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INFLUENCE OF PLANT-BASED INGREDIENTS ON THE SENSORY AND PHYSICOCHEMICAL INDICATORS OF SALAD DRESSINGS

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ABSTRACT

A healthy lifestyle and consumption of healthy food is becoming widespread. Scientists and manufacturers pay attention to the development of innovative low-calorie food from plant-based raw materials with low fat content. Mayonnaise, which is a high-fat and high-calorie food, is the most popular salad dressing. Recipe development for mayonnaise analogues, which do not contain animal-based ingredients and are also enriched with useful nutrients, is extremely relevant. The purpose of the research is to determine the influence of plant-based ingredients on the sensory and physicochemical indicators of salad dressings and optimize their recipes. The linear programming method was used to optimize the recipes. The methods of sensory analysis and expert method were used to determine sensory properties and quality of the developed salad dressings. The weighting coefficients of the sensory indicators of bean salad dressings were determined. According to experts' opinion, consistency, appearance and taste are the most important sensory indicators of salad dressings. The recipes of salad dressings were optimized by the content of protein, fat and carbohydrates. The developed salad dressings contain common beans, oat milk, freeze-drying fruit and vegetable powders, chicory paste. Plant-based ingredients enriched salad dressings with useful nutrients and provided them with high sensory properties. The developed salad dressings have uniform and thick purée texture, and pleasant taste and aroma. The physicochemical indicators of salad dressings were determined, in particular titratable acidity, fat and moisture content. The developed salad dressings expand the range of products from plant-based raw materials and can be positioned as healthy food. They can be used as low-calorie and low-fat analogues of mayonnaise.

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ВПЛИВ РОСЛИННИХ ІНГРЕДІЄНТІВ НА ОРГАНОЛЕПТИЧНІ ТА ФІЗИКО-ХІМІЧНІ ПОКАЗНИКИ САЛАТНИХ ЗАПРАВОК

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Здоровий спосіб життя та споживання здорової їжі стає все більш поширеним у світі. Вчені та виробники активно працюють над розробленням інноваційних низькокалорійних продуктів харчування з рослинної сировини з низьким вмістом жиру. Найпопулярнішою заправкою для салатів є майонез, що відноситься до висококалорійних продуктів із високим вмістом жиру. Надзвичайно актуальним є напрям розроблення рецептур аналогів майонезу, які не містять сировини тваринного походження та збагачені корисними поживними речовинами.

Метою дослідження є визначення впливу інгредієнтів рослинного походження на сенсорні та фізико-хімічні показники салатних заправок та оптимізація їх рецептур. Для оптимізації рецептур використовувався метод лінійного програмування. Для визначення органолептичних показників та якості розроблених салатних заправок використовували методи сенсорного аналізу та експертний метод. Визначено вагові коефіцієнти органолептичних властивостей салатних заправок із квасолі. На думку експертів, найважливішими органолептичними властивостями салатних заправок є консистенція, зовнішній вигляд та смак. Рецептури салатних заправок були оптимізовані за вмістом білків, жирів і вуглеводів. Розроблені салатні заправки містять квасолю, вівсяне молоко, фруктові та овочеві сублімовані порошки, а також цикорій. Компоненти рослинного походження збагачують заправки для салатів корисними поживними речовинами та забезпечують їх високі органолептичні показники. Розроблені салатні заправки мають однорідну густу консистенцію пюре, приємний смак і аромат. Визначено фізико-хімічні показники розроблених салатних заправок, зокрема кислотність, масова частка жиру та вологи. Розроблені салатні заправки розширюють асортимент продукції з рослинної сировини і можуть позиціонуватися як продукти для здорового харчування. Їх можна використовувати як низькокалорійні і нежирні аналоги майонезу.

