Article

Functional and Sensory Properties of Gingerbread Enriched with the Addition of Vegetables

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Abstract: The aim of the study was to evaluate the sensory quality and bioactive phenolic compounds and antioxidant activity of gingerbread cake with the addition of different vegetables, which was separately prepared as studied samples. The research material consisted of three gingerbread banana cakes and various vegetable ingredients: pumpkin (Cucurbita pepo L.), tomato (Solanum lycopersicum L.), and beetroot (Beta vulgaris L.). Blended roasted pumpkin, blended roasted beetroots, and baked tomatoes were used in the experiment. The evaluation of sensory quality was conducted using the QDP (Quantitative Descriptive Profiling) method and a hedonic evaluation by consumers was also performed. In the experiment, colour parameters were measured in the CIE L*a*b* system, and the total polyphenol content and the total antioxidant capacity were established. The test results showed that a vegetable addition of a level of up to 25% of different vegetables such as pumpkin, tomato, and beetroot to gingerbread provides an adequate effect on the sensory quality of the product while still being acceptable to consumers. Moreover, it increases the functional properties of the finished product \( (p < 0.01) \). The gingerbread dough with the addition of tomato (25%) contained the highest amount of polyphenols \(-40\, \text{mg GAE/100 g}\), and the gingerbread dough with the pumpkin addition was characterized by the highest total antioxidant activity at a mean value of 0.475 \( \mu \text{M TEAC/g}\) of product.

Keywords: gingerbread; bioactive properties; pumpkin; tomato; beetroot

1. Introduction

The increase in the nutritional awareness of consumers results in the creation of new products that are attractive not only in terms of sensory aspects but also nutritional value and/or health-promoting properties. For this reason, the market for functional food, which is defined as food that has a positive effect on human health, is developing more and more dynamically. Functional products are obtained by modifying the traditional product formula by adding selected nutrients whose pro-health effects have been scientifically proven [1]. Although the range of functional foods is constantly expanding, the demand for new products is constantly growing.

Confectionery products, including cakes, are eagerly eaten by consumers in the form of snacks due to their flavour and aroma; therefore, both of these features, alongside an attractive appearance, are important determinants for the consumer when choosing this type of product. Thus, creating a product with pro-health properties without lowering sensory quality is a challenge for manufacturers. The offer of low-calorie cookies with the addition of natural ingredients, such as fruit and vegetables, meets consumer expectations and may provide potential health benefits. The use of bakery products as an addition of natural plant-derived antioxidants is also positively perceived by consumers [2,3]. Antioxidant compounds have several properties that positively affect human health. It has been proven many times that they reduce the risk of cancer, diabetes, and obesity [4].

The addition of banana and vegetables is a substitute for fat, contributing to the reduction of the calorific value of the dough and due to the presence of hemicellulose...
and starch, it may have a positive effect on the sponginess, firmness, and moisture of the dough [5]. The addition of vegetable ingredients offers a greater variety of flavours and textures that differ from their conventional counterparts and increases the content of bioactive substances, vitamins, and minerals, which positively affects the quality of the product. The high content of biologically active compounds should be used as the first criterion for selecting food additives, however, the compound must be bioavailable [6]. It must be pointed out that sensory quality is also of crucial importance so that the product is acceptable to consumers.

Tomatoes (Solanum lycopersicum L.) are a vegetable commonly eaten both raw and processed. They are a rich source of antioxidants and also contain valuable nutrients such as vitamins A, C, potassium, calcium, zinc, manganese, copper, polyphenols, and lycopene. Research shows that they have many health-promoting properties and minimize the risk of cardiovascular diseases, hypertension, and atherosclerosis. In addition, they have a beneficial effect on the intestinal microbiome, stimulate the immune system, and reduce the risk of infertility [3,7].

Like tomatoes, beetroot (Beta vulgaris L.) contains a significant amount of vitamins, antioxidants, and essential amino acids, which may indicate their high potential for use as an additive in the production of functional food [8]. Beetroot pomace extract rich in betalains has been used in the production of antioxidant-rich ginger candies [9]. The use of betalains as antioxidants appears to be meeting increasing consumer demand for natural food; however, due to their pigmentation properties, their influence on the sensory quality of food should not be underestimated [10].

