

## INFLUENCE OF BEAR GARLIC ON SENSORY QUALITY OF COOKED MEAT PRODUCTS

Jarošová Alžbeta<sup>1</sup>, Kadlecová Kateřina<sup>\*1</sup>, Kácalová Tereza<sup>2</sup>, Slováček Jan<sup>1</sup>

### Address(es):

<sup>1</sup> Department of Food Technology, Faculty of AgriSciences, Mendel University Brno, Zemědělská 1, 613 00 Brno, Czech Republic.

<sup>2</sup> Lebgenco SAL, Hassan Bek Al Kaakour Main Road, Baassir, El Chouf, 5644 Lebanon.

\*Corresponding author: [xkadle12@mendelu.cz](mailto:xkadle12@mendelu.cz)

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### ABSTRACT

Bear garlic has a distinct pungent taste associated with the sulphur compound allin. When garlic is crushed or chopped, the enzyme allinase is activated, which produces allicin from allin. Allicin has antimicrobial, antifungal and antiviral properties. Sausages were produced with 0.4%, 0.8%, and 1.2% of kitchen and bear garlic and analyzed twice (day 1 after production and day 14 after production). Chemical analysis (dry matter, fat, protein and salt content), instrumental colour measurement and sensory evaluation of the sausages were conducted. The addition of bear garlic was particularly significant in the sensory evaluation for the pleasantness of the garlic flavour, while sausages with the addition of bear garlic scored higher than those with the addition of sausage with kitchen garlic. Sensory analyses conducted one day after production showed that the evaluators found the sausages with 0.8% and 1.2% addition of kitchen and bear garlic more acceptable in terms of garlic aroma intensity, garlic flavour intensity, garlic flavour pleasantness and overall impression. After 14 days of production, the sausage with 0.8% addition of kitchen's garlic and bear's garlic were the most acceptable to the panelists, particularly for the descriptors of overall appearance, garlic aroma intensity, garlic flavour intensity, garlic flavour palatability and overall impression. Comparing data from day 1 and day 14 after sausage production with 0.4%, 0.8% and 1.2% addition of kitchen garlic and bear garlic, the sausage with kitchen garlic and bear garlic on day 1 was the best evaluated, especially in the descriptors of juiciness, consistency and pleasantness of garlic flavour.

**Keywords:** bear garlic (*Allium ursinum* L.), kitchen garlic (*Allium sativum* L.), sensory analysis, pork, beef, meat product

## INTRODUCTION

Meat has been with mankind for many years. The consumption of meat has many health benefits, such as a high content of complete proteins, minerals (iron, magnesium, calcium, zinc, potassium) and vitamins (B, A, D) (Krčová, 2019). According to the WHO, it is recommended to include meat up to 3 times a week in your diet. Do not consume fatty meat but choose lean meat that does not contain large amounts of fat. People who do not consume meat should include dairy products, eggs, pulses and others in their diet (Čaha, 2021).

In 2022, total consumption of meat on the bone was 82.9 kilograms per person per year, of which pork accounted for 43.9 kg, poultry for 28.1 kg and beef for 8.8 kg. Meat consumption also includes meat products (CSU, 2023). Meat products are very popular not only in the Czechia but also worldwide. They are mainly made from meat, water and additives such as salt, spices, carbohydrates, protein additives and others. Due to the high salt content in meat products, it is recommended to reduce their consumption as they can cause high blood pressure, diabetes, stroke, cardiovascular disease, and others health problems (Kameník, 2014).

Bear garlic, *Allium ursinum* in Latin, is a perennial medicinal herb that is an excellent source of vitamin C and iron when consumed in large quantities (over 100g per day). It has a similar pungent taste to garlic, as both contain the main active sulphur compound allin (Novotný, 2021). If garlic is crushed and chopped before consumption, the enzyme allinase is activated, which forms allicin from allin (Bayan et al., 2014). Allicin in plants prevents seed germination and weakens root development. It is used in medicine and in organic farming (Borlinghaus et al., 2014). Allicin has antimicrobial, antifungal, antiviral and antiprotazoal effects (Marchese et al., 2016). Some scientific studies have reported that allicin may also regulate blood cholesterol levels (Liu and Yeh, 2000). Bear garlic is a valuable source of natural compounds for example phenolic acids, flavonoids, and vitamin C, all of which are known for their health-supporting properties. The concentration of these bioactives, and consequently the plant's antioxidant effectiveness, are influenced by its developmental stage and growing environment. Because of this unique composition, bear garlic is considered a promising functional food with potential health benefits that go beyond simple nutritional value (Voča et al., 2021).

