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EFFECT OF BLACKCURRANT AND KAMCHATKA HONEYSUCKLE EXTRACTS ON QUALITY PROPERTIES OF RAW-COOKED MEAT PRODUCT

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ABSTRACT

In recent years we notice customers demand for substitution of synthetic food additives, such as antioxidants, for natural and possibly healthier options. Lipid oxidation is the most important meat deterioration process. To retard the oxidation meat industry use variety of synthetic antioxidants. However, due to recent customer demands, industry is trying to replace those synthetic antioxidants for their natural counterparts. This is a challenging process because not only new additives must adequate antioxidant ability, but it also cannot alter sensory quality of products. Fruit extract seems to provide such an option. In our study, blackcurrant *(Ribes nigrum* L.*)* and Kamchatka *honeysuckle (Lonicera caerulea var. kamtschatica)* was incorporated into raw-cooked meat products (Frankfurters). Frankfurters were vacuum packed and stored at 4 °C for 21 days. During the storage period no significant differences in pH was recorded, with average value of 5.54. Also texture analysis did not reveal differences between the control and experimental groups. Both extracts decrease the amount of malondialdehyde (MDA) created in samples. Control groups increase of MDA levels at the end of storage was 108%, blackcurrant and honeysuckle extract groups were just 44 and 39% respectively. Sensory evaluation however revealed that honeysuckle extract altered taste of final product in significant way. This could pose a problem with customers' acceptance of such a product.

Keywords: lipid oxidation, malondialdehyde, natural antioxidant, sensory quality

INTRODUCTION

Lawrie and Ledward, (2006) define meat as the muscle tissue of animals used as food. In practice, this definition is limited to a few dozen of the 3,000 mammalian species; but it often spreads and includes the musculature as well as organs such as the liver and kidneys, brains, and other edible tissues. Meat contains proteins of high biological value. These contain all eight essential amino acids required for adults and all nine required for children. Protein is needed for growth, maintenance, and regeneration of the body. Meat contains an average of 20-24 g of protein per 100 g (raw) and is therefore considered a high source of protein. In most developed countries, average protein intake is above the minimum protein requirements for good health. Any excess protein in the diet is used to provide energy. The amount of energy supplied from meat is variable. Fat provides the richest source of energy and large differences in fat content are visible depending on the type, section, and method of treatment **(Higgs, 2000).**
Lipid oxidation is a series of complex process including several intermediate products and mechanisms that interact with each other. Plainly said, unsaturated fatty acids react with molecular oxygen through a free radical mechanism. The result of this reaction, and first oxidation products, are hydroperoxides. Unlike most other products derived from lipids, hydroperoxides have no odor and do not carry any flavor in food. These created compounds are, however, highly unstable. They decompose rapidly, leading to creation of a large number of secondary compounds, such as hydrocarbons, aldehydes, ketones, alcohols, esters, and acids **(Ross and Smith, 2006).** The rate and extent of lipid oxidation are influenced by a number of factors, which include iron content, distribution of unsaturated fatty acids, pH and antioxidant levels **(Gatellier et al., 2007).** Among all lipid-derived compounds of oxidative processes, aldehydes are considered to be the most important degradation products and contribute the most to volatile aromas in meat **(Cheng, 2016).** This aspect is related to the fact that they are olfactory perceptible even at low concentrations and occur in significant amounts in products that are subject to oxidative processes **(Domínguez *et al.*, 2019).**
The trend towards functional foods has led to the publication of many articles describing studies of the effects of including one or more ingredients with functional properties in different types of food, of which meat and meat products deserve special attention. The aim of including functional ingredients in the case of meat is not only to provide certain desirable properties, but also to try to change its image these days, which are focused on a healthy diet **(Fernández-Ginéz *et al.*, 2005).**