On the other hand, pumpkins (Cucurbita pepo L.), due to their technological properties, can be used in the production of new products, including confectionery. Both the seeds and their flesh contain some bioactive substances, such as amino acids, phytosterols, B-carotene, phenols, and flavonoids, showing several pro-health effects. Research shows that these compounds show anti-cancer and cytoprotective potential, reduce the risk of diabetes and depression, and inhibit the growth of microorganisms (including E. coli, S. auuerus) [4,11]. In addition to some bioactive compounds, both pumpkin, beetroot, and tomato, due to their low calorific value, high water content, and sweet flavour and wide acceptance by consumers, show high potential for use as a pro-health additive in different confectionery.

Therefore, this study aimed to investigate the use of tomato, pumpkin, and beetroot due to their health-promoting properties in gingerbread dough formulation to obtain an attractive sensory product with increased functional properties (antioxidant properties due to polyphenols present in vegetables). Therefore, the publication tested the hypothesis that the addition of popular vegetables containing bioactive compounds (polyphenols and carotenoids) to gingerbread cakes would improve their health-promoting value (introducing polyphenols and thus increasing antioxidant properties) without deteriorating their sensory quality.

2. Materials and Methods

2.1. Material

The research material was composed of three sponge-fat cakes with the addition of bananas and vegetables (tomato, beetroot, pumpkin) and spices.

In preliminary tests, attempts were made to obtain gingerbread with the addition of different vegetables. The optimization of the additive was aimed at the highest possible level of additive, taking into account the criterion of appropriate taste and the technological possibility of obtaining a dough with an attractive sensory texture and flavour properties.

The research material consisted of ripe bananas (Chiquita Europe b.v. Limited Liability Company, Branch in Poland, Kraków); rapeseed oil Kuyavian (Kruszwica® SA, Poland, Kruszwica); sugar Diamant Dry Demerara (Pfeifer & Langen® S.A., Poland, Poznań); wheat flour type 450 Szymanowska (Polskie Młyny® SA in Poland, Warszawa); oat flour ground oat flakes (Melvit® SA, Poland, Warszawa); dark cocoa Deco Morreno® (Maspex-Gmw, Wadowice, Poland), gingerbread spice Kamis® (McCormick S.A., Poland, Stefanowo);
baking soda Dr. Oetker® (Dr. Oetker, Poland, Gdańsk); baking powder Dr. Oetker® (Dr. Oetker, Poland, Gdańsk); salt (Kłodawa® SA, Poland, Kłodawa), as well as a vegetable additive in the form of blended roasted (60 min, 180 °C) pumpkin (Cucurbita pepo L.), sliced baked (30 min, 110 °C) tomato (Solanum lycopersicum L.), and blended roasted (50 min, 180 °C) beetroot (Beta vulgaris L.) purchased from the local market.

After a preliminary study, a composition of cakes was established. The studied cake samples were made in a laboratory at the Institute of Human Nutrition. The formulations of studied material is presented in Table 1. The dry ingredients of the sponge-fat cakes: wheat flour, oat flour, % sugar, gingerbread spice, dark cocoa, baking soda, salt, and baking powder were weighted (Radwag WTC 2000, Radom, Poland) and mixed by hand. Wet ingredients (banana, rapeseed oil, and appropriate vegetable additive were placed in a blender cup and mixed for 5 min using a 600 W blender (HR2118/01, Philips, Poland). The blend was then mixed with dry ingredients for the next 5 min. The studied cakes for this experiment were coded: pumpkin cake—PC; tomato cake—TC; beetroot cake—BC.

Table 1. The fixed recipe of the studied vegetable gingerbreads [%].

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Sample</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC [%]</td>
<td>TC [%]</td>
<td>BC [%]</td>
</tr>
<tr>
<td>Pumpkin purée</td>
<td>25.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tomato purée</td>
<td>-</td>
<td>25.00</td>
<td>-</td>
</tr>
<tr>
<td>Beetroot purée</td>
<td>-</td>
<td>-</td>
<td>25.00</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Oat flour</td>
<td>16.00</td>
<td>16.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Banana</td>
<td>15.00</td>
<td>15.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>14.00</td>
<td>14.00</td>
<td>14.00</td>
</tr>
<tr>
<td>Sugar</td>
<td>9.40</td>
<td>9.40</td>
<td>9.40</td>
</tr>
<tr>
<td>Gingerbread spice</td>
<td>2.20</td>
<td>2.20</td>
<td>2.20</td>
</tr>
<tr>
<td>Dark cocoa</td>
<td>1.25</td>
<td>1.25</td>
<td>1.25</td>
</tr>
<tr>
<td>Baking soda</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Salt</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Baking powder</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Explanation: PC—dough with pumpkin purée addition, TC—dough with the tomato purée addition, and BC—dough with beetroot purée addition.