Ключові слова: *салатна заправка, квасоля, вівсяне молоко, цикорій, сублімовані рослинні порошки.*

Formulation of the problem. In the food industry, salad dressing products have received growing attention due to increased consumer demand for salads as healthy food (De Melo, de Souza, da Silva Araujo, & Magnani, 2015). The trend of reducing fat content in food products has been increasing in recent years (Tekin-Cakmak, Karasu, Kayacan-Cakmakoglu, &Akman, 2021). Therefore, the food industry is seeking to develop a new reduced-fat and low-cholesterol salad dressings that have attributes similar to full-fat products (Ma, & Boye, 2013). Consumers increasingly pay particular attention to the food with potential health promoting compounds, such as common beans (Nyau, 2014).

Analysis of recent research and publications. Common beans (*Phaseolus vulgaris L.*) are nutritionally and economically important food crop, which are a source of protein (16…33%), dietary fibre (14…19%), lipids (1…3%) and vitamins (thiamine, riboflavin, niacin, vitamin B6, folic acid) (Kutoš, Golob, Kač, &Plestenjak, 2003; Hayat, Ahmad, Masud, Ahmed, &Bashir, 2013; Wainaina et al., 2021). Especially, common beans have a great potentialas resourceof qualitativeproteinsfor human body. Bean seeds also contain minerals including calcium, magnesium, potassium, phosphorus, copper, iron, zinc, manganese and sulfur (Suárez-Martínez et al., 2016). Beans have some bioactive components such as polyphenols, lectins, and carbohydrates, which are related with health benefits (Reynoso-Camacho, Ramos-Gomez, & Loarca-Pina, 2006).

Common beans are always consumed processed. During processing (soaking, cooking, canning), the content of health compounds changes depends on the type of beans, the processing method and its duration (Kutoš, Golob, Kač, & Plestenjak, 2003). Common bean is a traditional low-fat food in the human diet (Gallegos-Infante et al., 2010). Common beans can be included into recipes of products such as soups, meat products, bakery products, purees, extruded snacks, pasta, yogurts and salad dressings (Ma, Boye, Azarnia, & Simpson, 2016). Flour, which is produced from common bean using the different processing methods, is used to prepare bean sauces (Byarugaba, Nabubuya, & Muyonga, 2020). Also common bean flour is added to spaghetti pasta (Gallegos-Infante et al., 2010).

To soften the common beans, which are made up of seed coat and the cotyledon, and reduce the cooking time, several softening techniques including soaking, ultrasound assisted hydration, salts addition, blanching, autoclaving and extrusion are applied (Mba, Kwofie, & Ngadi, 2019). Water soaking is the most widely used technique (Wainaina et al., 2021). Soaking before cooking and discarding the soaking water is an effective way to reduce the amounts of oligosaccharides that cause flatulence (Fernandes, Nishida, & Da Costa Proença, 2010). For soaking, water ratios are varied from 1:1 to 1:5, and soaking durations are ranged from 12 to 16 h (Drulyte, & Orlien, 2019). Soaked beans are cooked (boiled) in water at temperatures 95...100 °C. Cooking beans can take around 1 hours or longer depending on the variety, age, storage history and other quality dependent factors. The cooking process influence on sensory properties of beans such as appearance and texture (Chigwedere et al., 2018). Cooked beans impart excellent aroma to food (Mishra, Tripathi, Gupta, & Variyar, 2017), which is a result of chemical reactions taking place during thermal treatment (Ma et al., 2016).

Soaking and thermal treatment improve protein digestibility of beans from 25...60% (raw beans) to 65...85% (cooked beans) (Rehman, & Shah, 2005; Zamindar, Baghekhandan, Nasirpour, & Sheikhzeinoddin, 2011). Thermal treatment does not effect on copper, iron, sulfur, and zinc concentrations in beans, but it increases calcium, potassium, magnesium, phosphorus concentrations in some bean species (Ferreira, Naozuka, Kelmer, & Oliveira, 2014). Minerals are not destroyed during cooking, but they may leach out into the cooking water during prolonged cooking. To reduce the cooking time, beans are cooked under pressure (Wainaina et al., 2021).

Another plant-based ingredient that is included in the recipe of salad dressings is plant milk. Due to its beneficial properties,oat milkis one of the most popular types of plant milk (Ismail, 2015; Collard, & Mc Cormick, 2021). Oat milk contains minerals such as (mg per 100 g): iron (Fe) 6.4...7.4, calcium (Ca) 84.3...85.6, potassium (K) 669.2...671.6, sodium (Na) 3.11...3.21, phosphorus (P) 672.3...816.32 (Paul, Kumar, Kumar, & Sharma, 2020).