Garlic (*Allium sativum* L.) is a plant with a long history of use for the treatment of various diseases due to its content of beneficial substances such as polyphenols, vitamins and minerals. These bioactive compounds include polyphenols, which are divided into several classes and contribute to the antioxidant effects of garlic

(Bystrická et al., 2018). A study by Čeryová et al., 2018 shows that garlic (*Allium sativum* L.) is an important source of polyphenols, flavonoids and other bioactive compounds with antioxidant effects. The content of these substances varies among varieties, with the highest values recorded in the variety Mojmir. These results confirm that the composition of garlic can significantly influence its antioxidant potential. Kitchen garlic contains significantly more polyphenols and shows stronger antioxidant effects than bear garlic (*Allium ursinum* L.). Nevertheless, bear garlic also has some antioxidant activity and due to its specific flavour, it may be an interesting addition in food production (Kovarovič et al., 2017). Garlic (*Allium sativum* L.) is a rich source of essential nutrients and diverse phytochemicals that contribute to immune support and protection against inflammation-related conditions. Its regular consumption has been associated with improved cardiovascular health, including better lipid balance and blood pressure control. These effects are largely attributed to garlic's potent antioxidant properties, which help reduce oxidative stress and its harmful impact on the body (Gupta et al., 2024).

The aim of the experimental part of the work was to produce sausages with 0.4%, 0.8% and 1.2% addition of kitchen garlic and bear garlic, to evaluate the sensory properties, measure the colour and to carry out chemical analysis of all the sausages.

## MATERIALS AND METHODS

### Materials

Sausages with bear garlic and kitchen garlic were used for the experiment. Both variants with 0.4%, 0.8% and 1.2% addition of garlic. All sausages were produced at the Department of Food Technology in the Meat pilot plant of the Mendel University in Brno. The sausages were evaluated on day 1 and day 14 after production. The individual sausage variants were produced in order to compare the quality parameters depending on the type of garlic (bear garlic, kitchen garlic) and the percentage of garlic added. The sausages were made using prime production beef (HPV), lean pork (VLII) and skinless production pork (VVbk). Other ingredients were nitrite salt mixture (DSS), kitchen garlic granules, dried bear garlic and the last ingredient was flake ice. The sausages were crammed into the pork intestine. All sausage variants were made from the same ingredients, differing only in the amount and type of garlic – kitchen garlic and bear garlic. The origin of both garlics was from the Czech Republic.

**Methodology**

The following analyses were carried out on all the sausage samples: sensory analysis, chemical analysis and instrumental colour measurement.

**Instrumental colour measurement**

The colour of all variants of sausages with bear garlic and kitchen garlic was measured in a physical laboratory at the Department of Food Technology of the Mendel University in Brno using a Konica Minolta CM 3500d benchtop spectrophotometer. The instrument can measure in the whole visible spectrum from 380 to 780 nm. The measured colour is described by the reflectance spectrum and numerical data. The values are recorded in the L\* a\* b\* (CIELab) colour system and then assigned. The instrument is connected to a computer where the CMs-100w Spectramagic NX program is installed. The L\* value indicates the lightness and ranges from 0 (black) to 100 (white). The a\* and b\* values are the chromatic axes, which have positive or negative values depending on their position in the colour system.

For the colour measurements of both the bear garlic and the kitchen garlic sausage, the reflectance mode of the instrument was used, the reflected light was measured at an angle of 8°, the illumination mode was D65, the aperture size was 8 mm and gloss elimination (SCE) were also applied. The colour of the sausages was measured on the cut and surface and the results were evaluated using STATISTICA 14 and Microsoft Office Excel.

**Chemical analysis**

The sausages produced were subjected to chemical analysis. The total salt content was determined, dry matter, fat and protein. Sodium chloride (salt) was determined by leaching the sample with water, in which all chlorides were determined and converted to sodium chloride. The dry matter content was then determined by weighing the homogenized sample in an aluminium dish and then moistening the sample with ethanol-ether solution. The sample was then dried to a constant weight and, after cooling, weighed to the nearest 0.01 g. Fat was determined by indirect extraction from the weight of the original sample by subtracting the weight of water and the dry weight obtained. Protein was determined by the Kjeldahl method using a Kjeltec 8200 automatic analyser. The results of the chemical analysis were processed using STATISTICA 14 and Microsoft Office Excel.