After that, the mass was put into moulds lined with baking paper. The cakes prepared in this way were baked for 40 min at 180 °C in an oven with a hot air function (oven GP, Easy 6, Gastroproduct, Poland). After baking, the dough was removed from the moulds and baking paper and cooled to ambient temperature, and samples were prevented from drying out. On the next day, the sensory evaluation and physical and chemical assessments were conducted.

2.2. Methods

2.2.1. Colour Parameters

The colour parameters were measured using the CR-310 Chroma Meter (Konica Minolta®, Osaka, Japan). Colour parameters were performed in the CIE LAB (L*a*b*) scale (colour space) after the cakes were ready. The system was calibrated before each assessment against a white tile (L = 90.7, a = 0.9, b = −0.1). The analyzes were made twice in three pieces/slices of cakes (n = 6) and individual measurements were averaged.

2.2.2. Total Phenolic Content

Extraction Preparation

An aliquot of 3 g of the studied samples with 30 mL of distilled water (20 °C) added were put into plastic, sterile Falcone tubes (Radwag, Radom, Poland). The samples were centrifuged at 2000 rpm (LP Vortex, Labo Plus, Warsaw, Poland). The incubation time was (IKA Shakers KS 4000 i Control, IKA, United Kingdom) 60 min at 30 °C, at 200 rpm. Then,
the tubes were vortexed for 15 min, at 10,000 rpm (MPW–380 R centrifuge, Warsaw, Poland). In the received supernatant, the determination of polyphenol content and antioxidant activity was performed.

Chemicals

Gallic acid (phenolics standard), Folin–Ciocalteu reagent, and anhydrous sodium carbonate were acquired from POCH S.A., Avator Performance Material Poland S.A. (Gliwice, Poland). The reagents used in the experiment were of analytical grade purity.

Standards

Gallic acid was dissolved in distilled water (100 mg/L). Aliquots of 0.0, 0.25, 0.50, 0.75, 1.00, 2.00, and 3.00 mL of stock solution were mixed with 2.5 mL of F–C reagent and 5.0 mL of aqueous sodium carbonate (20%). The incubation time was 30 min at ambient temperature in the dark. The absorbance was established spectrophotometrically at a wavelength $\lambda = 750$ nm (UV/Vis UV-6100A spectrophotometer, Metash Instruments Co., Ltd., Shanghai, China). The total phenolic content was computed from a standard calibration curve of the gallic acid ($y = 2.125x + 0.1317; R^2 = 0.9995$).

Total Phenolic Content with Folin–Ciocalteu Reagent Assay

Total phenolic content in aqueous extracts was measured according to Folin-Ciocalteu’s assay, as described by Singleton et al. (1999) [12]. A total of 1.00 mL of the supernatant from the studied sample, 2.5 mL of F–C reagent, and 5.0 mL of sodium carbonate solution (20%) were supplemented with distilled water (50.0 mL). The incubation time was 30 min at ambient temperature, without the presence of light. After this time, the absorbance of the mixture was read at a wavelength $\lambda = 750$ nm. Results were given in mg GAE/100 g of product. (GAE–Gallic Acid Equivalent). The analysis was done in six replicates.

2.2.3. Antioxidant Activity

Chemicals

Trolox (6-hydroxy-2, 5,7,8-tetramethylchroman-2-carboxylic acid) (as an antioxidant standard), 2,2-azinobis-(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS), potassium persulphate (K2S2O8), phosphate-buffered saline (PBS), and ethanol were purchased from Sigma-Aldrich Chemical Co. (Poznań, Poland). All components used in the study were of analytical grade.

Preparation of ABTS+

A solution of ABTS•+ radicals was received (7 mmol/L of ABTS stock solution with 2.45 mmol/L potassium persulphate). After the incubation (12 h in darkness at ambient temperature), ABTS•+ was diluted with a PBS until an absorbance of 0.700 ± 0.02 at $\lambda = 734$ nm was reached.