Using fruit and vegetables in the recipe of salad dressings is traditionalas they are essential for a balanced diet (Karam, Petit, Zimmer, Baudelaire Djantou, & Scher, 2016). But they are seasonal products that cannot retain their properties throughout the year. Also, fresh fruit and vegetables contain about 90% water by weight (Gaudel et al., 2022), which leads to their quick spoilage. Therefore, they are processed for preservation. Different techniques are used in food industry to dry fruit and vegetables including solar dryer, microwave heating, infrared irradiation, super-heated steam drying, fluidized drying, flash drying, freeze drying, and vacuum drying (Sagar,& Suresh Kumar, 2010; Salehi, & Aghajanzadeh, 2020). Freeze-drying technology ensurespreservation of the original color, flavor, taste and appearance of fresh food (Liu, Zhang, & Hu, 2022). Freeze-dried plant powders,which are used in the healthy food products,are known as a good source of nutrients. That’s why they are a good alternative to fresh fruit and vegetables (Harnkarnsujarit, & Charoenrein, 2011). For fruit and vegetables, dehydration process helps to preserve their sensory, physical, and chemical properties (Athmaselvi, Kumar, Balasubramanian, & Ishita Roy, 2014). Plant powders are mainly used as ingredients in baby food, sweets, fruit yogurts, soups, cakes, ice cream and confections, to enhance the color, flavor and nutritional value of the products (Saifullah, Yusof, Chin, &Aziz, 2016). For ease of storage and transportation, plant powders are processed into a tablet form (Aziz et al., 2018). Thus, the use of freeze-drying plant powders as ingredients of salad dressings is promising.

Soluble chicory is an innovative low calorie ingredient for salad dressings. Traditionally, chicory roots, leaves, and extracts are used in products such as alcoholic and non-alcoholic beverages as well as a coffee substitute (Schmidt, Ilic, Poulev, & Raskin, 2007). All parts of chicory possess great medicinal importance due to the presence of a number of medicinally important compounds (Abbas et al., 2015). Natural products extracted from chicory are an important source of inulin, vitamins, tannins, carotene, organic acids and minerals (Wang, & Cui, 2011).

Modern trend in the improvement of salad dressings is to reduce their caloric content. Height, weight, age, body composition, and gender influence daily caloric needs of human body (Kerksick, 2019). To achieve optimal nutrition for human body through the intake of healthy foods, population nutrition should be adopted in line with FAO/WHO recommendations. Dietary guidelineis included more than 400 g fruit and vegetables per day and limitation of total fat intake less than 30% of calories (WHO/FAO, 2003; Nehir El, & Simsek, 2011). Also, protein should comprise 10...30% of calories, fat — 25...35% of calories, and carbohydrates — 45...65% of calories (US Department of Health Human Services, 2019; Kwon, Lee, Park, & Lee, 2020). Humans need more than 22 mineral elements; their deficiencies are impairing the human health and productivity (Martínez-Ballesta et al., 2010). The recommended daily intake of mineral elements is as following: calcium (Ca) 800...1300 mg per day; magnesium (Mg) 200...400 mg per day; potassium (K) 3500 mg per day; sodium (Na) 2400 mg per day; phosphorus (P) 800—1300 mg per day; copper (Cu) 1...1.6 mg per day; iron (Fe) 8...18 mg per day; manganese (Mn) 2 mg per day; zinc (Zn) 8...11 mg per day (Martínez-Ballesta et al., 2010).

The purpose of the research is to determine the influence of plant-based ingredients on the sensory and physicochemical indicators of salad dressings and optimize their recipes.

