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EFFECT OF CARROT FIBER ADDITION ON THE QUALITY OF REDUCED FAT MUFFINS

S u m m a r y

Background. There is a discernible increase in consumer demand for products that contain reduced levels of fat. Such products are made using raw materials that have high biological potential as part of their production process. Materials such as protein fiber which can be obtained from by-products created during juice processing, are examples of such biological potential. The utilization of a fiber preparation derived from carrot pomace in pastry production presents novel possibilities for managing waste in the food industry and aligns with the ethos of sustainable development and a circular economy. Our study aimed to assess the possibility of decreasing fat content in sponge cake muffins by replacing it with a carrot fiber preparation. Rapeseed oil was substituted in muffin recipes with carrot fiber at a level of 10 ÷ 30 % fiber. The carrot fiber content in the analyzed samples ranged from 0.75 to 2.25 %. Texture, color and sensory evaluations were conducted for analysis.

Results and conclusions. Reducing the fat content in sponge cake muffins to 25 % and substituting it with up to 1.88 % of carrot fiber preparation neither led to weight loss nor affected the crumb bulk weight, diameter or texture parameters of the products. However, the preparation did cause significant changes in the products' color. Considering the physical and sensory quality, it was demonstrated that the utilization of a carrot fiber preparation in the production of sponge-fat products was feasible to some extent. The involvement of this preparation makes it possible to effectively decrease the fat content by 20 %, while maintaining the quality features and appeal of sponge-fat products. However, when more fat is reduced and more fiber is added, this lead to the product quality being impaired.

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Introduction

Consumers are expressing a heightened interest in healthy food options, such as energy-reduced products [1]. Simultaneously, there is a growing awareness of the necessity to augment dietary fiber intake, which results in an increased demand for products with high fiber content [28].

Fat plays a crucial role in the technological process of food production and enhances the sensory qualities and physical properties of baked goods and pastries [10, 25]. It is a significant component, providing ample energy, essential fatty acids and vitamins (A, D, E, K), improving the flavor and texture of food, enabling easy consumption and positively affecting the texture, mouthfeel and appearance of the final product [18, 31].

Excessive consumption of fat, particularly of the saturated fatty acid variety, can result in obesity and overweight, as well as ischemic heart disease [6, 12]. Due to this fact, great emphasis is being placed on enhancing the nutritional profiles of products that contain fats. This is achieved by substituting fats with alternate compounds during their production. Reducing the fat content of foods also decreases their calorie count [19], a crucial consideration given that approximately 40 % of adults are classified as overweight, according to the WHO [33].

The substitution of industrial fats in processed foods with ingredients of high biological potential is particularly justifiable. Researchers worldwide have shown interest in fat replacement using dietary fiberfibers such as inulin, psyllium and β-glucan [1, 8, 18, 23, 32, 35, 36, 37, 39]. These dietary fiber preparations are obtained, among others, from waste produced by the fruit and vegetable industry. Drying fresh pomace immediately yields a high-quality product that maintains its integrity during storage [26]. Carrot pomace is a by-product generated in large amounts during carrot processing. Rich in bioactive compounds, including carotenoids, phenolic compounds, ascorbic acid and tocopherol [16], it is typically processed into feed. However, disposing of this by-product can be costly and burdensome for the environment [7]. Such pomace is a significant source of dietary fiber, consisting of 85.19 % (d.m.) fiber, of which 2.07 % is soluble fiber and 83.12 % is insoluble fiber [34]. The consumption of soluble fiber can potentially reduce glycemic response and plasma cholesterol levels, while also offering protection against colorectal cancer and lowering the risk of cardiovascular disease [14, 30]. In contrast, the insoluble fiber component enhances stool output, slows gut movement and suppresses pancreatic function and lipase activity [2, 14, 15]

The use of fiber preparations made from pomace in pastry production presents novel opportunities for managing waste products from the fruit and vegetable industry in an environmentally sustainable manner. By adopting such practices, the concept of a closed loop economy can be implemented, thus promoting sustainable development. No studies on the use of carrot fiber as a fat substitute in muffins were found in the available scientific literature. This study aims to determine the feasibility of incorporating a carrot fiber preparation as a substitute for fats in sponge cake muffins. The impact of the reformulation of recipe composition on specific quality features of final products was examined.