Standards

An ethanolic solution of Trolox was made (74 mg/L). Working standards solutions were performed by diluting the stock solution with PBS phosphate buffer solution at concentrations: 0.0, 50.0, 75.0, 150.0, 225.0, 300.0 or 375.0 µL. The aliquots were put in 10-mL glass tubes and 1.5 mL was prepared with PBS buffer solution and then supplemented with 3.0 mL of radical cations ABTS•+ in PBS solution. The absorbance at the wavelength of $\lambda = 734$ nm was given after incubation of 6 min at ambient temperature). A calibration curve was determined for the reference–Trolox ($y = −5.6162x + 0.7132; R^2 = 0.9999$).

ABTS + Assay

Examination of antioxidant activity was carried out with the ABTS + cationic acid method [13,14]. Amount of 1.00 mL of the supernatant from the studied material was dissolved in 1.5 mL water, and 3.0 mL of ABTS•+ solution were added. Changes in the
concentration of ABTS•+ cation radicals were determined spectrophotometrically after 6 min of incubation at ambient temperature with the tested extracts. The absorbance was monitored at $\lambda = 734$ nm. The data were expressed as $\mu$mol TEAC/g (TEAC–Trolox Equivalent Antioxidant Capacity). Six replicates were used to calculate mean values.

2.2.4. Sensory Evaluation

Consumer evaluation. The consumer test was selected to determine the degree of appearance liking as well as aroma liking, texture liking, taste/flavour liking, and overall liking of the tested samples using a linear 9-point hedonic structured scale (1–extremely not like, 9–extremely like) [15]. The study was conducted with 50 young people (20–28 years old) declaring themselves as consumers of such products. Individual samples of the cakes (about 30 g) were placed in transparent, odourless, plastic packs and separately coded with three-digit numbers. The samples were served for the assessment in random order. All consumers were given an individual set of coded samples.

Trained Panel Evaluation

The sensory panel included 8 accessors (7 women and 1 man, aged 26–60) who were broadly tested before being chosen according to the procedure ISO 8586:2012 [16]. The experts had 4 to 20 years of practical experience with different sensory procedures and evaluation of varied food products (together with profiling). The panelists were selected on the basis of their ability to differentiate product samples by different concentrations of volatile and non-volatile stimuli. They underwent descriptive tests with multiple types of food products in which they characterized their sensory traits.

Sensory Descriptive Analysis. The sensory profile of the studied cakes was formulated by the QDP (Quantitative Descriptive Profile) method (ISO 13299:2016) [17]. The trained accessors evaluated the sensory profile of the studied cakes samples. During a panel discussion, 11 sensory attributes for the QDP method were selected and defined: 3 odour attributes—spicy, sweet, and other; 2 attributes of colour—brightness and intensity; 3 texture attributes—sponginess, density, and moisture; 4 attributes of flavour—spicy, sweet, vegetable, and other. On the basis of the all above-mentioned feature characteristics, an overall sensory quality (low intensity–high intensity) for each sample on a separate scale was indicated. The intensity of the descriptors was measured on an unstructured, linear scale of 100 mm (0–10 conventional units c.u.), anchored: none–very strong. There were two exceptions: for colour—dark–bright and for the texture descriptor—low–high. Two independent sessions (replications) were performed so the average result in this procedure was established on 16 single results. The samples were coded individually for each test with three-digit codes. The way in which the samples were served was to minimize the influence of a carryover effect (i.e., the impact of a previous sample on a subsequent one). The water was used during the evaluation to neutralize the taste. The procedure and the condition mode were established according to Meilgaard et al. [18].

2.2.5. Data Analysis

The data were carried out using STATISTICA version 13.3 software (TIBCO Software Inc. 2017, Statistica–data analysis software system, version 13, http://statistica.io, accessed on 22 January 2022). The basic descriptive statistics (mean, standard deviation) were computed. The normality of distribution of all studied traits was checked by the Shapiro–Wilk test. The significance of differences between the groups in terms of the analyzed traits was carried out using the ANOVA test. The significance of differences between means was estimated using the LSD (the Least Significant Difference) test at $p < 0.05$ and $p < 0.01$. Pearson’s linear correlation coefficient between the polyphenols content and antioxidant activity as well as between sensory traits and colour parameters instrumentally evaluated data was calculated. Principal Component Analysis (PCA) was carried out for the results collected in the QDP method of sensory analysis.
3. Results and Discussion

