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RESEARCH ARTICLE

An Attempt to use Black Chokeberry Pomace in the Production of Hamburgers

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Abstract

The aim of the study was to assess the possibility of using chokeberry pomace *(Aronia melanocarpa)* in amounts ranging from 0.5% to 7.0% in the production of minced meat products, such as pork hamburgers. The raw material composition of the hamburgers included pork ham (65%) and pork jowl (35%). In relation to the total weight of meat and fat raw materials, 1.5% of table salt and black chokeberry pomace were added to the batter in an amount of 0.5; 1.0; 2.0; 3.5; 5.0 and 7.0%. Chokeberry pomace was added to the batter in the form of shredded 'paste'. The control product did not contain pomace. The hamburgers were formed using a hand moulder and baked in a combi-steamer oven. The analytical scope of the work included: determination of the thermal losses of products and measurement of the change in the diameter of products after baking ('shrinkage'), instrumental measurement of cutting force and color parameters (CIEL*a*b*), determination of the content of basic chemical components using the instrumental method, as well as the organoleptic evaluation of products after baking. It was found that the inclusion of black chokeberry pomace in the form of 'paste' in the raw material composition of pork hamburgers is possible from a technological point of view. The modifications used in the raw material composition of hamburgers had an effect on the quality of this meat product. Despite the relatively small differences between the mean values, they were statistically significant ($p \leq 0.05$) for most of the quality attributes assessed. Based on the obtained results of physical, chemical and organoleptic quality characteristics, it was concluded that the acceptable addition level of chokeberry pomace to the batter for pork hamburgers with the raw material composition adopted in the study could be 2.0%.

KEYWORDS
hamburger, pork, black chokeberry, fruit pomace, quality features

Introduction

The utilization of waste products generated in the food industry, i.e. parts of raw materials not used in the technological process, is a topical issue in food science. Undertaking research in this area is fostered by, in particular, the growing concern for the state of the natural environment and the search for an ideal model of sustainable production and consumption ['Aqilah et al. 2023, Diez-Sánchez et al. 2023]. One of the by-products that are already finding applications in the production of various foodstuffs is fruit pomace. Among the methods of managing these waste products, their use as a raw material for the isolation of bioactive compounds is often mentioned. Furthermore, pomace in a more or less processed form, i.e. shredded or dried, can be an ingredient that improves the nutritional value and/or extends the shelf life of a food product [Kawecka, Galus 2021, Kitrytė et al. 2017].

Due to the high supply and high content of bioactive substances, pomace from black chokeberry *(Aronia melanocarpa)* has attracted the attention of researchers [Sidor, Gramza-Michałowska 2019, Sójka et al. 2013]. Little information has been found in the available literature regarding the applicability of raw, i.e. slightly processed (e.g. shredded), fruit pomace to minced meat products. The subject of previous research has mostly been the potential application of dried fruit or vegetable pomace in meat processing [Skwarek, Karwowska 2022, Tarasevičienė et al. 2022, Peiretti et al. 2020, Savadkoohi et al. 2014] or extracts obtained from these waste products [Babaoğlu et al. 2022, Tamkutė et al. 2021, Garrido et al. 2011]. These works however, were mainly aimed at assessing the possibility of reducing fat oxidation, slowing down microflora growth and improving the health-promoting properties of meat products.

It is expected that it will be technologically feasible to enrich a product made from minced meat with a plant-based ingredient, such as fruit pomace. However, the differences in properties between the raw meat material and the raw plant-based material should give rise to a justified expectation of an impact of the addition of fruit pomace on the quality of the meat product. Therefore, the aim of this study was to assess the possibility of using black chokeberry *(Aronia melanocarpa)* pomace in amounts from 0.5% to 7.0% (in relation to the weight of meat and fat raw materials) for a meat product from the convenience food category, which were pork hamburgers, as well as to evaluate the effect of the applied changes in the raw material composition of the meat product on some selected quality features.