Berries are considered a rich source of nutrients and phytochemicals such as phenolic acids, flavonoids, and anthocyanins. These phytochemicals are said to have strong antioxidant, anti-inflammatory, anticancer, antimicrobial, and anti-aging effects. Furthermore, some polyphenols have been found to act as neurohormetics by stimulating several cellular signaling pathways **(Nile and Park, 2014; Guo *et al.*, 2017).**
Blackcurrant *(Ribes nigrum L.)* is a woody deciduous shrub with dark-colored berries and belong to the *Grossulariaceae* family. Blackcurrants come from northern and central Europe and Asia and are grown for ornamental purposes and for berry production in Europe and North America **(Yang *et al.*, 2019).** The functional effects of blackcurrants are given by their health-promoting substances such as flavonoids (anthocyanins, flavonol glycosides and proanthocyanidins), phenolic acids, ascorbic acid and unsaturated fatty acids **(Tabart *et al.*, 2011).**
Edible fruits of the honeysuckle *(Lonicera caerulea L.)* are gaining popularity in many European countries, such as Russia, Poland, the Czech Republic, and others. The attractiveness of these fruits depends on many factors, including early ripening time (before strawberries in Poland), resistance to spring frost, taste, high content of vitamin C and polyphenolic compounds and health-related properties. Fruits are a good plant material for the food industry, for the production of juices, jams, purees and - for the pharmaceutical industry - for the production of nutritional supplements **(Oszmiański *et al.*, 2016).**
The quality profile of anthocyanins is specific and characteristic for earthworm fruits, which consist of the predominant compound cyanidine-3-glucoside (up to 90%), followed by cyanidine-3,5-diglucoside, peonidine-3-glucoside and other minor components - anthocyanins. Quantitative profiles vary significantly depending on horticultural, climatic conditions or growing area **(Auzanneau *et al.*, 2018).**

MATERIAL AND METHODS

Meat product

For the preparation of meat product, following ingredients were used: pork meat, water, salting mixture, black pepper, and nutmeg. Ingredients for manufacturing frankfurters are listed in **Table 1**. Those were divided into 3 groups. Negative control group (C-0) was prepared with no antioxidant additive at all. Experimental groups were prepared with 3 ml of blackcurrant extract (BCE group) and 3 ml of Kamchatka honeysuckle (KHE group). Finished pork sausages were heat cured for

10 minutes with temperature of 70 °C in core, cooled down and vacuum packaged in bags using Turbovac Double Chamber L10 (Netherlands) and stored at 4 °C. All manufacturing processes were carried out at experimental laboratory of meat products at Institute of Food Sciences, Slovak University of Agriculture in Nitra.
Laboratory examination of samples (pH, color, and oxidative stability) was performed on the 1st, 7th, 14th and 21st day of storage at 4 °C. Sensory evaluation of samples was conducted on the 21st day, at the end of storage period.

Table 1 Ingredients used to prepare 100 kg of final product

Ingredient (kg)	Con-0	BCE	KHE
Pork meat	93	93	93
Water	20	20	20
Black pepper	0.2	0.2	0.2
Paprika (sweet)	0.2	0.2	0.2
Paprika (spicy)	0.2	0.2	0.2
Salting mixture	0.2	0.2	0.2
Nutmeg	0.05	0.05	0.05
Antioxidants (L)			
Blackcurrant extract	-	0.3	-
Honeysuckle extract	-	-	0.3

Extract preparation

Extract preparation of both blackcurrant and honeysuckle was carried out according to work of authors Shirahigue et al. (2010). Plant material needed for extraction was supplied by Botanic Garden of Slovak University of Agriculture in Nitra.

pH measurement

Measurement of pH was carried out with usage of Orion Star™ A211 Benchtop pH meter (China).

Texture analysis

For analysis of texture TA.XT plus Texture Analyzer (UK) was used. As a testing setting was used default program for testing textural properties of Frankfurters using Warner-Bratzler probe (V-shaped blade).