**Sensory analysis**

Sensory evaluation was carried out at the Department of Food Technology, Mendel University in Brno. The evaluation was carried out by 6 trained evaluators using a pre-developed method. Prior to the evaluation, the evaluators were instructed in the sensory evaluation procedure. A total of 10 descriptors were assessed: overall appearance, appearance on the cut, garlic aroma pleasantness, garlic aroma intensity, colour, juiciness, consistency (texture), garlic flavour intensity, garlic flavour pleasantness and overall impression of the product. Graphical unstructured scales (100 mm) were used, with the extremes marked (from the left, 0 indicates unsatisfactory, and from the right, 100 indicates satisfactory). Bread was chosen as a flavour neutraliser. The sensory analysis was performed twice. The first evaluation took place 1 day after production and the second evaluation 14 days after production. All variants of sausages with bear garlic and kitchen garlic were evaluated at all concentrations. The first evaluation of the sensory questionnaires

was carried out by measuring the values on a scale using a ruler. The values were further evaluated using STATISTICA 14 and Microsoft Office Excel.

**Statistical processing**

Data from all measurements and sensory analysis were processed in Microsoft Office Excel and charts were created. The results were analyzed using STATISTICA 14. The Sharp-Wilk test was used to test the normality of the data. All data sets did not meet the requirements for normal distribution, therefore the non-parametric Kruskal-Wallis test was used to test the significance of differences. All samples were tested at the 95% confidence level ( $p < 0.05$ ).

**RESULTS**

**Instrumental colour measurement**

The colour of the sausages with kitchen garlic and bear garlic was measured using an instrumental method. All sausages were measured on the surface and in the cut. The results of the colour analysis were processed in STATISTICA 14, which showed statistically significant differences between the sausages. The measured values were recorded in individual tables.

**Comparison of the colour of sausages with the same additions of kitchen garlic and bear garlic between days 1 and 14**

Table 1 shows the values (L\*, a\*, b\*) of the colour measurements of the sausages on day 1 and day 14 after the production with 0.4% addition of kitchen garlic and bear garlic. The evaluation of the parameter L\* (brightness) on the surface showed a statistically significant ( $p < 0.05$ ) difference in this parameter between the sausage with the addition of kitchen garlic on day 1 after production and the sausage with the addition of bear garlic on day 14 after production. The lightest sausage was the one with the addition of kitchen garlic on the day 1 after production. The darkest sausage was the one with kitchen garlic addition on the day 14 after production. There was also a difference in cut between the sausage with the addition of kitchen garlic on the day 1 after production and the sausage with the addition of bear garlic on the day 14 after production. The sausage with the addition of kitchen garlic on the day 1 after production was the lightest on the cut and the sausage with the addition of bear garlic on the day 14 after production was the darkest on the cut. In the evaluation of parameter, a\*, all values were in the positive range, indicating a red spectrum. There was a statistically significant difference ( $p < 0.05$ ) between the sausage with the addition of kitchen garlic on the day 1 after production and the sausage with the addition of bear garlic on the day 14 after production. The sausage with the addition of kitchen garlic on the day 1 after production was the reddest on the surface and in the cut. The sausage with the addition of bear garlic on the day 1 after production was the least red in the cut and the sausage with the addition of bear garlic on the day 14 after production was the least red on the surface.

The b\* values were only in the positive range, all in the yellow spectrum. There was a statistically significant ( $p < 0.05$ ) difference between the sausages with kitchen garlic added on the day 1 and day 14 after production, both on the surface and in the cut. The sausage with kitchen garlic added on day 1 after production was the most yellow on the surface and in the cut, and the sausage with kitchen garlic added on day 14 after production was the least yellow.

**Table 1** Analysis of the colour of sausages with 0.4% addition of kitchen garlic (KG) and bear garlic (BG) on day 1 and day 14 after production