Materials and methods. *Caloric content calculation.* Salad dressing ingredients including common beans (Aromiks Grup, Kyiv, Ukraine), sunflower oil (Dnipro Oil Extraction Plant, Dnipro, Ukraine), oat milk (Loostdorf LLC, Illintsi, Ukraine), vinegar (Lutsk Foods, Lutsk, Ukraine), sugar (Hnidava Sugar Plant, Lutsk, Ukraine), salt (Artemsil, Soledar, Ukraine), mustard seeds (Rivne Product Company, Rivne, Ukraine), dried dill (Spays-Lutsk, Lutsk, Ukraine), freeze-dried blueberry, currant and carrot powders (Galfrost, Zhovkva, Ukraine), and soluble chicory (Slavuta Chicory Drying Plant, Slavuta, Ukraine) were purchased from local supermarkets (Ukraine). In the salad dressing ingredients, the content of protein, fat and carbohydrates was determined according to the manufacturer data (Table 1). For 100 g of each ingredient, the caloric content was calculated by Equation (1):

$$E = k_p P + k_f F + k_c C, \quad (1)$$

where E — ingredient caloric content, kcal; k_p, k_f, k_c — caloric content per 1 g of protein, fat and carbohydrates (k_p = 4 kcal; k_f = 9 kcal; k_c = 3,75 kcal), kcal; P, F, C — content of protein, fat and carbohydrates per 100 g of the ingredient, %.

In Table 1, the calculated caloric content of the salad dressing ingredients is presented.

Table 1. **Nutrients and caloric content per 100 g of the salad dressing ingredients**

Ingredients	Protein (P), %	Fat (F), %	Carbohydrates (C), %	Caloric content (E), kcal	Marking of ingredients
Cooked bean	22.1	2.5	59.9	335.5	x_1
Sunflower oil	0.0	99.9	0.0	899.1	x_2
Oat milk	1.3	0.5	7.0	36.0	x_3
Acetic acid 9%	0.0	0.0	0.0	0.0	x_4
Sugar	0.0	0.0	99.8	374.3	x_5
Salt	0.0	0.0	0.0	0.0	x_6
Mustard (seeds)	25.8	30.8	23.4	468.2	x_7
Dried dill	23.9	5.0	19.3	213.0	x_8
Blueberry powder	7.7	2.1	87.0	376.0	x_9
Currant powder	6.7	1.0	31.7	154.7	x_9
Carrot powder	7.8	0.6	49.2	221.1	x_9
Chicory soluble	4.2	0.0	62.2	250.0	x_9

Recipe optimization method. Five model compositions of salad dressing were developed. The model compositions, which were marked *S*1, *S*2, *S*3, *S*4, and *S*5, contained a specific set of ingredients (Table 2). All model compositions contained cooked common bean, sunflower oil, oat milk, acetic acid solution 9%, sugar, salt, mustard seeds and dried dill. Also, salad dressing *S*2 contained freeze-dried blueberry powder; salad dressing *S*3 contained freeze-dried currant powder; salad dressing *S*4 contained freeze-dried carrot powder; and salad dressing *S*5 contained chicory soluble (paste).

Table 2. **Ingredients of salad dressing model compositions**

Ingredients	Marking of ingredients	Model compositionsof salad dressing				
		*S*1	*S*2	*S*3	*S*4	*S*5
Cooked common bean	x_1	+	+	+	+	+
Sunflower oil	x_2	+	+	+	+	+
Oat milk	x_3	+	+	+	+	+
Acetic acid solution 9%	x_4	+	+	+	+	+
Sugar	x_5	+	+	+	+	+
Salt	x_6	+	+	+	+	+
Mustard (seeds)	x_7	+	+	+	+	+
Dried dill	x_8	+	+	+	+	+
Blueberry powder	x_9	-	+	-	-	-
Currant powder	x_9	-	-	+	-	-
Carrot powder	x_9	-	-	-	+	-
Chicory soluble	x_9	-	-	-	-	+

To optimize the salad dressing recipe, the linear programming method was used (Murota, 2020). The objective function which was desired to minimize was caloric content of the salad dressing samples:

$$z=\frac{\sum_{i=1}^{9} a_i x_i}{100} \to min \; , \qquad (2)$$

wherez — objective function (caloric contentof 100 g ofsalad dressing), kcal; a_1, ..., a_9 — objective function coefficients, which are equal to the caloric content of 100 g of salad dressing (Table 3), kcal; x_1, ..., x_9 — mass of ingredients per 100 g of salad dressing, g.