Materials and methodology

Materials

The study used muffins made from a control sponge cake and carrot fiber preparation. The control sample (K) fat-oil (Kujawski -ZT Kruszwica S.A., Poland) at 15 %, type 450 wheat flour (Polskie Młyny S.A., Poland) at 34 %, granulated sugar (Diamant - Pfeifer & Langen Polska S.A., Poland) at 15 %, milk with 2 % fat (Mlekovita Dairy Cooperative, Poland) at 25 %, hen’s eggs (Farmio S.A., Poland) at 10 %, and baking powder (Gellwe Sp. z o.o., Poland) at 1 %. Ingredients are given as a percentage of the dough mass (Table 1).

Table 1. The variability of the product's caloric content depending on the fat content in the product recipe.
Tabela 1. Zmienność kaloryczności produktu w zależności od zawartości tłuszczu w recepturze produktu.

The composition / Skład [%]								
Sample/ Próbka	Flour/ Mąka	Fat/ Tłuszcz	Sugar/ Cukier	Milk/ Mleko	Hen’s eggs/ Jaja kurze	Baking powder/ Proszek do pieczenia	Carrot fiber preparation/ Preparat błonnika marchwiowego *	Reduction in calories derived from fat/ Obniżenie kaloryczności pochodzącej od tłuszczu [kcal]
K - control	34.00	15.00	15.00	25.00	10.00	1.00	0.00	0.00
I	34.77	13.48	15.00	25.00	10.00	1.00	0.75	13.50
II	35.13	12.74	15.00	25.00	10.00	1.00	1.13	20.25
III	35.50	12.00	15.00	25.00	10.00	1.00	1.50	27.00
IV	35.88	11.24	15.00	25.00	10.00	1.00	1.88	33.75
V	36.25	10.50	15.00	25.00	10.00	1.00	2.25	40.50

Explanatory notes / Objaśnienia:
* for every 1 g of fiber, 0.25 g of water was added / na każdy 1g błonnika dodano 0,25g wody

Based on our preliminary research, it was assumed that 1 g of the preparation could substitute for 2 grams of fat. Given the high water absorption capacity of the fiber preparation, 0.25 g of water was added for every 1 g of fiber. The manufacturer's specifications for the carrot fiber preparation (ML-Tech Sp. z o.o., Warsaw, Poland) indicated a minimum of 48.8 % total fiber in dry matter, 6.3 % protein and 0.4 % fat content. Additionally, the product exhibited granulation of less than 60 µm, a pale cream hue, a smooth and effortless texture and a distinct aroma free from any residual or foreign scents. The substitution of fat for carrot fiber preparation resulted in reduced energy value of the goods (Table 1).

Test sample production method

Initially, the dry and wet components were separately weighed and mixed for 3 min using a Braun Multiquick kitchen processor (type 4644). The components were then combined. The uncooked dough was placed in 30 g molds. The convection oven used for thermal processing was a UNOX type XBC oven (Vie Dell Ariginato, Padova, Italy) and set to 175 °C (with thermo-circulation) for a duration of 17 min (the time was determined experimentally). Baking involved two repetitions for each variation, and the production process was repeated three times.

Methods

Determination of muffin geometry

The width (diameter) and height of the muffins at the maximum point were measured using an electronic caliper (TCM, type: 234990, Tchibo, Germany). The lubricity index was calculated based on the average diameter (D) and height (H) of the muffins using the formula:

$$SI = D/H.$$

The crumb mass by volume was determined through six replicates of each baked product.

Determination of the volumetric mass of the crumb

The volumetric mass of the crumb was measured from the middle section of the 20x20x20 mm cube-shaped muffin using the formula:

$$Mm= MV$$

where: Mm represents the volumetric mass [g/cm^3] of the crumb, M is the crumb mass [g]; V is the crumb volume [cm^3].

The crumb volume was determined following six repetitions for each bake, and the weight loss was calculated by taking the ratio of dough weight before and after baking [11].