3.1. Colour Parameters of Gingerbread Cakes

The obtained data regarding colour parameters are presented in Table 2. The gingerbread dough with the addition of tomato (*Solanum lycopersicum* L.) (TC) was characterized by the highest brightness of colour (*L*), and the pumpkin (*Cucurbita pepo* L.) dough (PC) had a similar brightness to TC. In contrast, the beetroot cake (*Beta vulgaris* L.) (BC) was much darker than the other two. The highest saturation of red (*a*) was found for tomato gingerbread, and this value was significantly different from the other two cakes (*p* < 0.05). Taking into account the yellow colour (*b*), the highest saturation was found in the tomato and beet dough samples, although these differences were not statistically significant (Table 2).

<table>
<thead>
<tr>
<th>Traits</th>
<th>Sample</th>
<th>F_{emp.}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour <em>L</em></td>
<td>PC</td>
<td>TC</td>
</tr>
<tr>
<td></td>
<td>29.65 ± 1.48</td>
<td>31.18 ± 1.30</td>
</tr>
<tr>
<td>Colour <em>a</em></td>
<td>5.09 ± 1.10</td>
<td>9.59 ± 1.98</td>
</tr>
<tr>
<td>Colour <em>b</em></td>
<td>7.66 ± 0.88</td>
<td>11.90 ± 3.21</td>
</tr>
<tr>
<td>ABTS (μmol TEAC/2 g)</td>
<td>24.94 ± 0.23</td>
<td>28.01 ± 0.09</td>
</tr>
<tr>
<td>Phenolic contents (GAE/100 g)</td>
<td>29.85 ± 0.00</td>
<td>39.02 ± 0.01</td>
</tr>
</tbody>
</table>

Explanation: PC—dough with pumpkin purée addition, TC—dough with the tomato purée addition, and BC—dough with beetroot purée addition. a, b, c—means in the same row marked with different letters differed significantly at *p* < 0.01; **—significant at *p* < 0.01. 1 GAE-Gallic Acid Equivalent. 2 TEAC—Trolox Equivalent Antioxidant Capacity.

Currently, natural dyes are preferred as replacements to their synthetic counterparts, so the cakes meet this requirement. The obtained colour measurement results indirectly indicate the type of vegetable addition, which, in the opinion of the authors, is consistent with the characteristics of the dough offered to consumers. It must be pointed out that the colour of products plays a relevant role at the stage of choosing in the marketing success of any product and generally positively influences consumer preferences [19]. Similar results were reported by Bhat et al. [20], who found greater saturation of red and yellow in cakes with tomato addition.

3.2. Total Polyphenol Content

In the tested gingerbread cakes with the addition of tomato, the total polyphenol content was 39.02 mg GAE/100 g of the product (Table 2). Tomatoes are a rich source of polyphenols, their content ranges from 64.6 to 440.0 mg GAE/100 g [21]. Likewise, Bhat et al. [7] found a significantly higher content of polyphenols (in the range of 62–87 mg GAE/100 g) in cakes with the addition of tomato compared to wheat cakes without vegetable supplementation. The higher content of polyphenols in cookies may have been the result, as the authors explain, of the Maillard reaction products formed during baking. In the case of the tested cakes with the addition of beetroot, the polyphenol content was also high and amounted to 33.88 mg GAE/100 g. The lowest polyphenol content was found in cakes with pumpkin, at −29.85 mg GAE/100 g (Table 2). According to Różyło et al. [6], pumpkin pulp is not a good source of hydrophilic phenolic compounds, including flavonoids.

As a result of the diverse composition of polyphenols in various vegetables and fruits as well as their varieties and due to the changes occurring during the baking process, to achieve an optimal nutritional effect, each additive should be considered individually [22,23]. The results of the polyphenol content in the tested gingerbread cakes indicate that, thanks to the addition of vegetables, it is possible to obtain bakery products that meet the conditions for functional food. Based on the data presented in Table 2, it can
be calculated that the consumption of a 150 g serving of gingerbread can introduce the following amounts of polyphenols into the consumer’s diet: for PC—44.78 GAE mg/150 g; TC—58.53 GAE mg/150 g and BC—50.82 GAE mg/150 g, respectively.

