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IMPROVEMENT OF THE QUALITY CHARACTERISTICS OF SEMI-FINISHED SPONGE CAKES BY USING APPLE POMACE POWDER

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Abstract. This study aims to assess the effect of powdered apple pomace on the technological characteristics of batter, and on the physicochemical and sensory quality characteristics of sponge cake. Apple pomace powder (10%, 25%, and 50 %) was introduced into the sponge cake formulation, where it replaced an equivalent amount of wheat flour. Assessment of the viscous properties of the composite flour has shown that the peak viscosity ranged from 330.00 to 731.00 Brabender units (BU) and its value decreased with an increase in the mass fraction of apple pomace powder. The gelatinisation temperature for the mixtures ranged 60.50–61.7°C and slightly decreased after adding by-products of apple processing. It has been found that the specific gravity of sponge cake batter increases when pomace powder is used (from 0.72±0.02^{c} to 0.78±0.03^{d}), which is due to the increase in the dietary fibre. The findings have shown that the volume of the cake samples containing apple pomace was smaller than that of the control sample (245.00±6.22 cm^3), and the cake with 50% of apple pomace powder had the smallest volume (215.00±7.32cm^3). The highest porosity was observed in the control cake sample (66.34±1.72%), while in the cake with 25 % of apple pomace powder, this parameter was 65.15±1.07%. The water absorption capacity of the control (312.60±3.15%) is the lowest compared with that of the cakes with apple pomace powder. Adding apple pomace resulted in a more intense brownish colour of the cakes and in the pleasant fresh apple taste. The semi-finished sponge cakes with 25% and 50% of apple pomace were characterised by an attractive brown colour, small-sized, properly distributed pores in the crumb, and high sensory characteristics. It can be concluded that powdered apple pomace can be successfully used as a functional and nutritionally valuable substitute for wheat flour, without a significant deterioration in the technological quality of products.

Keywords: apple pomace, sponge cake, functional component, technological properties, quality.

Introduction. Formulation of the problem

Bakery products, such as bread, biscuits, and cakes, are a large family of popular food products. A wide range of people all over the world consume them due to their varied flavours, a relatively long shelf-life, and low cost. These products can be enriched with vitamins, minerals, protein, polyphenols, and fibre by the incorporation of rich sources and carriers of these substances. The food industry produces significant amounts of by-products, and their disposal is quite a problem. Usually, these products are used in animal feeding. However, the high content of bioactive components makes them usable in food products [1]. Due to the growing interest in utilising by-products, it is necessary to study how their inclusion in the composition of sponge cake affects its quality characteristics.

Analysis of recent research and publications

Cake is considered a semi-dry spongy food item containing air pockets in a starch and protein network. Cake is prepared by using different constituents like eggs, flour, sugar. Each ingredient in cake performs a specific function. The final quality of the cake is determined by the different formulations used in it [2].

By-products from the food industry can be of high nutritional value. This holds good for apple pomace, a by-product that appears in the course of production of apple juice [3].

Apple pomace is composed of the solids remaining after extraction of juice, mostly peel, cores, seeds, and flesh. It is used for extraction of citric acid, pectin, alcohol and biofuels [4]. Conventional apple juice production results in juice that is poor in phenolic compounds (only 3% to 10% of the antioxidant activity of the fruit), because most of the compounds remain in the apple pomace, thus making it a good source of antioxidants. Apple pomace typically consists of 1.2–10.8% of moisture, 0.5–1.9% of ash, 2.4–7.3% of protein, 1.6–4.5% of fat, and 51.1–89.8% of total dietary fibre, which includes 36.5–81.6% of insoluble fibre and 4.14–14.6% of soluble fibre [5,6]. Dietary fibre is the remnants of the edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in the human small intestine and are completely or partially fermented in the large intestine. It includes polysaccharides, oligosaccharides, lignin polyphenols, and associated plant substances [7]. These components have positive and beneficial effects on health [8]. Also, polyphenols in apple pomace were reported to be beneficial in reducing the risks of certain chronic diseases such as hypercholesterolaemia and certain types of cancer [9].