Texture analysis

A double compression test (TPA) was conducted using a TextureAnalyser (TA-XT2i, Stable Micro Systems, UK, force 5 kg). Texture parameters, such as hardness, cohesiveness, gumminess and chewiness were determined [19]. The test (TPA) was performed at room temperature (23 ± 2 °C). The final outcome was determined by calculating the average of twelve measurements taken.

Color parameters

For the assessment of color parameters, a Chroma CR-200 calibrated instrument of type 381.7 from Konica Minolta in Osaka, Japan was utilized. The measurements carried out using the L*a*b* system were accurate to 0.01. L* represents the brightness of the sample, with 0 being the darkest possible black and 100 the brightest possible white, a* indicates red with a positive value, and green with a negative value, b* indicates yellow with a positive value, and blue with a negative value.
The color of the muffin was identified for each measurement. The following parameters were calculated based on the results: ΔE - total color difference, BI-browning index, color saturation (C) [3, 24].

ΔE was calculated as follows:

$$\Delta E = \sqrt{(a_c^* - a_x^*)^2 + (b_c^* - b_x^*)^2 + (L_c^* - L_x^*)^2}$$

where L^*_c, a^*_c, and b^*_c - color parameters of the control sample, and L^*_x, a^*_x, and b^*_x - color parameters of the β-glucan samples.

The BI index was calculated as follows:

$$BI = \frac{[100 \cdot (x - 0.31)]}{0.172}$$

$$x = \frac{(a^* + 1.75 \cdot L^*)}{(5.645 \cdot L^* + a^* - 3.012 \cdot b^*)}$$

Saturation (C) was calculated as:

$$C = \sqrt{a^{*2} + b^{*2}}$$

where a* and b* represent the color parameters of the test sample.

Descriptive analysis

A quantitative descriptive analysis (QDA) method was implemented for sensory evaluation [5]. The evaluation was conducted by a trained team of 12 individuals who established and defined the descriptors. These selected descriptors comprised of muffin appearance (color, evenness of rise and crumb porosity), texture (elasticity, firmness, moisture content), aroma and flavor (typical, oily, foreign) and overall quality. The intensity of sensory attributes was evaluated on an unstructured linear scale of 10 cm.

Samples were randomly chosen from each batch and offered in separate, coded containers in a random order.

Statistical analysis

The muffin parameters underwent a statistical analysis employing one-way analysis of variance and regression. Tukey's procedure with $p < 0.05$ was employed to determine the significance of differences in means. Additionally, the regression method was utilized to determine the model (x - the amount of added carrot fiber preparation). The statistical analysis was carried out using Statgraphics Plus 4 (Statgraphics Technologies Inc).

Discussion and result

Effect of carrot fiber preparation on physical parameters of muffins

Baked products, such as muffins, typically exhibit weight loss due to the evaporation of water during thermal processing [11]. The loss of weight of the carrot fiber-prepared muffins tested in this study ranged between 4.00 and 5.20 g/100 g of the dough (Table 2). Products containing a greater amount of carrot fiber preparation were observed to reach higher moisture loss levels due to the capacity of the fiber to retain water and hinder its evaporation during baking. Nonetheless, there were no significant differences in this metric ($p < 0.05$). Ateş and Elmac [1] reported analogous findings in their study by substituting fat in cakes with coffee bean silverskin. Martínez-Cervera et al. [20] found that by substituting fat with cocoa fiber in chocolate muffins, a weight loss of approximately 12 g/100 g of the product was observed.

The factor associated with the crumb quality of sponge products is bulk weight. Dhen et al. [11] stated that an increase in dough volume due to water evaporation during baking leads to a mass loss, affecting the crumb quality measured by volumetric mass. The product quality is better with lower values of the parameter. Muffins containing the greatest amount of carrot fiber were identified as having a notably inferior crumb quality (Table 2), which is also evident in the crumb cross-section of the examined products (Fig. 1). Similar findings were documented by other scholars, who observed a reduction in baked goods quality due to the reduction in fat content in the product formulation [17, 19, 23, 27, 37, 38, 40, 41]. The replacement of fat with other ingredients is typically linked to an adverse impact on product volume and geometric dimensions. This is due to the crucial role fat particles play in entrapping air in the dough, which increases its volume and shapes the structure of the end product [8, 37].