Sensory evaluation

Sensory evaluation of products was performed by sensory panel of five evaluators on 21st day, at the end of storage period as in our previous work **Jurčaga et al. (2021a)** Sensory panel consisted of experienced evaluators from both genders in age group from 25 to 50 years. All evaluators were from Institute of Food Sciences. They are skilled and experienced with meat products evaluation. To evaluate samples, table with every parameter and point values were used as well. All samples were heated by wet cooking in pot before evaluating to reach 70 °C in sausage core. Following sensory parameters were judged: appearance (surface and on cut), color, aroma, consistency, and taste. Every parameter was evaluated on 5-point scale where 5 is best and 1 is worst rate of selected parameter. For analysis detailed descriptor scale with every point value were described with product properties. Together, product can obtain 25 points at best.

Oxidative stability

The oxidative stability of a soft meat product was evaluated based on measurements of malondialdehyde (MDA) concentration by thiobarbiturate test using 2-thiobarbituric acid (TBA) according **Jurčaga *et al.* (2021b).** Measurement was done by UV-spectrophotometry at wavelength of 532 nm (Jenway 7305, UK). Results were calculated using a calibration curve and expressed as the quantity of malondialdehyde (MDA) (mg) present in 1 kg of sample.

Statistical analysis

Statistical analysis was performed using XLSTAT software **(Data Analysis and Statistical Solution for Microsoft Excel, Addinsoft, Paris, France, 2017).** To compare the results Duncan's test ANOVA analysis was used. Significance level for all tests was set as $\alpha = 0.05$.

RESULTS AND DISCUSSION

pH measurement

pH measurement was carried out on 1st, 7th, 14th and 21st day. When compared, no significant differences among groups was observed at any day of measurement. Similarly, changes of pH values of raw-cooked meat products during the storage period were compared. No significant change was observed in this case as well. To determine significancy of those differences ANOVA analysis with Duncan test was used with value $\alpha = 0.05$. Based on this result we are able to state that addition of blackcurrant extract and Kamchatka honeysuckle extract (3ml.kg^{-1}) do not alter the pH value of our experimental raw-cooked meat product (Frankfurters). Data of pH measurements are shown in **Table 2.**

Table 2 pH values of meat product group measured during the storage

Group	Day 1	Day 7	Day 14	Day 21
C-0	6.65 ± 0.03^{aA}	6.53 ± 0.08^{aA}	6.56 ± 0.06^{aA}	6.57 ± 0.07^{aA}
BCE	6.53 ± 0.06^{aA}	6.54 ± 0.08^{aA}	6.54 ± 0.07^{aA}	6.55 ± 0.08^{aA}
KHE	6.50 ± 0.11^{aA}	6.52 ± 0.05^{aA}	6.51 ± 0.12^{aA}	6.52 ± 0.04^{aA}

Note: C-0 – negative control group without antioxidant, BCE – experimental group with blackcurrant extract (3 mL.kg^{-1}), KHE – Kamchatka honeysuckle extract (3 mL.kg^{-1}); a, b = groups within a column with different superscripts differ significantly at $\alpha = 0.05$, one-way ANOVA; A, B = groups within a row with different superscripts differ significantly at $P \leq 0.05$, one-way ANOVA

Results of pH measurement in our conducted work are not in line with multiple authors who used various natural extracts. In previous works authors that used barberry and chokeberry extract reported decrease of pH when compared to negative control **(Jaberi et al., 2020; Tamukaté et al., 2021).** In our study, this extract effect was not observed.

Texture analysis

In our texture analysis three parameters were observed: hardness, cohesiveness, and chewiness. Measurement was carried out at the end of storage period. In all three parameters we did not observe any significant differences among all groups ($\alpha = 0.05$). Our measurement shows that natural antioxidant has no effect on textural properties of raw-cooked meat product (Frankfurters). Those results are in line with the results of our sensory evaluation in which similar score was obtained in consistency parameter. Also, this finding support conducted sensory analysis where evaluators didn't observed significant difference in consistency parameter.

