et al.*, 2016; Fructuoso *et al.*, 2021). Fortification of drinks can cause significant changes in their physicochemical properties and affect the taste of the product, as noted by A. Angelov *et al.* (2018), E. Vasquez-Orejarena *et al.* (2018). Therefore, it is important that the sensory properties of plant-based milk are acceptable to consumers, as this affects the success of the product on the market (Gorman *et al.*, 2021).

In the scientific study by C. Alsado *et al.* (2023), it was proposed to fortify oat milk with  $\beta$ -glucan (6.25 g L<sup>-1</sup>). Soluble fibre in the form of  $\beta$ -glucans reduces LDL cholesterol (low-density lipoprotein), in particular, consumption of 750 ml of oat milk with a  $\beta$ -glucan content of 0.5 g 100 g<sup>-1</sup> per day reduces LDL cholesterol (Chalupa-Krebzdak *et al.*, 2018).

In the scientific study by H. Zhou *et al.* (2021), it was proposed to fortify almond milk with calcium and vitamin D, the lack of which in the human body can cause long-term health problems. Almond milk contains 6.33 mg 100 g<sup>-1</sup> of vitamin E, which is 42% of the recommended daily dose of 15 mg. Hemp milk contains  $\alpha$ -linoleic acid 0.4 g 100 mL<sup>-1</sup>, which is 25% of the recommended daily dose of 1.6 g.

At the same time, the plant raw materials used for the production of plant-based milk have disadvantages. S. Chalupa-Krebzdak *et al.* (2018) proved that, in particular, cereals and legumes contain phytic acid, which is considered an anti-nutrient due to its ability to combine with macro- and microelements (calcium, zinc, iron, magnesium and copper) to create insoluble complexes of these minerals that prevent their absorption in the intestine. Soybeans, almonds, cashews and other nuts contain oxalates, which not only interfere with calcium absorption but also act as a component in the formation of calcium stones in the kidneys. Soybeans, peanuts and other beans contain lectins that inhibit the absorption of glucose in the intestine. Soybeans, oats, peas and beans also contain saponins, which affect the digestion of proteins by creating insoluble saponin-protein complexes.

Scientists A. Drewnowski *et al.* (2021) proposed requirements (standard) for the nutrient content of plant-based beverages (per 100 g), which are positioned as an alternative to traditional milk: protein – more than 2.2 g; saturated fat – less than 0.75 g; added sugar – less than 5.3-6.25 g; sodium – less than 120 mg; calcium, vitamins A, D, B<sub>2</sub> and B<sub>12</sub> – in a 200 g serving, more than 15% of the daily requirement; calorie content – less than 85-100 kcal.

As a result of the current study, model compositions of drinks with high sensory characteristics, including taste, smell, colour, appearance and consistency, were

developed. The physicochemical properties of these drinks were also investigated and it was found that the use of powders from freeze-dried fruits and berries enriches the drinks with useful substances and makes them more diverse in taste and aroma. The results of the study indicate the potential of the proposed drinks for implementation in the food industry, craft production and restaurant business.

## Conclusions

Using freeze-dried fruit and berry powders to make oat milk-based drinks is promising, because these drinks are fortified with nutrients. Freeze-dried fruit and berries, particularly in powder form, retain macro- and microelements and vitamins contained in fresh fruit and berries without significant loss. Plant powders also preserve the colour, taste and aroma of fresh fruit and berries. The use of powders in drinks helps to expand the range of non-alcoholic drinks that are plant-based alternatives to milk for vegans and consumers who are allergic to milk protein and lactose intolerant or who do not consume animal-based beverages for other ethical or environmental reasons. Among the developed and studied craft drink compositions, the following are recommended for implementation, which have the highest values of the quality indicator: composition: oat milk – 89 wt.%, mango powder – 11 wt.%; composition: oat milk – 94 wt.%, bilberry powder – 6 wt.%; composition: oat milk – 99 wt.%, strawberry powder – 1 wt.%; composition: oat milk – 99 wt.%, blueberry powder – 1 wt.%; composition: oat milk – 99 wt.%, raspberry powder – 1 wt.%. The density of the recommended drinks with oat milk and fruit and berry powders ranges from 1032.9 to 1052.4 kg m<sup>-3</sup>. The active acidity (pH) of the recommended drinks ranges from 4.0 to 5.4. The addition of fruit and berry powders to oat milk increases the content of protein and carbohydrates in the drinks. The calorie content of the proposed drinks ranges from 52.9-85.0 kcal 100 g<sup>-1</sup>. The developed drinks with freeze-dried strawberry, blueberry and raspberry powder have a liquid consistency, and the drinks with freeze-dried mango and bilberry powder have a creamy consistency, which makes them similar to smoothies. The colour of the developed craft drinks corresponds to the fruit and berry raw materials used, and its intensity depends on the content of these raw materials.

Further research should be directed towards the development of drinks with different combinations of powders from freeze-dried berries, fruits and vegetables, as well as using different plant-based milk.

## Conflict of interest

None.

## Acknowledgements

None.

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## Розроблення крафтових напоїв з «вівсяним молоком» та фруктово-ягідними порошками

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**Анотація.** Споживання «рослинного молока» зростає щороку, особливо серед алергіків та осіб з непереносимістю лактози. Розробка напоїв на його основі із додаванням корисних речовин та поліпшенням смакових властивостей є трендом серед виробників безалкогольних напоїв. Мета статті – розроблення рецептур крафтових напоїв з «вівсяним молоком» та порошками із сублімованих фруктів і ягід, а також визначення їх органолептичних і фізико-хімічних показників. Дослідження проводили, застосовуючи метод експертного оцінювання органолептичних показників композицій напоїв, розрахунковий метод обчислення поживної та енергетичної цінності напоїв, методи кваліметрії для обчислення комплексного показника якості напоїв, методи визначення фізико-хімічних показників напоїв, мобільний застосунок Color Detector & Catcher для визначення кольору напоїв із використанням адитивної колірної моделі RGB, методи статистичного оброблення даних із використанням комп'ютерного програмного забезпечення Mathcad 14. Для напоїв на основі «рослинного молока» запропоновано в якості рецептурного компонента використовувати порошки із сублімованих фруктів і ягід, спосіб виробництва яких дозволяє зберегти колір, аромат та смак натуральної сировини, а також її корисні речовини. Розроблені модельні композиції напоїв з «вівсяним молоком» та порошками із сублімованих манго, чорниці, полуниці, лохини та малини. Експертне оцінювання дозволило визначити кращі композиції напоїв, що мають високі органолептичні властивості (смак і запах, колір, зовнішній вигляд та консистенцію). Досліджені густина та активна кислотність розроблених композицій напоїв та обчислена їх поживна і енергетична цінність. Встановлено, що густина напоїв зі збільшенням вмісту фруктово-ягідних порошків збільшується, а показник рН напоїв – зменшується. Також встановлено, що збільшення вмісту в напої порошків із сублімованих фруктів і ягід спричиняє збільшення у ньому вмісту білків та вуглеводів. Використання фруктово-ягідної сировини в рецептурі напоїв дозволяє збагатити їх корисними речовинами та урізноманітнити смак і аромат. Запропоновані напої можуть бути рекомендовані до впровадження на підприємствах харчової промисловості, на крафтових виробництвах харчових продуктів та у закладах ресторанного господарства

**Ключові слова:** рослинне молоко; рецептура напою; властивості напою; сублімовані фрукти; сублімовані ягоди