Table 2. The characteristics of muffins.
Tabela 2. Charakterystyka muffin.

Sample / Próbka	Weight loss / Ubytek masy [g/100g]	Volumetric weight of the crumb / Masa objętościowa miękiszu [g/cm^3]	Diameter / Średnica (D) [mm]	Height / Wysokość (H) [mm]	D/H	Water content / Zawartość wody [%]
K	$4.00^{a} \pm 0.02$	$0.47^{ab} \pm 0.00$	$58.49^{bc} \pm 0.54$	$40.18^{c} \pm 0.05$	1.46	$36.85^{a} \pm 0.05$
I	$4.82^{a} \pm 0.05$	$0.46^{ab} \pm 0.02$	$58.86^{bc} \pm 1.34$	$40.40^{c} \pm 0.03$	1.46	$38.25^{b} \pm 0.80$
II	$4.82^{a} \pm 0.01$	$0.53^{b} \pm 0.01$	$59.08^{c} \pm 1.43$	$39.03^{c} \pm 0.27$	1.51	$38.87^{b} \pm 0.12$
III	$5.05^{ab} \pm 0.12$	$0.53^{ab} \pm 0.00$	$58.42^{bc} \pm 0.57$	$36.72^{bc} \pm 0.56$	1.59	$39.55^{c} \pm 0.23$
IV	$5.19^{ab} \pm 0.24$	$0.50^{ab} \pm 0.01$	$58.12^{b} \pm 2.34$	$34.08^{ab} \pm 0.12$	1.71	$41.02^{d} \pm 0.09$
V	$5.20^{b} \pm 0.36$	$0.54^{a} \pm 0.00$	$56.95^{a} \pm 1.17$	$30.07^{a} \pm 0.55$	1.89	$42.63^{e} \pm 0.98$

Explanatory notes / Objaśnienia:
a, b, and c - describe homogeneous groups, with $p \leq 0.05$, a,b,c – oznaczenia grup jednorodnych $p \leq 0.05$.

Increasing the amount of carrot fiber in the preparation, while simultaneously decreasing the proportion of fat, led to a reduction in muffin diameter (D), with less variation for muffin height (H) shown in Table 2. The results indicate that this reformulation had an impact on the D/H ratio. Gupta et al. [13] similarly observed changes in this ratio following the addition of fiber to their products. Sudha and colleagues (29) reported on the relationship between the fat content of food products and the D/H ratio.

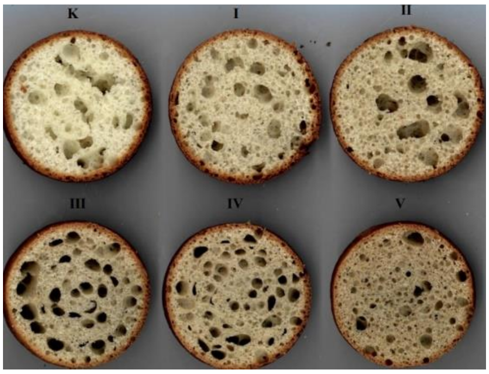

Fig. 1. Photo showing cross-section of muffin.
Rys. 1. Zdjęcie przekroju muffin.

The water content of the muffins differed significantly ($p \leq 0.05$) between the samples, with the control group having the lowest water content. It is important to note that the results might have been impacted by the addition of water, as well as the ability of the fiber to retain water in the product. Other researchers [29, 35, 41] also observed a rise in water content in cupcakes that utilized other substances (such as carbohydrates, apple fiber and inulin) as fat replacements.