Materials and Methods

Study material

The study material were pork hamburgers, differing in the amount of black chokeberry pomace added. The raw material composition of the burgers included ham pork (65%) and pork jowl (35%). Relative to the total weight of the meat and fat raw materials, 1.5% of table salt and black chokeberry pomace were added to the meat batter at 0.5; 1.0; 2.0; 3.5; 5.0 and 7.0%. The control product (W1) did not contain added pomace. Hamburgers with added chokeberry pomace were coded from W2 to W7, respectively from the smallest to the largest amount of pomace in the raw material composition.

Two separate series of experiments were performed in the Department of Meat Technology of the Warsaw University of Life Sciences (WULS).

Purchases of fresh raw meat and fat were made at the Makro Cash and Carry wholesale store on the day of burger production. The pomace from black chokeberry *(Aronia melanocarpa)* of the Nero variety in the form of vacuum-packed and frozen at the temperature of –(20 ± 1)°C, was obtained from the Department of Fruit, Vegetable and Cereal Technology of the WULS. When starting the production of pomace, fresh chokeberry fruits were washed and then pressed in a BUCHER Unipektin AG HPL 14 laboratory hydraulic press (Bucher Unipektin AG, Niederweningen, Switzerland). A drainage filter recommended for pressing berries and pome fruits was used. A 10 kg portion of fruit was pressed using the pressure of 5 bar. The process of pressing juice from the fruit batch was carried out in three cycles. After each cycle, the material was loosened to increase the efficiency of the pressing process and at the same time reduce the water content in the pomace. The content of water or other chemical components in the pomace was not determined. Immediately prior to use, i.e. on the day of the burger production, chokeberry pomace in the amount necessary for a given experimental series was defrosted in a microwave oven and then shredded to a 'paste' consistency in a Thermomix® device (Vorwerk, Warsaw, Poland).

The meat and fat raw materials were ground separately in a Mesko WN40 laboratory grinder (Mesko AGD Sp. z o.o., Skarżysko-Kamienna, Poland), equipped with a grinding set with a sieve with a hole diameter of 4.5 mm. The weighed raw materials were mixed in a Kenwood Major KM800 mixer (Kenwood Ltd., Havant, UK) for 5 min to obtain the meat batters. The ingredients were added to the mixing bowl of the mixer in the following order: ham meat and table salt first, followed by jowl and chokeberry pomace. The burgers were formed using a hand moulder (Hendi BV, Rhenen, the Netherlands) and baked in a Rational SCC WE61 combi steamer (Rational AG, Landsberg am Lech, Germany), in air at 180°C (relative humidity 10%). Thermal processing was carried out until the temperature in the center of the product reached 80°C. The burgers were cooled at room temperature (approx. 18°C) for 30 min, placed on metal trays, covered with aluminum foil and stored in a cold room (temp. +4°C±1°C) until the next day.

Research methods

On the day of production, the culinary quality features, i.e. weight losses and the change in the diameter of the products after baking ('shrinkage'), were measured in the hamburgers, while the other quality features of the hamburgers were assessed on the day after production.

Weight losses after heat treatment (thermal losses) of the burgers were determined using the weighing method. A batch of meat products was weighed with an accuracy of 0.01 g before and after baking (and cooling), and the result was expressed as a percentage in relation to the weight of the raw product.

For each hamburger variant, the change in diameter after baking ('shrinkage') was calculated by measuring the diameter of three randomly selected pieces of product before and after baking (and cooling). Measurements were taken using a caliper with an accuracy of 0.01 mm and the result was expressed as a percentage of the raw product diameter.

The pH was measured using a temperature-compensated digital bayonet pH meter Testo 206-pH2 (Testo SE & Co. KG, Titisee-Neustadt, Germany). The measurement sample was prepared by weighing it in a beaker 10 g (±0.01 g) of meat product ground in a meat grinder equipped with a sieve with a 2 mm diameter hole and mixing with 30 mL of distilled water. The measurement was performed by dipping an electrode into the beaker with the sample and the measurement result was read on the display of the measuring instrument. In each series of experiments, the measurement was performed in duplicate for each hamburger variant.