It was studied whether apple powder could be used in the gluten-free bread technology. It was found that the introduction of 5% of powder provided high organoleptic characteristics of products and increased the content of polyphenols. Based on the experimental data about high antioxidant potential of apple pomace, it was recommended to add enriched products into the diet for the consumers with coeliac disease to reduce oxidative stress and prevent chronic non-communicable diseases and even cancer [10].

It was suggested that apple pomace should be used in bakery and pastry production. Adding up to 20% of this raw material in the muffin recipe led to the improvement of the sensory characteristics of the final product – colour, taste, and texture. Also, enriched products were rich in dietary fibre, had a high total polyphenolic content and a high level of antioxidant activity. The chemical composition of powdered apple pomace also made it possible to suggest using it in jelly confectionery products and biscuits with a reduced sugar content [11].

It was examined whether it was possible to replace 5–15% of rice flour with apple (APP), carrot (CPP), and orange (OPP) pomace powders in the recipe of gluten-free cake. The batter used in the cake with the powders was characterised by a higher fibre, ash, protein, and sugar content, as compared with the control samples, which led to an increase in the density and viscosity of the batter. The samples enriched with apple pomace powder were darker-coloured and had the lowest L* value. The sensory evaluation results showed that using over 10% of APP and CPP produced a negative effect on the overall acceptability of the final products. The highest overall quality scores were obtained for the cakes with 5% of OPP added [12].

P. Sobczak *et al.* suggested utilising waste (apple pomace) according to the requirements of the sustainable agriculture system. A line of food products containing apple by-products and wheat bran was developed. These products and the technologies implemented (heat treatment in a convection oven, treatment with infrared radiation, and two types of barothermal treatment – extrusion and granulation) allow using these solutions for small processing facilities. It was found that a mixture of 75% of apple pomace and 25% of wheat bran, obtained by infrared radiation treatment, has a positive effect on the wholesomeness of the products obtained [13].

The by-product of apple juice processing (5–25%), as a rich source of various bioactive components and fibre, was suggested for the production of biscuits. The width of the samples that were prepared based on a mixture of apple pomace powder and wheat flour ranged from 44.75 mm to 45.13 mm. The use of the raw material suggested positively affected the content of ash (0.47±0.05–0.62±0.02%) and crude fibre (1.05±0.01–2.61±0.18%) in the finished products [14]. Based on the above, using apple pomace to produce pastry and flour-based products is a prospective solution for the fortification of this group of products with essential nutrients. Still, there is not enough information about the technological properties of wheat flour and apple pomace blends used to produce sponge cake. That is why, in our opinion, this research is topical, because it considers these issues by studying the effect of different doses of wheat flour and apple pomace blends on the quality of sponge cake.

The purpose is to study the quality of sponge cake enriched with powdered apple pomace as a substitute for wheat flour in cake production.

For this purpose, it is necessary to achieve the following **objectives**:

– to make sponge cake samples based on flour mixed with different quantities of apple pomace powder;

– to study how combining wheat flour and apple pomace affects the viscous, physical, and colour parameters of the sponge cake;

– to evaluate the sensory properties of the sponge cake samples with and without apple pomace added.

Research materials and methods

2.1. Materials

Preparation of apple pomace powder

Commercial apples (variety *Red Delicious*) were refrigerated and stored until juice processing. Apple pomace was obtained by washing, coring, and chopping the apples, and separating the juice from the pomace using a juice extractor. Then, the pomace from the extractor was washed twice with warm water (30°C) and dried at 60°C in a tray dryer. The dried pomace was ground using a hammer mill. Apple pomace powder was added to commercial wheat flour in the ratio 10:90, 25:75, and 50:50. The flour blends were packed and stored in a refrigerator at 4°C till used [15].

Preparation of sponge cakes

Standard raw materials such as wheat flour, sugar, and eggs used in the current study were manufactured in Bulgaria and authorised by the Ministry of Health. The control cake was prepared according to the traditional technology and formulation [16]. The formulation of the control cake batter was as follows (based on the flour weight): egg yolk 43.23%, egg white 96.77%, refined granulated sugar 83.87%, and wheat flour 100%. In particular, the procedure of double mixing was applied by whipping egg whites and yolks separately. The apple pomace powder was added to sponge cakes in different quantities (10%, 25%, and 50%) and replaced the equivalent amounts of wheat flour. 75 g portions of sponge cake batter were poured out into metallic forms and baked in an electric oven at 180°C for 30 min.