Table 3 Data measured by texture analyzer on 21st day of storage

Group	Hardness (g.cm^{-2})	Cohesiveness	Chewiness
C-0	143.70 ± 3.87^{a}	0.91 ± 0.02^{a}	142.37 ± 2.78^{a}
BCE	145.26 ± 2.44^{a}	0.94 ± 0.02^{a}	146.60 ± 3.52^{a}
KHE	148.68 ± 3.92^{a}	1.02 ± 0.02^{a}	143.10 ± 2.45^{a}

Note: C-0 – negative control group without antioxidant, BCE – experimental group with blackcurrant extract (3 mL.kg^{-1}), KHE – Kamchatka honeysuckle extract (3 mL.kg^{-1}); a,b = groups within a column with different superscripts differ significantly at $\alpha = 0.05$, one-way ANOVA

Other authors chose only one parameter of textural analysis in sausage, hardness. **Seo et al (2019) and Zhang et al. (2017)** used *Caesalpinia sappan* L. and clove extract incorporated into pork sausage respectively. Both authors reported decrease in hardness in experimental meat products compared to negative control. As in case of pH, these results were not replicated in our work. Natural antioxidants may delay changes in the hardness of meat products by reducing emulsion destabilization and decreasing protein oxidation. Antioxidants may maintain the preservation of muscle membranes by inhibiting lipid oxidation and prevent moisture loss and changes into the texture of sausages **(Estévez et al. 2006).**

Sensory evaluation

Sensory evaluation of meat product (Frankfurters) was carried out at the end of storage period, on 21st day. In parameters of aroma and consistency we observed very little variance among all studied groups. Average score for consistency ranged just from 4.1 to 3.9 points. With this evidence and conducted texture analysis we could say that extract addition causes no expressive change of consistency of meat products. Similar low variance was observed in aroma parameter. Difference between experimental and control group was on average just 0.1 point. As it's presented on **Figure 1** control group scored lower average score in terms of color evaluation and overall appearance. Color of experimental Frankfurters were brighter and described as more "reddish", this could be caused by coloring ability of extract as well as natural darkening of meat which is not compensated in control group of products. Control group showed deficit in appearance parameter. Evaluators described various air bubbles and deformities. However, this seems as problem of product manufacturing more than a problem of extract addition. Most important parameter in our evaluation is taste. Control group (C-0) and experimental group with blackcurrant extract (BCE) scored average the same score of 3.8. On the other hand, group with honeysuckle extract (KHE) obtain lower average score (3.4). Evaluators reported bitter aftertaste in this experimental group. Natural honeysuckle extract has bitter taste and in used amount effected the taste of Frankfurters. However, total scores of all groups were comparable and without significant difference ($\alpha = 0.05$).

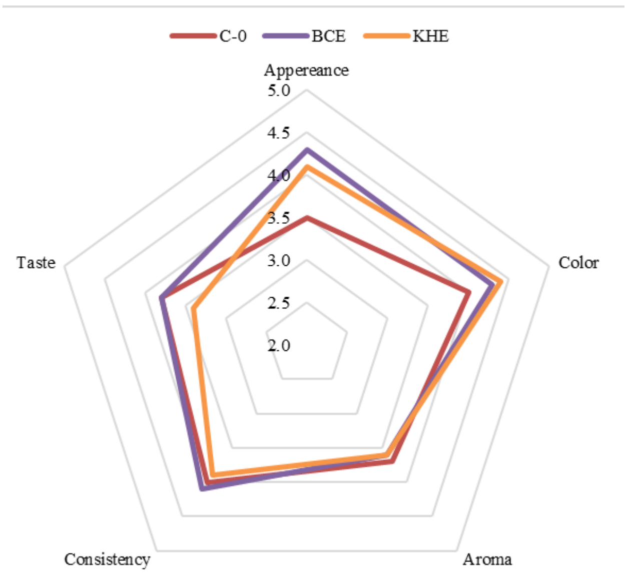

Figure 1 Sensory scores of experimental groups

Authors experimented with berries extract incorporation into meat products and evaluated sensory changes. **Nowak *et al.* (2016)** used blackcurrant leaves extract and reported no negative effect on sensory quality of sausages. Authors **Tamkutė *et al.* (2021)** studied chokeberry pomace extract (2%) addition into cooked pork ham. They reported no significant changes between control and experimental group, except in color. Chokeberry extract caused more bright and reddish coloring of product as in our case. **Bobko et al. (2019)** used sea buckthorn berries extract incorporated into Wiener type sausage. They did not report negative effect of extract on sensory quality.