The shear force in the hamburgers was measured using a Zwicki 1120® universal testing machine (Zwick GmbH & Co., Ulm, Germany). A measuring head equipped with a flat blade knife was used. The speed of movement of the measuring head during the test was 50 mm/min, the initial force was 0.5 N, and the force deactivation threshold was 50% of the maximum force recorded during the test. The maximum shear force recorded when the knife cut through the product sample was taken as the measurement result. Samples were cut from the burgers in a shape similar to a cuboid, i.e. approximately 10 cm long (product diameter), 3 cm wide and approximately 0.8 cm thick. In each series of experiments, the measurement was carried out in eight repetitions for each hamburger variant.

The CIEL*a*b* color parameters were measured on the surface of the hamburgers. A Konica Minolta CR-200 colorimeter (Osaka, Japan; 8 mm measuring aperture diameter, D65 light source, 2° observer) was used. The instrument was calibrated on a white plate standard (L* = 99.18, a* = −0.07, b* = −0.05) before measurement. In each series of experiments, the measurement was performed at six different points for each hamburger variant. In addition, the total color difference ΔE [Mokrzycki, Tatol 2011] was calculated between the products containing chokeberry pomace in their composition and the control product using the formula:

$$\Delta E = \sqrt{(L_{WX} - L_{W1})^2 + (a_{WX} - a_{W1})^2 + (b_{WX} - b_{W1})^2} ,$$

where Lwx, awx, bwx refer to the mean values of color parameters for the given variant of burgers with added chokeberry pomace, while Lw1, aw1, bw1 refer to the mean values of color parameters for W1 burgers (without added fruit pomace).

The content of water, protein, fat and table salt in the raw meat and pork hamburgers was determined by near-infrared spectroscopy [PN-A-82109:2010] using a FoodScan™2 spectrometer (Foss Analytical A/S, Hillerød, Denmark) operating in the wavelength range from 850 nm to 1500 nm, using a calibration based on an artificial neural network model. The measurement sample was prepared by grinding approximately 300 g of product twice in a meat grinder (2 mm mesh diameter) and mixing thoroughly. A measuring cuvette of approximately 100 g was filled with the sample and placed on the measuring station of the apparatus. Once the apparatus was started, the measurement took place automatically and the results were read out on a computer monitor. In each series of experiments, the measurement was carried out in duplicate.

The organoleptic evaluation of the hamburgers included the following quality attributes: external appearance and colour, palatability and consistency. Burgers heated on an electric grill to about 60°C, cut into quarters, placed on white plates and coded were assessed. A trained team of six people made the assessment using a five-point scale, where individual scores meant: 1 point - unacceptable quality, not in accordance with the accepted criteria, 2 points - significant deviations from the accepted criteria, but not disqualifying the product, acceptable quality, 3 points - satisfactory quality, noticeable quality deviations from the accepted criteria, 4 points - good quality, insignificant quality deviations, 5 points - very good quality, fully acceptable, 'no objections'. The assumptions of the organoleptic evaluation, i.e. the characteristics of the individual quality characteristics for the burger-type minced meat product, were developed on the basis of the literature [Baryłko-Pikielna, Matuszewska 2009].

In order to determine the influence of the applied modifications in the raw material composition of the hamburgers on their quality, the results obtained were subjected to statistical analysis using the STATISTICA 13PL software (StatSoft Inc., Tulsa, OK, USA). The differences between the mean values were identified using the one-way ANOVA test, while the Tukey HSD post hoc test was used to identify homogeneous groups for a significance level of α = 0.05. The Pearson's linear correlation analysis test was performed to investigate the significance of the relationship between the selected quality characteristics of the hamburgers.

Results and discussion

The incorporation of black chokeberry pomace in the form of shredded 'paste' into the raw material composition of pork burgers, irrespective of the amount of added, did not result in a significant ($p > 0.05$) deterioration in the culinary quality traits of the product, such as the amount of weight loss and the change in diameter after heat treatment (see Table 1). The results obtained suggest that, with the amount of chokeberry pomace addition adopted in the study (0.5-7.0%), the weight loss values and the change in external dimensions of the burgers taking place during heating were mainly dependent on the denaturation of muscle proteins.