Table 3. **Objective function coefficients for different model compositions of salad dressings**

Salad dressings	Objective function coefficients								
	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9
*S*1	335.5	899.1	36.0	0.0	374.3	0.0	468.2	213.0	0.0
*S*2	335.5	899.1	36.0	0.0	374.3	0.0	468.2	213.0	376.0
*S*3	335.5	899.1	36.0	0.0	374.3	0.0	468.2	213.0	154.7
*S*4	335.5	899.1	36.0	0.0	374.3	0.0	468.2	213.0	221.1
*S*5	335.5	899.1	36.0	0.0	374.3	0.0	468.2	213.0	250.0

To simplify the mathematical model, such ingredients as freeze-dried powders of blueberry, currant and carrot, and chicory soluble are marked the same x_9. Since only one of these ingredients x_9 can be in the recipe of salad dressings *S*2, *S*3, *S*4 and *S*5.

Optimization mathematical model included restriction conditions. For content of salad dressing ingredients, restriction conditions were formed:

1) total weight of the salad dressing ingredients was 100 g:

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 = 100 \, , \qquad (3)$$

2) content of cooked beans (x_1), sunflower oil (x_2) and oat milk (x_3) could vary within:

$$0 < x_1 < 100,\ 0 < x_2 < 100,\ 0 < x_3 < 100, \quad (4)$$

3) based on spice content in similar salad dressing, content of spices was accepted:

$$x_4 = 0.9,\ x_5 = 0.9,\ x_6 = 0.7,\ x_7 = 0.2,\ x_8 = 0.05, \quad (5)$$

4) content of additives (freeze-dried powders and chicory) did not exceed 2%:

$$0 < x_9 < 2. \quad (6)$$

Taking into account the ratio of protein, fat and carbohydratesin law-fat salad dressingand sauces, the restriction conditions were formed:

1) for protein content:

$$\frac{\sum_{i=1}^{9} p_i x_i}{100} \geq 10;\quad \frac{\sum_{i=1}^{9} p_i x_i}{100} \leq 30; \quad (7)$$

3) for fat content:

$$\frac{\sum_{i=1}^{9} f_i x_i}{100} \geq 20;\quad \frac{\sum_{i=1}^{9} f_i x_i}{100} \leq 35; \quad (8)$$

3) for carbohydrate content:

$$\frac{\sum_{i=1}^{9} c_i x_i}{100} \geq 45;\quad \frac{\sum_{i=1}^{9} c_i x_i}{100} \leq 65, \quad (9)$$

where p_i, f_i, c_i — coefficients, which are equal to the content of protein, fat and carbohydrates in 100 g of salad dressing ingredients (Tables 4—6), %; 10, 30 — restriction on the protein content per 100 g salad dressing, %; 20, 35 — restriction on the fat content per 100 g salad dressing, %; 45, 65 — restriction on the carbohydrate content per 100 g salad dressing, %.

Optimization of salad dressing recipes was carried out according to the mathematical model, which was implemented using Mathcad 14 software.

Table 4. **Coefficients of restriction conditions on protein content**

Salad dressings	Coefficients of restriction conditions on protein content p_i								
	p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9
*S*1	22.1	0.0	1.3	0.0	0.0	0.0	25.8	23.9	0.0
*S*2	22.1	0.0	1.3	0.0	0.0	0.0	25.8	23.9	7.7
*S*3	22.1	0.0	1.3	0.0	0.0	0.0	25.8	23.9	6.7
*S*4	22.1	0.0	1.3	0.0	0.0	0.0	25.8	23.9	7.8
*S*5	22.1	0.0	1.3	0.0	0.0	0.0	25.8	23.9	4.2

Table 5. **Coefficients of restriction conditions on fat content**

Salad dressings	Coefficients of restriction conditions on fat content f_i								
	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9
*S*1	2.5	99.9	0.5	0.0	0.0	0.0	30.8	5.0	0.0