2.2. Methods

Viscous properties of the composite flour

The viscous properties of the composite flours containing wheat flour and powdered apple pomace in the ratios 90:10, 75:25, and 50:50 respectively were evaluated with a Micro Visco-Amylo-Graph (Brabender OGH, Duisburg, Germany), and the viscosity was expressed in Brabender units (BU). The following data were recorded: gelatinisation temperature (°C), peak viscosity (BU), peak temperature (°C), breakdown viscosity (BU), and setback viscosity (BU). All the tests were performed in triplicate [17].

Physical and colour characteristics of sponge batters and cakes

The specific gravity of the sponge cake batter was calculated by dividing the weight of a standard batter cup by the weight of an equal volume of distilled water at the batter temperature 20°C [18].

The physical characteristics of the sponge cakes were determined 2 hours after baking. The volume was measured by the small uniform seed displacement method [19], and the porosity was assessed according to Goranova *et al.*, 2020 [15]. The porosity of the sponge cake was defined as the ratio of the volume of air pockets in the cake crumb to the volume of the crumb, and determined using a calibration cylinder (Zhuravliov's probe). The specific volume was expressed as the ratio of the sponge cake volume to its weight. The water absorption capacity of the sponge cake was measured by the extent of swelling of the cake, according to Goranova *et al.*, 2020 [20].

The baking loss was calculated by the following formula after measuring the weight of the batter (BW) and that of the cake (CW), according to Hathorn *et al.*, 2008 [21]:

$$\text{Baking loss} = \frac{BW - CW}{CW} * 100 \qquad (1)$$

The instrumental measurement of the colour of the cake was carried out with a colorimeter, and the results were expressed in the CIELAB system. The colour was measured in four predetermined places of the sponge cake's crust and crumb. The parameters determined were L* (-L* = 0 [black] and +L* = 100 [white]), a* (–a* = greenness and +a* = redness), b* (–b* = blueness and +b* = yellowness). Colorimeters give measurements that can be correlated with human eye-brain perception, and allow obtaining tristimulus (L*, a*, and b*) values directly.

The total colour difference (ΔE*) between the control cake and the sponge cakes with the functional ingredients was calculated as follows:

$$\Delta E = \sqrt{(\Delta L)^{*2} + (\Delta a)^{*2} + (\Delta b)^{*2}}, \qquad (2)$$

as: $\Delta L^* = L_1 - L_0$; $\Delta a^* = a_1 - a_0$; $\Delta b^* = b_1 - b_0$,

where L_0, a_0, and b_0 are values for control samples, and L_1, a_1 and b_1 are values for sponge cakes with apple pomace powder.

The values used to determine if the total colour difference was visually obvious were the following.

ΔE* < 1 – colour differences are not obvious to the human eye;

1 < ΔE* < 3 – colour differences cannot be evaluated with the human eye;

ΔE*>3 – colour differences are obvious to the human eye [22, 23].

Sensory evaluation

A descriptive test for quantitative sensory profiling was used to establish the sensory characteristics (shape, colour, cell size and uniformity, smell, sweetness, aftertaste, crumb tenderness) of the sponge cakes, 6 hours after baking, according to the methods provided for by ISO 8586:2014 and ISO 13299:2016. The sponge cake samples were prepared 1 h before the evaluation. Samples of different cakes were kept in coded plates covered with aluminium foil. Twelve trained panellists were selected to guarantee the evaluation accuracy. The intensity of each sensory characteristic was recorded on a ten-point linear scale after 1 h orientation sessions, where the panellists specified the terminology and the anchor points on the scale. The coded samples were shown simultaneously and evaluated by the panellists in random order.

Statistical analysis

All experiments were performed in triplicate. The data were analysed and presented as mean values ± standard deviation. Statistical analysis was conducted using the software Statgraphics Centurion XVI Version 16.2.04 (Statpoint Technologies Inc., USA). Analysis of variance (ANOVA), including Levene's test and Multiple Range Test, were used to determine significant differences at the confidence level 95% (p<0.05).

Results of the research and their discussion

The developed recipe composition of sponge cake with apple pomace added was prepared by replacing wheat flour with apple pomace powder in the quantity 10%, 25%, and 50%. The recipe compositions of the control sample and the cakes under study containing powdered apple pomace are presented in Table 1.