In recent years, foods enriched with polyphenols are gaining popularity. The addition of various food products of vegetables such as pumpkin, tomato, and beetroot can play a role in the diet as a source of carotenoids and polyphenols, along with many vital compounds (minerals, vitamins, amino acids) [24]. The positive effects of incorporating polyphenols into foods, such as cakes, bread, muffins, and cookies, express increasing antioxidant activity, reducing the content of toxins in food (including those formed during heat treatment) and lowering serum glucose levels [25,26]. Polyphenols and carotenoids (mainly β-carotene) can possibly strengthen the human defence system by preventing the damaging effects of free radicals that cause various diseases such as hypertension, atherosclerosis, type 2 diabetes, cancer, and Alzheimer’s disease [27–30]. On the other hand, polyphenols can negatively affect the colour, texture, and taste of food [31], therefore, food products with the addition of ingredients rich in polyphenols require simultaneous sensory evaluation of the acceptability of the product by consumers, which was also studied in this experiment.

3.3. Total Antioxidant Capacity

The antioxidant activity in the tested cakes is shown in Table 2. The highest antioxidant activity was detected in the gingerbread dough with the beetroot addition (30.44 µM TEAC/g product). Beetroot is a rich source of antioxidant compounds such as betalain and its two metabolites betanin and betamin, rutin, epicatechin, and caffeic acid [32,33]. According to Kidon and Czapski [33], the antioxidant capacity of beetroot increases after it is subjected to the drying process (90 °C for 3 h). An increase was found from 50 µM TEAC/1 g of product before drying to 65 µM TEAC/1 g of product after drying [34]. In our study, the gingerbread dough with the tomato addition antioxidant activity was established at the level of 28.01 µM TEAC/g, and dough with the addition of pumpkin resulted in lower antioxidant activity and was 24.94 µM TEAC/g of the product. The antioxidant activity of the examined gingerbread cakes can be largely attributed to the polyphenols introduced with the added vegetables. The calculated relationship between the content of polyphenols and the antioxidant activity was \( r = 0.5 \). For comparison, the relationship between the antioxidant activity and the content of polyphenols reported by other authors ranged from \( r = 0.3 \) to 0.9 and depended on the methods of analysis used and many other factors [35–37]. Bakery products such as cakes and bread made from white flour are foods with low antioxidant activity. Enriching bakery products with natural antioxidants due to their safety and potential nutritional and health beneficial effects has recently garnered much interest. Rich sources of natural antioxidants are fruits and vegetables, including some plant-based waste products of the food industry [38]. In the Bhat et al. [7] study, the antioxidant activity in a dough containing tomato powder and raw lycopene was significantly higher than in a control dough. The authors give the presence of phenolic antioxidants, i.e., caffeic and chlorogenic acid in tomatoes, as a possible reason for the increased activity of radical scavenging. In addition, heat treatment resulted in an increase in antioxidant activity, which may have been the result of the formation of melanoids produced by the Maillard reaction at elevated temperatures [39]. The lowest total antioxidant activity of studied cookies was found in gingerbread dough with the pumpkin addition (24.94 µM TEAC/g product). The lower antioxidant activity may have been due to the 25% pumpkin supplement. Similar results were obtained by Różyło et al. [6], who found that enriching bread with pumpkin pulp in the amount of 10% and 15% causes an increase in antioxidant activity, whereas the addition of 20% of pulp caused a slight decrease in the antiradical activity.

The use of synthetic antioxidants is limited mainly due to their safety profile. In this context, the valuable alternative is natural antioxidants derived from edible sources and
by-products. Moreover, there is growing evidence that phenolic compounds may reduce the risk of serious health hazards due to their antioxidant activity [40,41].

3.4. Sensory Quality of the Tested Cakes

**Consumer evaluation.** The results obtained in the hedonic study are shown in Figure 1. The evaluation showed a variation between the tested attributes in terms of appearance liking, aroma liking, texture liking, taste/flavour liking, and overall liking.