Continuation of table 5

*S*2	2.5	99.9	0.5	0.0	0.0	0.0	30.8	5.0	2.1
*S*3	2.5	99.9	0.5	0.0	0.0	0.0	30.8	5.0	1.0
*S*4	2.5	99.9	0.5	0.0	0.0	0.0	30.8	5.0	0.6
*S*5	2.5	99.9	0.5	0.0	0.0	0.0	30.8	5.0	0.0

Table 6. **Coefficients of restriction conditions on carbohydrate content**

Salad dressings	Coefficients of restriction conditions on carbohydrate content c_i								
	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9
*S*1	59.9	0.0	7.0	0.0	99.8	0.0	23.4	19.3	0.0
*S*2	59.9	0.0	7.0	0.0	99.8	0.0	23.4	19.3	87.0
*S*3	59.9	0.0	7.0	0.0	99.8	0.0	23.4	19.3	31.7
*S*4	59.9	0.0	7.0	0.0	99.8	0.0	23.4	19.3	49.2
*S*5	59.9	0.0	7.0	0.0	99.8	0.0	23.4	19.3	62.2

*Preparation of salad dressing samples.*Common white beans were soaked in filtered water (300 ml of water were added to 100 g of bean seeds) for 10 h at 20 °C the soaked seeds were drained (Kutoš, Golob, Kač, & Plestenjak, 2003). Soaked beans were cooked in fresh filtered water (volume ratio of beans to water being 1:4, boiling water temperature — 98...100 °C) until they became suitable for consumption (approx. 90 min). Cooked beans were drained, and dried on a paper towel. Oat milk was added to the cooked beans and grounded with an electric hand mixer (Braun Minipimer 3 / MultiQuick 3 MQ 3038) to a homogeneous mass (approx. 3 min). Then, recipe ingredients were added to the bean semi-finished product and mixed with a hand mixer for 2 min.

Sensory analysis. The sensoryindicators of the salad dressingsamples such as consistency and appearance, taste, smell and color were determined according to the international standard ISO 13299:2016. Sensory analysis was carried out by seven experts. They evaluated the salad dressing samples using a numerical scale from 1 to 5 (5 points — the quality is excellent; 4 points — the quality is good; 3 points — the quality is satisfactory; 2 points — the quality is poor quality (barely acceptable); 1 point — the quality is very poor).The average value of sensoryindicators was calculated. Sensory profiles of bean salad dressing with plant-based ingredients were created.

Quality assessment method. The quality index of salad dressing samples was determined by an expert method (Pudovkin, 2021). The weighting coefficient of each sensoryindicator of salad dressing samples was calculated.

*Physicochemical indicators of salad dressings measurements***.** Physicochemical indicators of salad dressings, which were prepared according to optimized recipes, were determined. Fat content of salad dressings was determined by the Soxhlet method (Carpenter, 2010). Moisture content and titratable acidity were determined according to AOAC official methods (AOAC, 1995). All experiments were replicated three times.All the statistical analysiswas conducted using the Mathcad 14 software.

Results and discussion. In Table 7, the optimization results of salad dressing recipes are presented. In the salad dressings, cooked commonbeans content,which are plant-based sources of protein, is about 69.7...72.8 wt.%. In Table 8, calculated nutrient and caloric content of salad dressingsare presented. Developed salad dressings are low-calorie foods, as their caloric content is about 411.7…413.7 kcal per 100 g of product. Due to the sunflower oil content of 18.5%, salad dressings are low-fat products.