The stages of technology were kept because of their easiness and quite small duration of the technological cycle. The sponge cake samples containing apple pomace powder were processed under constant baking conditions concurrent with those of the control sample, which, according to the technological guidelines, was baked for 30 min at 180 °C.

Viscous properties

The viscous characteristics of the composite flour blends are shown in Table 2. The peak viscosity (the maximum viscosity developed during or soon after the heating stage of the test [24]) ranged from 330.00 to 731.00 BU and decreased with an increase in apple pomace powder. This may be due to the swelling capacity of the starch granules in apple pomace and wheat flour. The low peak viscosity seen in some composite blends indicates that the flour blend without modifications is suitable for the preparation of complementary foods.

The peak viscosity, which shows the maximum swelling of a starch granule before disintegration, is also described as the equilibrium point between swelling and breakdown of the granules. The viscous properties are greatly influenced by a plant source, starch content, interaction among the components, and testing conditions [25]. Hoover, 2001 [26] stated that granules with a high peak viscosity had weaker cohesive forces within than those with lower values and would disintegrate more easily.

The breakdown viscosity of the apple pomace powder, a measure of the resistance to heat and shear, varied significantly between 59.50 BU (50% AP + 50% WF) and 205.50 (100% WF). Since breakdown viscosity is an estimation of the paste’s resistance to disintegration in response to heat and shear, lower breakdown viscosity shows greater resistance which would be expected of flours with lower peak viscosities [27].

Setback viscosity is defined as the difference between the breakdown viscosity values and determines the tendency of starch to retrogradation. The setback values differed significantly ($p<0.05$) between 241.00 BU (50% AP + 50% WF) and 508.50 BU (100% WF). The higher the setback value, the lower the retrogradation during cooling, and the lower the staling rate of the products made from the flour [28].

Final viscosity (FV) measures the ability of the starch to form viscous paste, or gel, after cooking and cooling [29]. The final viscosity of the flours ranged from 504.50 BU to 950.00 BU, and that of the composite flours decreased as the percentage of apple pomace added increased. This may be due to the high carbohydrate content in both flours. This marked increase could result from the alignment of the chains of amylose in the starch.

Gelatinisation temperature depends on the size of the starch granules in the flour: small starch granules are more resistant to rupture and loss of molecular order [30]. Gelatinisation temperature is the temperature at which the first detectable increase in the viscosity is measured, and it is a parameter characterised by the initial change due to swelling of starch [31].

Table 1 – Formulations of sponge cakes (amounts based on the flour weight)

Ingredients	Sponge cakes			
	Control sample	Cake with 10% of apple pomace powder	Cake with 25% of apple pomace powder	Cake with 50% of apple pomace powder
Yolk of egg, [%]	43.23	43.23	43.23	43.23
White of egg, [%]	96.77	96.77	96.77	96.77
Sugar, [%]	83.87	83.87	83.87	83.87
Wheat flour, [%]	100.00	90.00	75.00	50.00
Apple pomace, [%]	–	10.00	25.00	50.00

Table 2 – Viscous properties of flour

Apple pomace powder (%)	Peak viscosity (BU)	Breakdown (BU)	Setback (BU)	Final viscosity (BU)	Gelatinisation temperature (°C)
0	731.00±31.82[a]	205.50±2.12[a]	508.50±2.12[a]	950.00±5.66[a]	61.78±0.11[a]
10	668.00±19.80[b]	193±15.56[b]	467.50±13.44[b]	916.00±19.80[b]	61.55±0.92[a]
25	542.00±33.94[c]	147.50±17.68[c]	339.50±16.26[c]	720.50±33.23[c]	60.50±0.57[ab]
50	330.00±2.83[d]	59.50±2.12[d]	241.00±0.00[d]	504.50 ±0.71[d]	60.70±0.57[ab]

[a–d] Values in the same column with different letters are significantly different ($p<0.05$).