The impact of carrot fiber preparation on muffin texture parameters

Fat is a crucial component of pastry products, affecting their quality significantly. Prior studies suggest that decreasing the fat content and introducing alternative ingredients influence the texture profile of bakery products [8, 10, 36, 41]. An adequately aerated, flexible and resiliently soft crumb of the product denotes the desirable texture characteristics and high quality. The chewiness of product bites is correlated with sensations produced while chewing and swallowing. Additionally, objective evaluations were used. This study analyzed the hardness, elasticity, cohesiveness and chewiness of muffin crumb (Fig. 1).

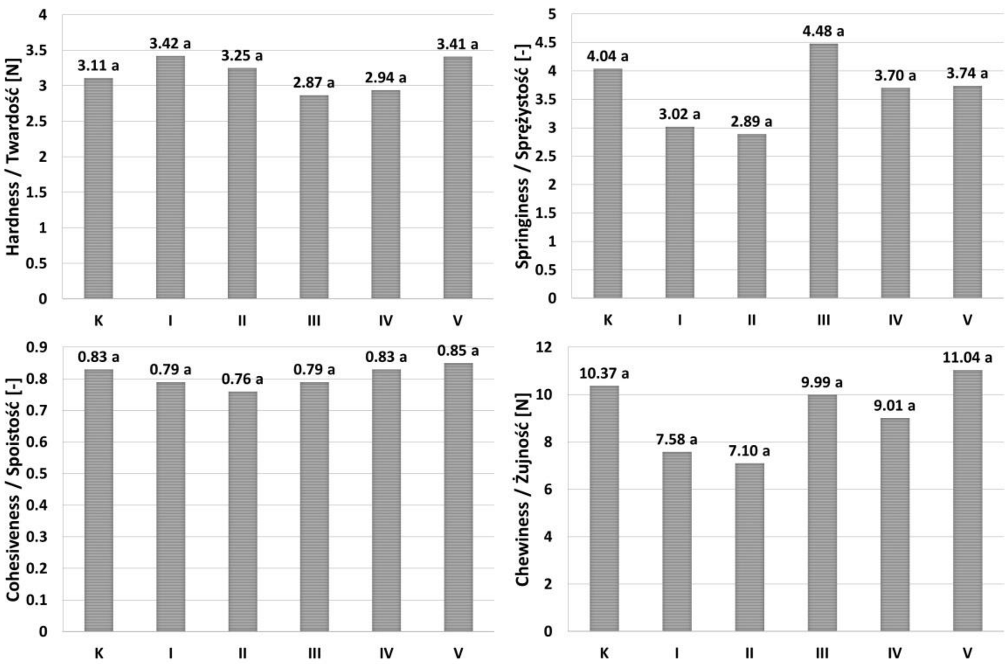

Fig. 2. Muffin crumb texture parameters.
Rys. 2. Parametry tekstury miękiszu muffin.
Explanatory notes / Objaśnienia:
a, b, and c – describe homogeneous groups, with $p \leq 0.05$, a,b,c – oznaczenia grup jednorodnych $p \leq 0.05$.

The firmness of muffins is linked to the volume of the product, as well as to the volume of air bubbles in the crumb [21]. As the size of these air bubbles, or pores, increases, the muffin texture becomes softer. This association was partially supported by the current study. While an increase in crumb hardness was noted in the sample with the highest fat substitution, statistically significant differences in hardness values between individual samples were not observed (Fig. 2). Cohesiveness varied the most amongst the crumb samples examined. Sample II showed the lowest cohesiveness (1.5 % carrot fiber and 60 % fat), while also showing the highest proportion of the preparation (total fat reduction). The TPA test results demonstrate no significant impact of the formulated amendments on texture parameters ($p < 0.05$), signifying that the substitution of fat with carrot fiber did not compromise the texture parameters, measured instrumentally.

The effect of carrot fiber preparation on muffin color parameters

Differences were found in the values of the muffin color parameters (Table 3). As the content of carrot fiber preparation increased, the values of L* and b* decreased, and the values of a* increased. The control products without the addition of carrot fiber preparation were characterized by the lightest crumb color and the lowest share of red color. For variant V, where fat was completely removed and replaced with 100% fiber, the L* parameter was 49.36.