Oxidative stability

Lipid oxidation in foods is generally detected by measuring the concentration of malondialdehyde (MDA), as MDA is the most important secondary product of lipid oxidation and is relatively stable compared to lipid hydroperoxides, primary products of lipid oxidation that readily decompose to other products **(Jung *et al.*, 2016)**. Data from MDA measurement shows that after seven days of storage values of MDA in negative control group is rising in higher rate than experimental group. However, statistically it's insignificant difference. In later days of storage, after 14th days, contrast between control and experimental groups became more prominent. On 14th and 21st day we observed statistically significant differences. Both blackcurrant and Kamchatka honeysuckle extract significantly reduced amount of malondialdehyde created in meat product during long-term storage (α = 0.05). Level of MDA in negative control group (C-0) increased during 21 days storage by 108%. In experimental groups those increments were 44% in BCE group and just 39% in KHE group. This suggest that honeysuckle is more effective in retardation of lipid oxidation in meat products. All data regarding the malondialdehyde are shown in **Table 4.**

Table 4 MDA values measured in meat product groups during the storage

Group	Day 1	Day 7	Day 14	Day 21
C-0	0.156 ± 0.006^a	0.172 ± 0.003^a	0.249 ± 0.006^a	0.325 ± 0.004^a
BCE	0.149 ± 0.005^a	0.152 ± 0.006^a	0.180 ± 0.005^b	0.216 ± 0.009^b
KHE	0.146 ± 0.009^a	0.146 ± 0.011^a	0.176 ± 0.005^b	0.204 ± 0.006^b

Note: C-0 – negative control group without antioxidant, BCE – experimental group with blackcurrant extract (3 ml.kg^{-1}), KHE – Kamchatka honeysuckle extract (3 ml.kg^{-1}); a,b = groups within a column with different superscripts differ significantly at α = 0.05 , one-way ANOVA.

Our results are in line with the findings of authors **Jia *et al.* (2012).** In their work authors tested addition of blackcurrant into pork meat patties stored at 4 °C. Authors claims that addition to blackcurrant extract (5, 10 and 20 g.kg^{-1}), significantly (α = 0.05) inhibited malondialdehyde production throughout the storage period of nine days in pork patties. Furthermore, authors state that the use of 10 and 20 g of extract was comparable in its effect to the addition of 0.2 g of .kg^{-1} butylated hydroxyanisole (BHA).

In time of writing, we did not find any studies that incorporated honeysuckle berries into meat products. Our finding suggests that its effect is similar to blackcurrant and other berries used in various studies conducted by other authors. For example, authors **Muzolf-Panek *et al.* (2016)** studied incorporation of blueberries extract into port meatloaf. Authors confirmed that this addition reduced the amount of malondialdehyde created in samples during the storage compared to negative control. **Ganhão *et al.* (2013)** incorporated blackberry extract into the pork patties that were stored 12 days in 2 °C. Authors observed significant differences (α = 0.05) between negative control group and experimental groups with berries extract.

CONCLUSION

In our study we incorporated blackcurrant and Kamchatka honeysuckle extracts (3 ml.kg^{-1}) into raw-cooked meat products (Frankfurters). During analysis, no significant differences in pH and texture analysis was registered among all groups. On the other hand, both natural extracts proved to efficient in retardation of lipid oxidation and lowering the amount of MDA created during storage. In sensory evaluation we observed differences only taste parameter. Experimental group with honeysuckle obtain lower score and all evaluators reported bitter aftertaste. This is striking disadvantage for honeysuckle extract. Even though we prove its oxidation preventing properties in meat products, its negative taste altering suggest that it's not suitable for meat industry. We recommend further study of this extract in different foods because of its antioxidant abilities. On the other hand, blackcurrant extract seems as a viable replacement of synthetic antioxidant in meat products and deserve more attention in this matter.

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