Table 3 – Physical characteristics of sponge batters and cakes[a]

Physical characteristics	Sponge cakes			
	Control sample	Cake with 10% of apple pomace powder	Cake with 25% of apple pomace powder	Cake with 50% of apple pomace powder
Specific gravity (for batter)[b]	0.72±0.02[c]	0.75±0.04[d]	0.76±0.01[d]	0.78±0.03[d]
Volume, cm³	245.00±6.22[c]	233.00±3.17[c]	238.00±3.82[c]	215.00±7.32[d]
Specific volume, cm³/g	3.27±0.10[d]	3.11±0.211[c]	3.17±0.14[c]	2.87±0.13[e]
Porosity, %	66.34±1.72[c]	64.72±1.65[c]	65.15±1.07[c]	61.12±1.22[d]
Water absorption capacity, %	312.60±3.15[c]	323.27±3.42[d]	327.86±4.03[d]	331.43±4.20[e]
Baking loss, %	16.22±0.15[c]	14.33±0.12[d]	13.86±1.15[de]	13.07±0.55[e]

[a] The values are mean ±SD; values in the same column with different letters are significantly different (p<0.05).
[b] The temperature of the batter is, on average, 23.7±0.5°C.
[c–e] The values in a line with identical letters have no statistically significant difference (p<0.05).

A high gelatinisation temperature usually means that the flour has high water absorption capacity. The gelatinisation temperature ranged from 60.50°C to 61.78°C and decreased as the percentage of apple pomace increased in the composite flours.

Specific gravity in the cake batter indicates the total air-holding capacity of the batter. Low specific gravity values indicate good incorporation of air resulting in a higher final volume after baking. However, many other factors also affect this quality parameter. The difference in the specific volume between the control cake sample and the sponge cakes with 10% and 25% of apple pomace is minimal. Cakes with higher specific volumes generally lose more water during baking because they have a greater surface area that contacts with air [22]. The occlusion of air cells in the batter during mixing produces an aerated emulsion, or foam, which is converted into a semi-solid, porous, and soft structure during baking. The volume of the finished cake depends on air incorporation and retention, and these are influenced by the viscosity of the batter and the distribution of air cells inside the batter matrix [32]. The volume of cake indicated the ability of the batter to expand and incorporate gas during the baking process.In this study, the volume of the cakes with apple pomace was smaller than that of the control (245.00±6.22 cm^3), as the volume of the cake with 50% of apple pomace powder had the smallest volume (215.00±7.32 cm^3). The greatest porosity was observed in the control cake (66.34±1.72%) and in the cake with 25 % of apple pomace powder (65.15±1.07%). The water absorption capacity of the control cake (312.60±3.15%) is the lowest, as compared with that of the cakes with apple pomace powder.

Gas formation during baking caused an increase in the vapour pressure, which might be due to the expansion of liquids when heat was applied to the batter. The loss of gas during baking is called “baking loss” [33]. Baking losses of all the samples were within the range 16.22–13.07%. The cakes with apple pomace had lower baking loss and were statistically different from the control. Addition of apple pomace and wheat flour mixed could therefore strengthen the batter matrix by the formation of strong viscoelastic films surrounding the air bubbles. This can help entrap and hold more gas during the expansion of the cake matrix throughout the baking process. Mohamed *et al.*, 2010 [34] reported that green banana flour components with high water-binding capacity, especially insoluble fibre (lignin, cellulose, hemicellulose), could cause water intake from other ingredients in the product’s formulation. They also reported that high percentage substitution of green banana flour leads to high water intake from other ingredients in the product’s formulation, and this adversely affects the quality characteristics of the dough and the finished product (volume, hardness, colour). In another study (Alkarkhi *et al.*, 2011 [34]), a decrease in baking loss with an increasing level of powdered green banana peel used as a substitute may result from high water absorption capacity (4.91–5.88 g water/g dry matter), which is a functional characteristic of green banana flour.

Colour characteristics of the sponge cakes

Colour is one of the most important characteristics showing whether foods are acceptable, because it determines a consumer’s expectations for the freshness and flavour of food. Especially important it is for consumer’s acceptance of bakery products. In this study, colour measurements including the L* (light/ dark), a* (green/blue), and b* (red/yellow) values of the crust and crumb of the sponge cakes with different apple pomace levels are shown in Fig. 1 and 2. In general, the colour of baked products depends on the physicochemical characteristics of the dough (water content, pH, reducing sugars, and amino acid content), baking time, and temperature of baking [35].