Table 7. **Optimization results of salad dressing recipes**

Ingredients	Marking of ingredients	Ingredient mass per 100 g of salad dressing, g (or wt.%)				
		*S*1	*S*2	*S*3	*S*4	*S*5
Cooked common bean	x_1	72.8	69.7	71.8	71.2	70.7
Sunflower oil	x_2	18.15	18.15	18.15	18.15	18.15
Oat milk	x_3	6.3	7.4	5.3	5.9	6.4
Acetic acid solution 9%	x_4	0.9	0.9	0.9	0.9	0.9
Sugar	x_5	0.9	0.9	0.9	0.9	0.9
Salt	x_6	0.7	0.7	0.7	0.7	0.7
Mustard (seeds)	x_7	0.2	0.2	0.2	0.2	0.2
Dried dill	x_8	0.05	0.05	0.05	0.05	0.05
Blueberry powder	x_9	-	2.0	-	-	-
Currant powder	x_9	-	-	2.0	-	-
Carrot powder	x_9	-	-	-	2.0	-
Chicory soluble	x_9	-	-	-	-	2.0

Table 8. **Calculated nutrient and caloric content per 100 g of salad dressings**

Salad dressing	Nutrient content per 100 gof salad dressing, % (or wt.%)			Caloric content z_{min}, kcal
	Protein	Fat	Carbohydrates	
*S*1	16.2	20.0	45.0	413.7
*S*2	15.7	20.0	45.0	411.7
*S*3	16.2	20.0	46.1	413.3
*S*4	16.0	20.0	45.8	412.9
*S*5	15.9	20.0	45.5	412.2

In Table 9, results of evaluating the sensory indicators of salad dressings are presented. All salad dressings have a uniform consistency of thick purée with splashes of ground mustard seeds and dry dill. The taste, aroma and color (Fig. 1) of salad dressings depend on the ingredients.

According to the sensory indicators such as consistency and appearance, smell and color, salad dressing S1 be awarded with higher scores than other developed salad dressings (Fig. 2). The salad dressing with freeze-dried currant powder (*S*3) has the best taste among others.

Table 9. Results of evaluating the sensory indicators of salad dressings

Sensory indicators	Model compositions of salad dressing				
	*S*1	*S*2	*S*3	*S*4	*S*5
Consistency and appearance	uniform and thick purée texture with splashes of mustard and dill	uniform and thick purée texture with splashes of mustard and dill	uniform and thick purée texture with splashes of mustard and dill	uniform and thick purée texture with splashes of mustard and dill	uniform and thick purée texture with splashes of mustard and dill
Taste	delicate, noticeable bean taste	pleasant, noticeable berry taste, slightly sour, not spicy	pleasant, noticeable berry taste, slightly sour, not spicy	pleasant, noticeable vegetable taste, not spicy	pleasant, noticeable chicory taste, slightly spicy
Smell	pleasant, light smell of spices	pleasant, berry aroma with sour	pleasant, berry aroma with sour	no pronounced aroma	pleasant, light coffee aroma
Color	cream	pearl violet	pastel violet	light ivory	ochre brown


a


b


c


d


e


f

Figure 1. Model compositions of salad dressing: a — bean semi-finished product; b — salad dressing *S*1; c — salad dressing *S*2; d — salad dressing *S*3; e — salad dressing *S*4; f — salad dressing *S*5

Corresponding to the results of quality assessment, the weighting coefficients of organoleptic properties of salad dressings are as follows: for consistency and appearance is 0.36; for taste is 0.34; for smell is 0.2; for color is 0.1. For salad dressings, consistency and appearance, and taste are the most important sensory indicators. The quality indexes of salad dressings are as follows: for salad dressing *S*1 is 0.919; for salad dressing *S*2 is 0.795; for salad dressing *S*3 is 0.851; for salad dressing *S*4 is 0.828; for salad dressing *S*5 is 0.875. So, model compositions *S*1 and *S*5 are better than other proposed salad dressings.