The substitution of fat with carrot fiber led to a decrease in the yellow color component (b* parameter) in our study. A ΔE value above 3 suggests that an inexperienced observer could perceive discrepancies in color between the reduced-fat carrot fiber preparation products (I-V) and the control sample [3, 24]. Other research also indicated the effect of substituting fat with other fiber preparations on the color of bakery products [1, 20, 41]. Browning index indicates the purity of brown color, which is particularly important when products are baked, like cookies [24].

Table 3. Parameters of color of muffins.
Tabela 3. Parametry barwy muffin.

	Parameters/Parametry					
	L*	a*	b*	CHROME	BI	Δ E
K	66.79d	0.46a	21.08d	21.09	1.97	-
I	59.67c	2.14b	17.12c	17.25	4.23	8.32
II	54.91b	3.87c	15.76bc	16.23	6.83	12.36
III	51.86ab	4.34cd	14.17ab	14.82	7.87	16.9
IV	50.08a	4.85d	13.65a	14.49	8.86	18.81
V	49.36a	4.80d	13.55a	14.38	8.91	19.48

Explanatory notes / Objaśnienia:
a, b, and c – describe homogeneous groups, with $p \leq 0.05$, a,b,c – oznaczenia grup jednorodnych $p \leq 0.05$.

The effect of carrot fiber preparation on sensory quality of muffins

Fat is a crucial component responsible for mouthfeel, flavor, texture, color and the overall appearance of baked goods [4]. The reduction in the nutritional value of the muffins resulted in slight alterations in their sensory quality (Fig. 3). Muffins II-IV exhibited statistically significant differences in terms of bake uniformity compared to the control products ($p \leq 0.05$). The panelists observed that only a 3.8 % inclusion of the preparation (resulting in a 30 % reduction of fat) caused a significant change in color. It can be inferred that the increasing content of carrot fiber in the ingredients caused the soft crumb to darken. Similar observations were made during the sensory evaluation of fat-free sponge products with added apple fiber [42]. However, the desirability of color of all muffins was assessed by the panelists at the same level. According to the product evaluators, the samples did not differ significantly in terms of softness and moisture content. However, the addition of 3.8 % of the ingredient and a 30 % reduction in fat resulted in an increase in the hardness of the products.

The reformulation of the composition did not have a statistically significant impact on the detectability of vegetable, foreign or desired aromas. With the highest contribution of the prepared substance and the simultaneous greatest reduction of fat, the smell of carrot and a foreign aroma became noticeable.

In a general evaluation, the products did not differ significantly. The panelists considered the product with a 1.5 % addition of the preparation (reducing 15 % of fat) to be the most desirable sensory option. The sensory analysis conducted demonstrated that reducing fat content to 30 % and adding carrot fiber to the product composition did not cause significant negative changes in most of the evaluated factors [36]. Additionally, it was reported that substituting 25 % of fat with microcrystalline cellulose yielded favorable results, and the resultant baked goods exhibited high sensory quality. Similarly, Mohebbi et al. [22] showed that using β-glucans (0.8 ÷ 1.2%) does not affect the quality of bread negatively. However, Zoulias et al. [40] identified the upper limit of fat reduction in biscuits. In my opinion, its contribution to sensory quality is around 50 %, and further elimination of this component results in a significant decline in overall quality. According to researchers, inulin is an excellent substitute for fat in bakery products. It can replace up to 75 % of fat in crackers and pastries without affecting consumer acceptance of the products [8].