The results of the instrumental colour analysis of the experimental samples are shown in Fig. 1 and 2. The values of the parameters *L*, *a**, and *b** for the crust and crumb of the control sample were significantly (p<0.05) different from those observed in the sponge cakes with apple pomace. The crust and crumb of the control cake were characterised by the highest lightness (58.50 and 59.51 respectively) and redness (9.90 and 0.96 respectively), but yellowness in the crumb (positive *b** value) was significantly (p<0.05) lower in comparison with the cakes containing apple pomace.

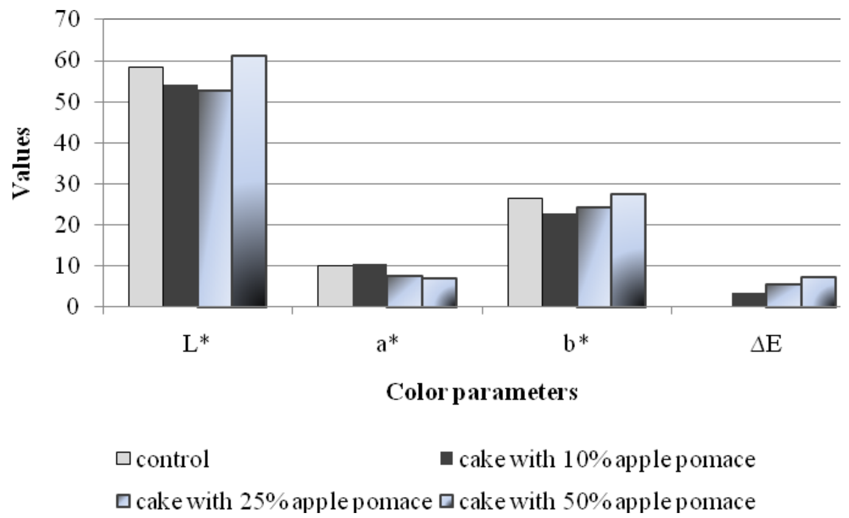

Fig. 1. Crust colour parameters of the sponge cakes

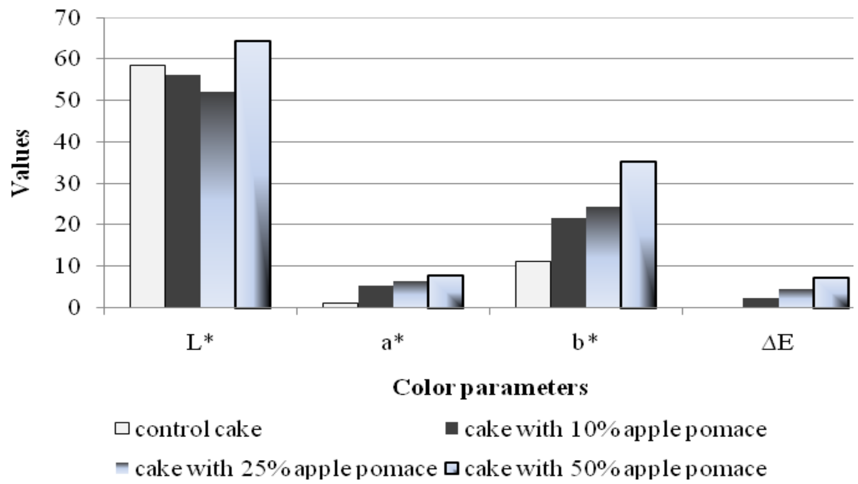

Fig. 2. Crumb colour parameters of the sponge cakes

As expected, due to its vivid brown colour, apple pomace applied in the formulation significantly influenced the colour of the finished cake. The crust and crumb of the experimental sponge cakes containing apple pomace also had the highest values of brown (parameter *a**) that increased gradually with an increase in the content of golden brown pomace. According to these results, in the cakes with apple pomace powder, the ΔE* was appreciable by the human eye (ΔE*>3). However, the yellowness of the crust and crumb decreased with an increase in the amount of apple pomace in the formulation. Pigmented ingredients (apple by-products) significantly influence the colour of the finished products.