![Figure 1. Consumers’ evaluation (n = 50) of tested attributes and overall liking of gingerbread samples; TC—dough with the tomato addition, PC—pumpkin addition and BC—beetroot addition.](image)

The overall liking of the studied cakes with the addition of tomato and pumpkin was rated high, whereas the beetroot cake was rated the lowest in terms of this attribute. The addition of beetroot reduced the intensity of all examined attributes in comparison with the other samples. The acceptability of texture was highest in the case of tomato cake (TC). The gingerbread dough enriched with tomato (TC) was also the most liked flavour, whereas this value is not significantly different from the PC- pumpkin sample (p > 0.05). It must be pointed out that the overall liking of the dough was satisfactory, despite the addition of vegetable additives where polyphenols negatively affect the colour, texture, and taste of food [31]. Similar conclusions were reached by Górnaś et al. [22], who found comparable results in the sensory quality of muffins with the addition of 50 g/kg of various fruit pomace (blackcurrant, strawberry, cherry, raspberry). It is known that even a minor increase in the intensity of negative attributes, mainly flavour and especially odour, is associated with a severe reduction in the overall sensory quality of food products. The sensory quality of foods is one of the crucial features in the acceptance of a product on the market. For this reason, studying factors that influence sensory quality is fundamental in food product development.

**Sensory laboratory evaluation.** Based on results obtained using the QDP method, a PCA matrix is presented in Figure 2. The first two principal components accounted for 100% of the total variability of all the sensory attributes, whereas the first component PC1 explains 88.27% of the variability (Figure 2). In this condition, the overall quality of cakes was strongly positively correlated with sponginess as well as a spicy flavour and odour. In the studied samples, the overall sensory quality was negatively correlated with “other” flavour and odour notes (like bitter, sour, pungent) and density, as well as moisture perceptibility. The position of the sample with tomato addition, TC samples, were found to have different characteristic to samples BC and PC. It is worth noting that the
sample with beetroot addition (BC) differed from the others in terms of color attributes assessed sensitively (brightness and color intensity) (Figure 2). These differences were also noticeable in the instrumentally assessed colour (Table 2). Statistical analysis showed a high correlation between the colour parameters assessed with the sensory profiling method and the instrumental method ($L^*$ and $a^*$; $r = -0.9$). It is worth mentioning that a fairly high correlation was found between the $b^*$ color parameter (yellowness) and the content of polyphenols ($r = 0.7$). Moreover, the sweet flavour and odour vector, as well as a vegetable note, indicate that these attributes were of lower importance in overall sensory quality perception (Figure 2).

In the presented study, it was shown that some attributes called “others”, like bitter, sour, and pungent had a negative connotation and had a negative sensory impact on the overall sensory quality of the studied cakes and were of significant importance for the overall sensory characteristics. After exceeding a critical value, negative attributes strongly reduced the overall sensory quality of the tested cakes, so introducing a higher level of vegetable additives was not possible.

Designing cakes with vegetable additives is a process that requires the selection of appropriate ingredients, amounts, and proportions so that they do not unfavourably affect the sensory traits of the product.

The composition of food in such a way as to maintain its high nutritional value and adapt it to the needs of various population groups is a huge challenge. The pro-health additives can decrease the sensory quality of the product. It is recognized by consumers and results in reduced willingness to purchase them. In the study of Lyly et al. [42], it has been demonstrated that consumers prefer the taste over the health benefits of functional foods. Opposite data were reported by Verbeke [43], namely that consumers prefer health benefits of functional foods than the taste. Such an observation was also found in this study.

**Figure 2.** PCA (Principal Component Analysis) matrix of the mean sensory attributes achieved using the QDP (Quantitative Descriptive Profile) method, TC—dough with the tomato addition, PC—pumpkin addition and BC—beetroot addition; o.—odour, f.—flavour, t.—taste.
Nevertheless, the discussion on health-promoting food and consumer preferences indicates that the taste characteristics of the product are of great importance.

The presented study showed that the addition of different vegetables such as tomato, pumpkin, and beetroot to gingerbread dough enables the production of cakes with satisfactory sensory values that are acceptable to consumers.

4. Conclusions

Gingerbread cake with tomato contained the most polyphenols (39.02 mg GAE/100 g), and the highest total antioxidant activity was observed in the gingerbread cake with the addition of beetroot (30.44 µM TEAC/g of product). Moreover, the addition of beetroot reduced the acceptability of all examined attributes in comparison to the other studied samples. The gingerbread dough with the addition of tomato (TC) was also the most acceptable, and the acceptability of evaluated features in the case of the sample was high. It can be concluded that it is possible to produce gingerbread cakes with a 25% addition of pumpkin, tomato, and beetroot puree and obtain gingerbread dough while maintaining good sensory quality and showing the characteristics of health-promoting functional food (antioxidant properties due to polyphenols present in vegetables).

This experiment needs continuation and for further studies, changes in cakes during storage should be examined. Moreover, different packaging methods should be taken into account.

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