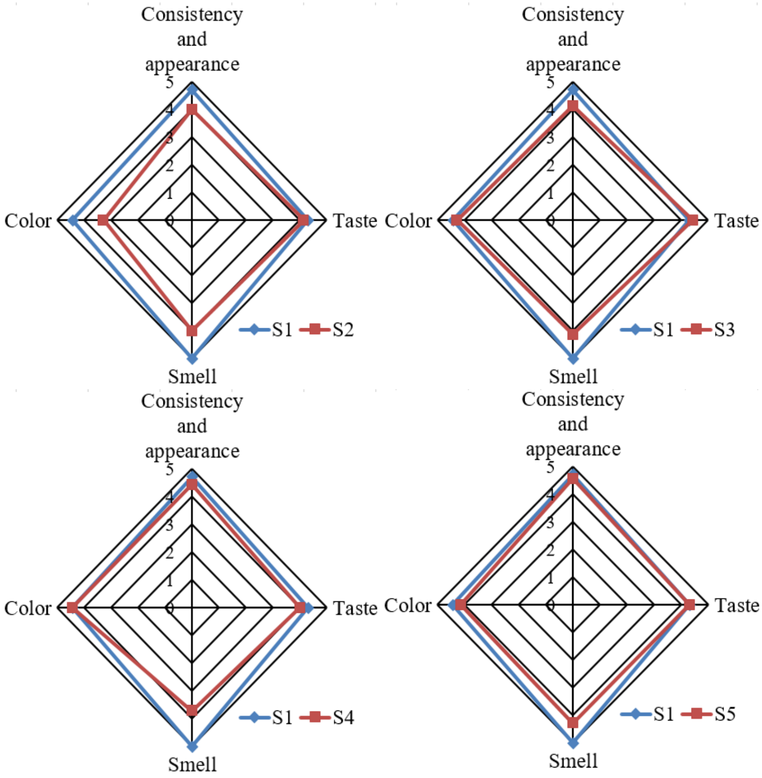

Figure 2. Sensory profiles of salad dressings

In Table 10, physicochemical indicators of salad dressings are presented. The titratable acidity of salad dressing *S*1 is lower than titratable acidity of dressings that contain plant powders and chicory soluble. The moisture content of salad dressings is varied between 54.8...56.0%. Moreover, salad dressings with freeze-dried plant powder and chicory have a lower moisture content. The fat content in salad dressings, which was obtained experimentally, is the same as that calculated according to the mathematical model.

The proposed salad dressings are analogues of traditional mayonnaise. They have similar sensoryindicators to traditional mayonnaise. But salad dressings with plant-based ingredients are significantly lower in fat (20%) than mayonnaise, which contains 70...80% fat (Gorji, Smyth, Sharma, & Fitzgerald, 2016). The caloric content of the developed salad dressings is also lower than the caloric content of traditional mayonnaise, which is about 680 kcal.

Traditional mayonnaise contain egg, which is animal-based product. Instead, salad dressings contain only plant-based ingredients, excluding the acetic acid solution. Also, they contain oat milk and freeze-dried berry and vegetable powders, as well as chicory, which enrich them with useful vitamins, minerals. The developed salad dressings comply with the recommended content of useful nutrients (proteins, fats, carbohydrates) for the human body. Salad dressings with plant-based ingredients can be recommended to anyone who follows a healthy diet. But developed salad dressings contain ingredients such as mustard seeds and oat milk that can cause allergic reactions.

Table 10. **Physicochemical indicators of salad dressings**

Physicochemical indicators	Indicator value of salad dressings				
	*S*1	*S*2	*S*3	*S*4	*S*5
Titratable acidity in terms of acetic acid, %	0.11±0.02	0.15±0.02	0.16±0.02	0.14±0.01	0.18±0.02
Moisture content, %	56.0±0.3	55.1±0.3	54.8±0.2	54.8±0.4	54.9±0.3
Fat content, %	20.00±0.03	19.93±0.04	19.98±0.03	19.96±0.02	19.95±0.03

Conclusions

Using the developed mathematical model, recipes of salad dressings with plant-based ingredientssuch as common beans, oat milk, freeze-dried plant powders, and chicoryare optimized. Caloric content of salad dressingsis varied between 411.7...413.7 kcal, which is significantly lower than the caloric content of traditional mayonnaise. The fat content of developed salad dressings is about 20%, so they can be classified as low-fat products. According to sensory indicators, salad dressings without plant powders and with chicorysoluble are the best. But, use of freeze-dried berry and vegetable powdersas additives permit to expand the range of salad dressings, enrich them with useful nutrients and satisfy the taste preferences of different categories of consumers.Further research of the influence of different types of plant milk on sensory and physicochemical indicators of salad dressings are relevant.

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