The colour difference, ΔE* was used to show the influence of adding fibre. According to statistical analysis, there was a significant difference in the crust colour of the cakes having different concentrations of fibre ($p \leq 0.05$). The colour of the crumb and crust of cake is mainly associated with the Maillard and caramelisation reactions. However, the incorporation of insoluble fibre did not alter the number of sugars and amino acids [36]. There was a significant difference between the crust colour of the cakes containing apple pomace and of the control cake ($p \leq 0.05$). This fact could be due to the original colour of apple pomace. Gómez *et al.*, 2003 [37] examined the effects of different fibre types on the crust colour and did not find any significant difference in the crust colour of cakes containing fibre (orange, pea, wheat, and cellulose) and the control cake ($p > 0.05$). However, when cocoa and coffee fibre was used, cakes with lower lightness were obtained due to the original colour of the fibre. For the same reason, Bchir *et al.*, 2014 [38] found that bread enriched with date fibre had a darker colour than the control cake.

The change in the colour was primarily due to the naturally occurring polyphenol oxidase found in both apple pomace and wheat flour. Polyphenol oxidase is the catalyst of the enzymatic browning reaction and triggers the generation of dark pigments in fruit and vegetables. In apples, phenolics such as catechin, epicatechin, and chlorogenic acid are the substrates for polyphenol oxidase, and oxidation results in the browning of apples after cutting. In ripe apples, polyphenol oxidase activity was reported to range from 69.2 to 1,307.9 (units/100 g fresh weight) depending on the apple variety. In contrast to apples, comparatively low polyphenol oxidase activity exists in wheat, which was reported to be around 1 AU depending on the wheat variety [6].

Sensory evaluation

The sponge cakes enriched with apple pomace have good sensory characteristics presented in Fig. 3.

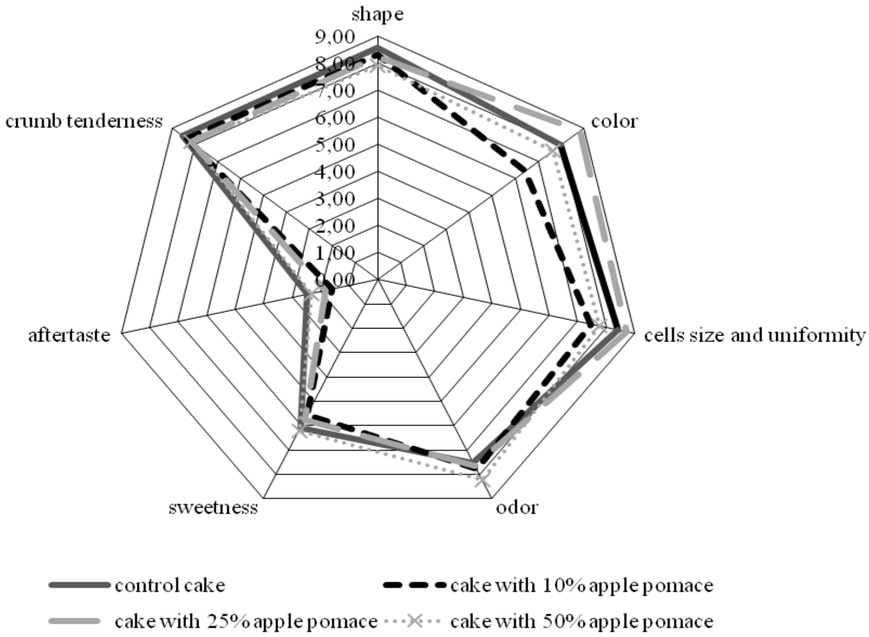

Fig. 3. Sensory characteristics of the sponge cakes

The sensory analysis demonstrates that the structure is fine-porous in all kinds of the sponge cake investigated. The control cake and the samples with apple pomace have an approximately similar shape. The pores in the crumb of the cakes with apple pomace in the three kinds of cake investigated have thicker walls and are small and equal in size. The smell of the cakes with apple pomace is perceived as more pleasant than that of the control sample. The colour of the cakes with apple pomace is perceived well by the testers. The intensity of sweetness in all sponge cakes investigated is similar. Cakes with 25% and 50% of apple pomace were characterised by an attractive brown colour, small size, and proper distribution of pores, and were distinguished for their desirable sensory quality.