Place of measurement	Variants	L*(D65)	a*(D65)	b*(D65)
		( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )
Surface	1. KG 0.4%	53.21 <sup>a</sup> ± 0.58	13.07 <sup>a</sup> ± 0.06	23.51 <sup>a</sup> ± 0.07
	14. KG 0.4%	31.79 <sup>b</sup> ± 0.02	11.63 <sup>a,b</sup> ± 0.08	12.01 <sup>b</sup> ± 0.1
	1. BG 0.4%	51.67 <sup>a,b</sup> ± 0.01	10.98 <sup>a,b</sup> ± 0.01	21.95 <sup>a,b</sup> ± 0.04
	14. BG 0.4%	33.54 <sup>a,b</sup> ± 0.04	10.49 <sup>b</sup> ± 0.01	15.01 <sup>a,b</sup> ± 0.02
Cut	1. KG 0.4%	53.79 <sup>a</sup> ± 0.33	11.81 <sup>a</sup> ± 0.02	10.58 <sup>a</sup> ± 0.21
	14. KG 0.4%	42.01 <sup>a,b</sup> ± 0.06	10.9 <sup>a,b</sup> ± 0.01	6.73 <sup>b</sup> ± 0.03
	1. BG 0.4%	48.99 <sup>a,b</sup> ± 0.06	7.92 <sup>b</sup> ± 0.01	10.16 <sup>a,b</sup> ± 0.01
	14. BG 0.4%	38.39 <sup>b</sup> ± 0.05	10.16 <sup>a,b</sup> ± 0.01	8.18 <sup>a,b</sup> ± 0.03

Note: Different indices in a column indicate statistically significant differences at the  $p < 0.05$  significance level

Table 2 shows the values (L\*, a\*, b\*) of the colour measurements of the sausages on the day 1 and 14 after the production with 0.8% addition of kitchen garlic and bear garlic. The evaluation of the parameter L\* brightness on the surface showed a statistically significant difference ( $p < 0.05$ ) between the sausage with the addition of kitchen garlic on the day 1 after production and the sausage with the addition of bear garlic on the day 14 after production. The lightest sausage was the one with the addition of kitchen garlic on the day 1 after production and the darkest sausage was the sausage with the addition of bear garlic on the day 14 after production. A

statistically significant difference ( $p < 0.05$ ) was found between the sausage with the addition of kitchen garlic on the day 1 and on the day 14 after production.

The sausage with the addition of kitchen garlic was the lightest on the day 1 after production and the darkest on the day 14 after production.

When evaluating the a\* parameter, all the values were in the positive range, indicating a red spectrum. There was a statistically significant difference on the surface between the sausage with the addition of kitchen garlic on the day 14 after production and the sausage with the addition of bear garlic on the day 14th after production. The sausage with the addition of kitchen garlic on the day 14 after

production was the reddest and the sausage with the addition of bear garlic on the day 1 after production was the least red.

All *b\** values were in the positive range, i.e. in the yellow spectrum. There was a statistically significant ( $p < 0.05$ ) difference on the surface between the sausage with bear garlic added on day 1 and day 14 after production. The sausage with bear garlic added on day 1 after production was the most yellow and the sausage with

bear garlic added on day 14 after production was the least yellow. In addition, there was a statistically significant ( $p < 0.05$ ) difference in cut between the sausage with the addition of kitchen garlic on the day 14 after production and the sausage with the addition of bear garlic on the day 1 after production. The sausage with addition of bear garlic on day 1 after production was the most yellow. The sausage with kitchen garlic added on day 14 after production was the least yellow.

**Table 2** Analysis of the colour of sausages with 0.8% addition of kitchen garlic (KG) and bear garlic (BG) on day 1 and day 14 after production

Place of measurement	Variants	L*(D65)	a*(D65)	b*(D65)
		( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )
Surface	1. KG 0.8%	51.61 <sup>a</sup> ± 0.02	12.42 <sup>ab</sup> ± 0.01	20.82 <sup>ab</sup> ± 0.01
	14. KG 0.8%	38.88 <sup>ab</sup> ± 0.01	13.92 <sup>a</sup> ± 0.01	18.41 <sup>ab</sup> ± 0.01
	1. BG 0.8%	50.52 <sup>ab</sup> ± 0.04	8.15 <sup>b</sup> ± 0.01	22.13 <sup>a</sup> ± 0.02
	14. BG 0.8%	34.56 <sup>b</sup> ± 0.02	9.56 <sup>ab</sup> ± 0.02	16.05 <sup>b</sup> ± 0.02
Cut	1. KG 0.8%	52.56 <sup>a</sup> ± 0.02	9.71 <sup>b</sup> ± 0.01	9.51 <sup>ab</sup> ± 0.01
	14. KG 0.8%	40.41 <sup>b</sup> ± 0.01	12.10 <sup>a</sup> ± 0.04	8.41 <sup>b</sup> ± 0.01
	1. BG 0.8%	51.75 <sup>ab</sup> ± 0.01	10.14 <sup>ab</sup> ± 0.01	10.05 <sup>a</sup> ± 0.01
	14. BG 0.8%	44.82 <sup>ab</sup> ± 0.03	9.84 <sup>ab</sup> ± 0.01	9.16 <sup>ab</sup> ± 0.01

Note: Different indices in a column indicate statistically significant differences at the  $p < 0.05$  significance level

Table 3 shows the values (*L\**, *a\**, *b\**) of the colour measurements of the sausages on the day 1 and 14 after production with the addition of 1.2% kitchen and bear garlic.