The results of other studies have shown that the production yield of a burger-type meat product determined after heat treatment can be influenced by the addition of a plant-based ingredient. Cegiełka et al. [2015] found a significant (p ± 0.05) reduction in the production yield of beef and pork hamburgers when a 6.0% oat fibre preparation was added. On the contrary, another study [Cegiełka and Bonderski 2010] showed that the production yield of hamburgers could be significantly increased (p ± 0.05) with the use of a 3% addition of wheat fibre preparation.

Table 1. Characteristics of the physical quality features of pork hamburgers differing in the amount of black chokeberry pomace added (mean value ± standard deviation)

Quality feature	Pork hamburger variants						
	W1	W2	W3	W4	W5	W6	W7
Thermal losses [%]	27.6 a ± 1.02	27.9 a ± 1.17	28.1 a ± 1.09	28.3 a ± 1.12	28.4 a ± 0.86	28.7 a ± 0.79	28.9 a ± 0.44
Diameter change [%]	12.7 a ± 3.40	12.9 a ± 2.28	15.3 a ± 0.76	15.3 a ± 1.50	15.4 a ± 2.15	15.4 a ± 1.63	15.6 a ± 2.19
pH	6.19 e ± 0.02	6.18 de ± 0.01	6.17 de ± 0.02	6.15 cd ± 0.00	6.14 c ± 0.02	6.10 b ± 0.01	6.02 a ± 0.01
Shear force [N]	15.77 a ± 3.04	17.06 a ± 1.91	17.12 a ± 1.89	17.14 a ± 1.69	17.25 a ± 1.19	17.29 a ± 1.73	17.87 a ± 2.98
ΔE	—	5.41	8.15	14.62	18.00	21.17	24.63

Explanatory notes to table 1: W1 – product without the addition of chokeberry pomace, W2 – product with the addition of 0.5% chokeberry pomace, W3 – product with the addition of 1.0% chokeberry pomace, W4 – product with the addition of 2.0% chokeberry pomace from chokeberry, W5 – product with the addition of 3.5% chokeberry pomace, W6 – product with the addition of 5.0% chokeberry pomace, W7 – product with the addition of 7.0% chokeberry pomace; a, b, c – mean values in the row marked with different letters are statistically significantly different (p – 0.05)

Similarly, to the present study, enrichment of the raw material composition of meat patties from minced pork with the addition of 1% or 2% dried berry pomace did not significantly differentiate ($p > 0.05$) the yield or the change in the diameter of the patties after heat treatment [Peiretti et al. 2020]. However, unlike in the present study, a tendency to reduce thermal loss and the degree of 'shrinkage' of the meat product containing the addition of fruit pomace was reported. According to the authors, the good properties of dried fruit pomace towards retaining some moisture and fat in the meat product matrix were mainly due to the high fibre content of this raw material.

The addition of black chokeberry pomace resulted in a significant ($p \leq 0.05$) reduction in the pH of the pork hamburgers (see Table 1). The most significant ($p \leq 0.05$) difference was found between the products: without pomace (W1) and with the highest addition of this ingredient (W7), but a significant change in pH was already observed for the 2% addition of chokeberry pomace (W4). The differences identified were most likely due to the low pH of the chokeberry pomace (3.36), resulting from the presence of organic acids in this raw material.