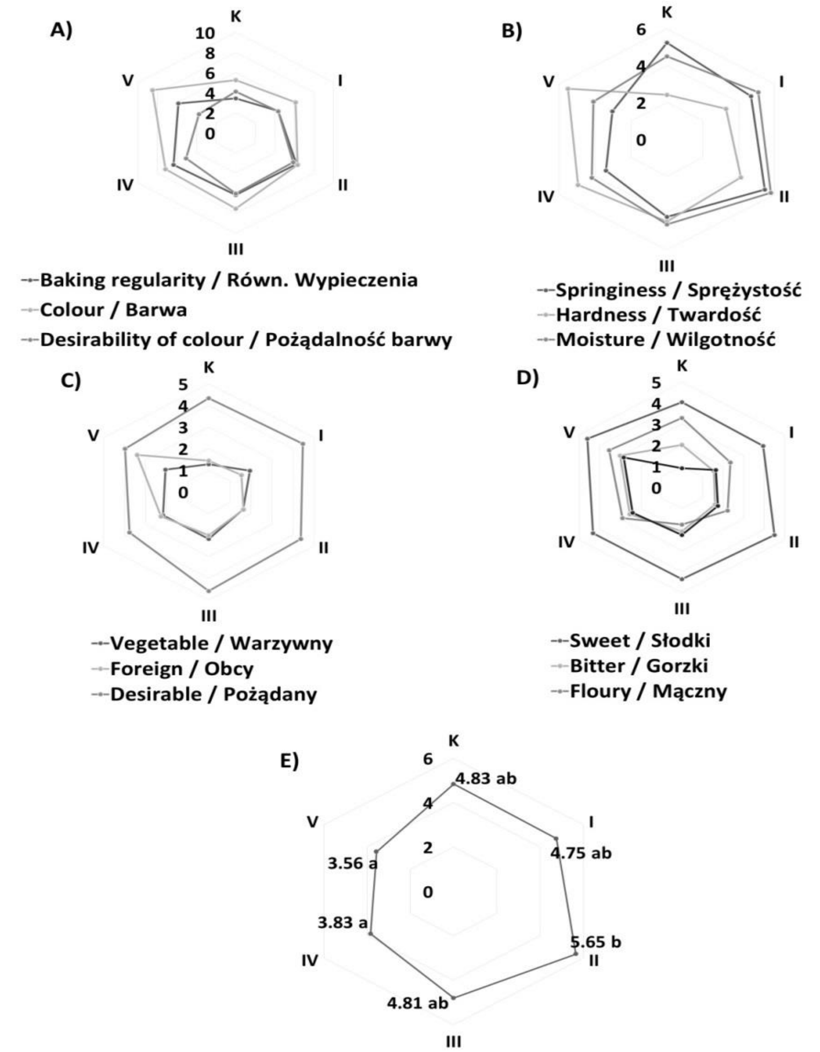

Fig. 3. Results of sensory analysis of muffins: A) External appearance, B) Texture, C) Odor, D) Taste, E) Overall quality, K – control sample, I-V – analyzed samples

Rys. 3. Wyniki analizy sensorycznej muffin A)Wygląd zewnętrzny, B) tekstura, C) Zapach, D) Smak, E) Jakość ogólna, K – próba kontrolna, I – V – analizowane próbki

Explanatory notes / Objaśnienia:

a,b,c - describes homogeneous groups, $p \leq 0.05$, a,b,c – oznaczenia grup jednorodnych $p \leq 0.05$.

Correlation analysis between muffin properties and carrot fiber preparation content

Based on the results, correlations between the content of carrot fiber and the values of the tested muffin parameters were examined.

Table 4. Correlations between the content of dietary fiber preparation supplement and muffin parameters.
Tabela 4. Korelacje pomiędzy zawartością preparatu błonnika pokarmowego a parametrami muffin.

Parameter / Parametr	p-Value	r		R^2	Function/Równanie
Weight loss / Ubytek masy	0.03	0.87		75.22	y = 4.33699=0.273039x
Height / Wysokość	0.00	-0.95		90.80	y=41.8128-2.71401x
Diameter / Średnica	0.08	-0.76		57.90	y=59.0709-0.402241x
Color /Barwa					
L*	0.01	-0.94		88.59	y=63.7416-4.44463x
a*	0.01	0.92		84.12	y=1.2968+1.13207x
b*	0.01	-0.95		89.48	y=21.529-2.30937x
C	0.02	-0.89		79.50	y=19.3817-1.60982x
BI	0.00	0.95		89.32	y=2.97979+1.85636x
ΔE	0.00	0.94		89.13	y=3.34723=4.98095x

Explanatory notes / Objaśnienia:
The table shows results of analyses for $p < 0.05$ / Tabela przedstawia wyniki analiz dla $p < 0,05$

The determination of the linear equation of dependencies obtained from the correlations is presented in Table 4. Strong positive correlations were observed between the content of fiber preparation and the color parameter a*, as well as the BI and ΔE indices. A less negative impact of the preparation used as a replacement for fat was found in a sensory evaluation and product diameter. Conversely, opposite tendencies were observed regarding height and L*, b* and CHROME parameters .