It has been observed that the higher crumb tenderness scores for the control increased the overall liking values. The crumb pores of the cake with 50% of apple pomace had thicker walls, were larger and equal in size. These results are also consistent with findings of Sudha *et al.*, 2007 [39], who stated that the grain size of the cake decreased with apple pomace added. The cells of the control sponge cake were smaller and almost uniformly distributed in the crumb, and had thinner walls. The control had a crust and crumb with a more pronounced light-yellow colour due to the presence of the colour components in the yolks of the eggs (carotenoids). The colour of the crust and crumb of the cakes with 10%, 25%, and 50% of apple pomace powder are light-brown, with a brown shade. The smell of all cakes was perceived by the sensory panellists as pleasant. The intensity of the sweetness of all the sponge cakes investigated is similar.The colour of any product is the first thing a consumer perceives when choosing a product. The mean values indicate that the lightness of the cake decreased with an increase in the apple pomace concentration. These results are also in conformity with Sudha et *al.*, who stated that the lightness of the cake significantly decreased with apple pomace added. The results of assessing the sensory characteristics of the sponge cake where flour was partially replaced with up to 50% of powdered apple pomace are satisfactory.

Conclusion

This study has demonstrated that apple by-products can be used to produce apple pomace powder, which can be further applied as an ingredient in sponge cake. Apple pomace powder can be successfully used as a functional and nutritionally valuable substitute for wheat flour, even in quantities of up to 50%, without a significant deterioration in the technological quality of sponge cake. The research results have shown that adding apple pomace slightly decreased the specific gravity, volume, and porosity of the cakes but still produced highly acceptable cakes with an attractive brownish colour and a pleasant specific flavour. The viscous properties of the composite blends decreased as the percentage of apple pomace increased. Based on this, we consider that the newly prepared products have good qualitative characteristics and are suitable as intermediate products in confectionery intended for rational and functional nutrition.

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ПІДВИЩЕННЯ ЯКОСТІ БІСКВІТНИХ НАПІВФАБРИКАТІВ ЗА РАХУНОК ВИКОРИСТАННЯ ПОРОШКУ ЯБЛУЧНИХ ВИЧАВКІВ

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Анотація. Метою дослідження було оцінити вплив порошку яблучних вичавків, на технологічні характеристики тіста, фізико-хімічні та сенсорні показники якості бісквітів. Порошок яблучних вичавків (10%, 25% і 50%) було включено до рецептури бісквітних напівфабрикатів при заміні еквівалентної кількості пшеничного борошна. Оцінка в`язкісних властивостей композитних сумішей показала, що максимальна в`язкість клейстеру становила від 330,00 до 731,00 од. Брабендера та її значення зменшувались з підвищенням масової частки порошку з яблучних вичавків. При цьому, температура клейстеризації для сумішей знаходиться у діапозоні 60.50–61.78°C та несуттєво знижується при внесенні продуктів переробки яблук. Встановлено, що питома густина тіста для бісквітів збільшується при внесенні порошку (від $0.72{\pm}0.02^{c}$ до $0.78{\pm}0.03^{d}$), що обумовлено підвищенням вмісту харчових волокон. (Результати показали, що об’єм виробів з яблучними вичавками був меншим, ніж у контрольного зразку (245,00 ± 6,22 $см^3$), при цьому найменшим об’ємом характеризувався бісквіт з 50% яблучного порошку (215,00 ± 3 $см^3$). Контрольний зразок характеризувався найбільшою пористістю (66,34 ± 1,72 %) та для зразку з 25 % порошку яблучних вичавків даний показник становив 65,15 ± 1,07 %. Водопоглинальна здатність контрольного зразку (312,60 ± 3,15%) є найнижчою, порівняно з бісквітами, які збагачені порошком яблучних вичавків. Внесення яблучного порошку сприяло тому, що зразки набули більш насиченого коричневого кольору і приємного смаку свіжих яблук. Бісквітні напівфабрикати з 25% і 50% яблучних вичавків характеризувалися більш привабливим коричневим кольором, дрібнопористою м`якушкою, високими сенсорними характеристиками. Можна зробити висновок, що порошок яблучних вичавків може бути використаний як перспективний функціональний інгредієнт для заміни пшеничного борошна, використання якого не призводить до суттєвого погіршення якості бісквітів.

Ключові слова: яблучні вичавки, бісквітні напівфабрикати, функціональний компонент, технологічні властивості, якість.