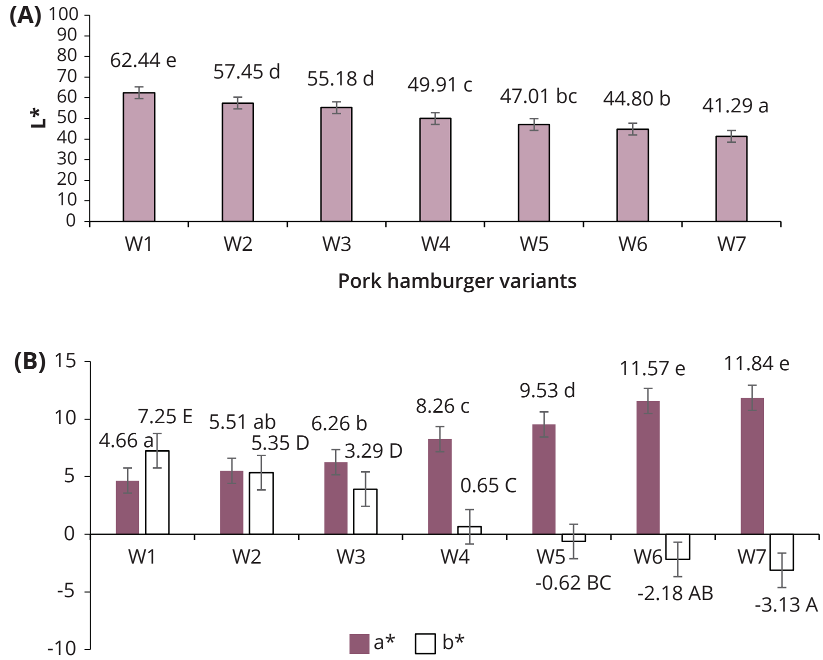
Previous studies have demonstrated that the effect of fruit pomace on the pH of a meat product depends, among other things, on the type of fruit [Babaoğlu et al. 2022], the amount added [Tarasevičienė et al. 2022] and the form (or degree of processing) of the pomace [Tamkutė et al. 2021]. Modification of the raw material composition of burgers from minced pork by enriching the product with a 2% addition of ethanolic extract of chokeberry pomace resulted in a significant reduction in the pH of the raw product [Tamkutė et al. 2021]. According to Babaoğlu et al. [2022], the application of aqueous chokeberry, blackberry, red currant and blueberry pomace extracts to ground beef patties also reduced the active acidity (pH) of the meat product, but on the day after production a significant ($p < 0.05$) difference compared to the control product was found only in patties with red currant pomace extract added. In contrast, the pH of raw pork burgers was not significantly ($p > 0.05$) differentiated by the addition of alcohol in the red grape pomace extract to the meat batter [Garrido et al. 2011]. Tarasevičienė et al. [2022], who added pomace obtained from berries: raspberries and black berries, in amounts of 1, 3 and 5%, to the batter for minced beef patties, found a significant reduction in pH on the third day of storage of the patties only in the products with the highest amount of pomace added.

The obtained results show that increasing the addition of black chokeberry pomace resulted in a progressive but insignificant ($p > 0.05$) increase in the shear force values of the hamburgers (see Table 1).

The texture of minced meat products such as burgers largely depends on the raw material composition. This thesis was confirmed, among others, by Cegiełka and Wójcik [2015] in a comparative study of poultry meat burgers containing mechanically deboned poultry meat in the raw material composition. In order to obtain the accepted technological quality, including the desired texture of burger-type products, the addition of cereal fibre preparations with proven texturizing properties was also used. However, in light of the available results, enrichment of the raw material composition of beef and pork burgers with various wheat [Cegiełka, Bonderski 2010] and oat [Cegiełka et al. 2015] fibre preparations did not significantly ($p > 0.05$) differentiate the hardness of the products expressed by the sheer force value.

Regardless of the amount of chokeberry pomace added to the meat batter, there was a significant ($p \leq 0.05$) effect of this ingredient on the value of the color parameters L*, a* and b* of the pork hamburgers (see Figure 1).