Conclusions

1. Adding the carrot fiber preparation, up to a level of 1.88 %, to the formula of the sponge cake muffins, while reducing fat content to 25 %, had no effect on weight loss, crumb bulk weight, diameter and texture parameters of the products. However, when the proportion of this ingredient was increased, and fat further reduced, there was a decrease in muffin height.
2. The carrot fiber preparation, regardless of the amount, brought about significant color alterations in the products. There was significant statistical darkening of the sponge-fat muffins, with a decrease in the value of the L* parameter and an increase in the browning index. Additionally, there was an increase in the share of red color and a decrease in the proportion of yellow color and a degree of saturation.
3. The sensorial analysis revealed that the muffins with a 15 % reduction in fat content were considered the most desirable. In contrast, the addition of a greater amount of carrot fiber and a further reduction in fat led to a decrease in the sensory quality of the products.

4. The carrot fiber preparation showed limited potential for use in the production of sponge-fat products. It should be noted that further research is necessary to fully explore the potential of a carrot fiber preparation in this context. By utilizing a fiber preparation, it is possible to lower the fat content by 20 % without compromising the quality characteristics and attractiveness of sponge cake and fat products. However, further reduction of fat and increase in fiber content adversely affects product quality

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WPŁYW DODATKU BŁONNIKA MARCHWIOWEGO NA JAKOŚĆ MUFFIN O OBNIŻONEJ ZAWARTOŚCI TŁUSZCZU

S t r e s z c z e n i e

Wprowadzenie. Wciąż rośnie zainteresowanie konsumentów produktami o obniżonej zawartości tłuszczu, do wytworzenia, których zastosowano surowce o wysokim potencjale biologicznym. Mogą być one pozyskane z produktów ubocznych, powstających m.in. w przetwórstwie soków. Wykorzystanie w produkcji ciastkarskiej preparatu błonnikowego, otrzymanego z wytłoków marchwiowych, stwarza nowe możliwości zagospodarowania produktów odpadowych branży spożywczej, tym samym wpisuje się w ideę zrównoważonego rozwoju i gospodarkę obiegu zamkniętego. Celem pracy była analiza możliwości obniżenia zawartości tłuszczu w muffinach biszkoptowo-tłuszczowych, poprzez zastąpienie go preparatem błonnika marchwiowego. Dokonano substytucji oleju rzepakowego w recepturach muffin, na poziomie 10 ÷ 30 % błonnikiem marchwiowym. Zawartość preparatu w próbkach wynosiła od 0,75 % do 2,25 %. Analizowano parametrów tekstury i barwy, dokonano oceny sensorycznej.

Wyniki i wnioski. Obniżenie zawartości tłuszczu, w składzie muffin biszkoptowo-tłuszczowych, do 25 % i zastąpienie go preparatem błonnika marchwiowego (do 1,88 %), nie wpływało na ubytek masy, masę objętościową miękiszu, średnicę i parametry tekstury wyrobów. Preparat powodował znaczące zmiany w barwie wyrobów. Biorąc pod uwagę jakość fizyczną i sensoryczną wykazano możliwość zastosowania preparatu błonnika marchwiowego w produkcji wyrobów biszkoptowo-tłuszczowych w ograniczonym zakresie. Z powodzeniem można obniżyć zawartość tłuszczu o 20 % przy udziale preparatu, zachowując cechy jakościowe i atrakcyjność wyrobów biszkoptowo-tłuszczowych. Natomiast dalsza redukcja tłuszczu i wzrost zawartości błonnika skutkuje pogorszeniem jakości wyrobów.

Słowa kluczowe: zamienniki tłuszczu, aspekt żywieniowy, wyroby ciastkarskie, jakość sensoryczna, tekstura, gospodarka obiegu zamkniętego