Figure 1. The effect of the addition of black chokeberry pomace on the value of the color parameters L* (A), a* and b* (B) of pork hamburgers



Explanatory notes to figure 1: W1 – product without the addition of chokeberry pomace, W2 – product with the addition of 0.5% chokeberry pomace, W3 – product with the addition of 1.0% chokeberry pomace, W4 – product with the addition of 2.0% chokeberry pomace from chokeberry, W5 – product with the addition of 3.5% chokeberry pomace, W6 – product with the addition of 5.0% chokeberry pomace, W7 – product with the addition of 7.0% chokeberry pomace; a-e; A-E – mean values for a given colour parameter marked with different letters are statistically significantly different ($p \leq 0.05$)

Compared to the control product (W1), even the smallest addition of black chokeberry pomace (product W2) caused a significant darkening of the surface color of the meat product. The significantly ($p \leq 0.05$) lowest value of the color parameter L* was found for the product with the highest addition of chokeberry pomace (W7). Increasing the share of chokeberry pomace in the composition of pork hamburgers also resulted in a progressive significant ($p \leq 0.05$) increase in redness (an increase in the value of the colour parameter a*) and a decrease in the yellowness (a decrease in the value of the colour parameter b*). Starting with the product with 3.5% fruit pomace (W5), the colour parameter b* took on negative values, indicating the dominance of blue over yellow. Black chokeberry fruit pomace is a rich source of pigments, giving this raw material a dark purple color [Sidor, Gramza-Michałowska 2019, Białek et al. 2012]. Therefore, it is most likely that water-soluble anthocyanin pigments were the cause of the observed significant color changes in the meat product. The large effect of chokeberry pomace on the color of the hamburgers was confirmed by calculating the value of the ΔE parameter (see Table 1). Irrespective of the amount of pomace added, the value of ΔE was higher than 5. Thus, hamburgers with chokeberry pomace differed in color from the control product to a sufficient extent that even an ordinary observer could get the impression of two different colors [Mokrzycki, Tatol 2011].

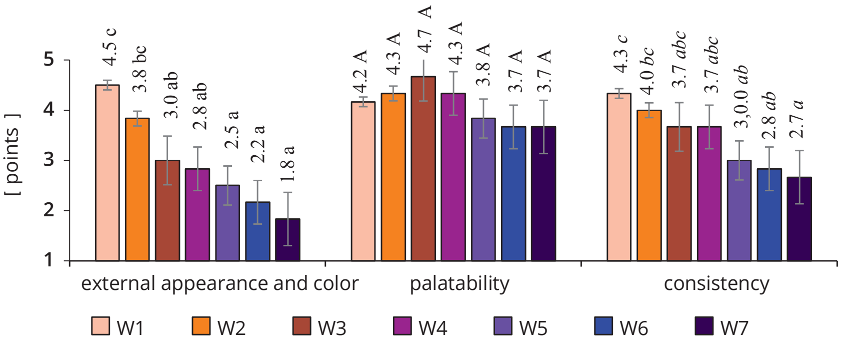
In the light of previous studies [Babaoğlu et al. 2022, Tamkutė et al. 2021, Garrido et al. 2011], the effect of the addition of fruit pomace on the color of minced meat products is not unequivocal. However, it seems to depend, among other things, on the form of pomace used as an ingredient in the meat product. The results obtained in the present study on the effect of fruit pomace on the color of the minced meat product are consistent with the results of Tamkutė et al. [2021], who found that a 2% addition of ethanolic extract of de-fatted chokeberry pomace to pork burgers resulted in a significant decrease in the value of the color parameter L* and a significant increase in the value of the color parameter a* compared to a similar product without the addition of pomace. In contrast, the effect of chokeberry pomace extract on the value of the color parameter b* of the burgers was not significant. According to Babaoğlu et al. [2022], however, the differences regarding the values of the color parameters L*, a* and b* between the control product and ground beef patties containing added aqueous extracts of pomace from different fruits: chokeberry, blackberry, red currant and blueberry, were statistically insignificant. Similarly, Garrido et al. [2011] showed no significant effect of the addition of extracts that contained alcohol from red grape pomace on color lightness (L*) and redness (a*) in pork hamburgers. However, a significant ($p < 0.05$) reduction in the value of the color parameter b* (yellowness) was observed in meat products containing pomace extract compared to the reference product.

The content of the basic chemical components of pork hamburgers is shown below in Table 2. Although the differences found between the meat product variants were relatively small, increasing the addition of black chokeberry pomace resulted in a significant ($p \leq 0.05$) reduction in their water, protein, fat and chloride contents. The reason for the observed changes was most likely due to differences in the chemical composition of the raw materials used to make the burgers: meat, fat and plant. Chokeberry pomace contains less water than meat, and carbohydrates are the quantitatively dominant nutrients [Kawecka, Galus 2021, Sidor, Gramza-Michałowska 2019, Białek et al. 2012].

The results of studies on the quality of hamburgers available in the retail trade [Krygier, Maksimowicz 2008] revealed that these products may significantly vary in terms of the content of basic chemical components. This is mainly due to the type of raw meat material, but also to the share of other components, e.g. starch additives or protein preparations, in the ingredients of the recipe. This thesis was confirmed, among others, by Cegiełka and Bonderski [2010] and Cegiełka et al. [2015], who enriched burgers with various fibre preparations derived from cereals. In contrast, a significant effect of the addition of dried tomato pomace on protein, fat, and water content was found in studies on the quality of nitrite-reduced fermented sausages [Skwarek, Karwowska 2022] and frankfurters [Savadkoohi et al. 2014].

Hamburgers containing chokeberry pomace in their composition were scored slightly but significantly ($p \leq 0.05$) lower in organoleptic evaluation of such attributes as external appearance and color, and consistency (Figure 2). According to the panelists, the negative effect of chokeberry pomace on the organoleptic quality attributes mentioned above was due to the too dark color of the meat product with a clearly discernible violet hue and the perceptibility of plant material particles in the oral assessment. In contrast, the appearance of a 'fruity', 'slightly sour' flavour note did not significantly ($p > 0.05$) differentiate the palatability of the pork burgers, regardless of the amount of plant ingredient added.

Figure 2. The effect of the addition of black chokeberry pomace on the organoleptic quality of pork hamburgers



Furthermore, it was found that the organoleptic assessment of the color of the meat products was highly correlated with each of the measured color parameters. The value of the correlation coefficient 'r' between the external appearance and color of the products and the value of the colour parameters L*, a* and b* were respectively: 0.73843, –0.6909 and 0.70587. Thus, the mean scores in the evaluation of the external appearance and color of the pork hamburgers gradually decreased significantly ($p \leq 0.05$) with darkening, increased redness and a decreased yellowness of the color. In contrast, there was no significant correlation between the consistency of the hamburgers as assessed organoleptically and their texture as measured instrumentally (sheer force; $r = 0.013264$). Presumably, therefore, the distinction in the homogeneity of the texture of the products caused by the presence of the vegetable ingredient particles had a greater effect on the assessment of the texture of the hamburgers than the slight increase in the sheer force of the hamburger samples recorded with increasing amounts of pomace added.

Similar to the present study, color was the sensory attribute most affected by the use of plant pomace being added in the case of beef frankfurters [Savadkoohi et al. 2014] and pork pâtés [Martín-Sánchez et al. 2013]. The significant effect of chokeberry pomace used as an extract containing alcohol on the sensory perception of the color of raw pork burgers is also reported by Tamkutė et al. [2021]. According to Babaoğlu et al. [2022], however, who subjected burgers heated on an electric grill for sensory evaluation, the use of the aqueous extract of chokeberry pomace and other fruits did not significantly ($p > 0.05$) impair any of the sensory characteristics, with the exception of taste.

Conclusions

To summarize, it was found that black chokeberry pomace in a slightly processed form, i.e. only shredded to a 'paste', could be a potential ingredient of a meat product from the convenience food category, such as hamburgers. It was found, however, that chokeberry pomace had a significant effect on most of the quality characteristics of the hamburgers assessed, i.e. the pH of the product, instrumentally measured color parameters and the content of basic chemical components, as well as the organoleptically assessed external appearance, color and consistency.

According to the results of the study, the amount of the addition of black chokeberry pomace to pork hamburger batter with the raw material composition adopted in this study could be 2.0% in relation to the total weight of meat and fat raw materials. The quality problems of the meat product found in the study, mainly concerning color and organoleptic quality, should be resolved in the subsequent stages of further research.

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