The evaluation of the brightness (parameter *L\**) on the surface showed a statistically significant ( $p < 0.05$ ) difference between the sausages with the addition of bear garlic on the day 1 and 14 after production. The sausage with the addition of bear garlic on the first day of production was the lightest and the sausage with the addition of bear garlic on the day 14 after production was the darkest. Statistically significant ( $p < 0.05$ ) difference in the *L\** parameter between the sausage with the addition of kitchen garlic on the day 1 after production and the sausage with the addition of bear garlic on the day 14 after production was shown on the cut. The lightest sausage was the one with the addition of kitchen garlic on the day 1 after production and the darkest was the sausage with the addition of bear garlic on the day 14 after production.

When evaluating the *a\** parameter, all values were in the positive range, indicating a red spectrum. There was a statistically significant ( $p < 0.05$ ) difference between the sausage with the addition of kitchen garlic and bear garlic on the day 14 after production, both on surface and cut. The sausage with the addition of kitchen garlic on the day 14 after production was the reddest and the sausage with the addition of bear garlic on the day 14 after production was the least red.

The *b\** values were all in the positive range in the yellow spectrum. There was a statistically significant ( $p < 0.05$ ) difference in colour on surface and cut between the sausage with the addition of bear garlic on the day 1 and 14 after production. The sausage with addition of bear garlic added evaluated on day 1 after production was the most yellow and the sausage with bear garlic on the day 14 after production was the least yellow.

**Table 3** Analysis of the colour of sausages with 1.2% addition of kitchen garlic (KG) and bear garlic (BG) on day 1 and day 14 after production

Place of measurement	Variants	L*(D65)	a*(D65)	b*(D65)
		( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )
Surface	1. KG 1.2%	49.91 <sup>ab</sup> ± 0.01	12.09 <sup>ab</sup> ± 0.01	21.71 <sup>ab</sup> ± 0.01
	14. KG 1.2%	40.48 <sup>ab</sup> ± 0.02	13.34 <sup>a</sup> ± 0.03	21.16 <sup>ab</sup> ± 0.01
	1. BG 1.2%	51.52 <sup>a</sup> ± 0.04	12.38 <sup>ab</sup> ± 0.02	23.31 <sup>a</sup> ± 0.04
	14. BG 1.2%	34.36 <sup>b</sup> ± 0.04	7.62 <sup>b</sup> ± 0.02	15.25 <sup>b</sup> ± 0.03
Cut	1. KG 1.2%	55.25 <sup>a</sup> ± 0.01	9.57 <sup>ab</sup> ± 0.01	10.59 <sup>ab</sup> ± 0.01
	14. KG 1.2%	45.08 <sup>ab</sup> ± 0.08	11.6 <sup>a</sup> ± 0.03	10.58 <sup>ab</sup> ± 0.03
	1. BG 1.2%	52.56 <sup>ab</sup> ± 0.02	9.34 <sup>ab</sup> ± 0.02	10.87 <sup>a</sup> ± 0.02
	14. BG 1.2%	38.74 <sup>b</sup> ± 0.08	9.08 <sup>b</sup> ± 0.02	6.75 <sup>b</sup> ± 0.01

Note: Different indices in a column indicate statistically significant differences at the  $p < 0.05$  significance level

**Chemical analysis**

Chemical analysis of all sausage varieties with bear and kitchen garlic on day 1 and 14 after production. Dry matter, fat, protein and NaCl were determined (Table 4–5).

**Chemical analysis of sausages with kitchen and bear garlic at different concentrations on day 1 after production**

Table 4 shows the values of the chemical analysis of the sausages with kitchen garlic and bear garlic on the first day after production. Slight differences in the

chemical composition were observed, which could be caused by inhomogeneity of product after the mixing process.

Statistically significant ( $p < 0.05$ ) differences in the dry matter and fat content of the kitchen garlic were found between the 0.4% and the 1.2% garlic. For protein, there was a statistically significant difference ( $p < 0.05$ ) between the sausage with 0.8% and 1.2% added kitchen garlic. There was no statistically significant difference ( $p > 0.05$ ) in NaCl content, dry matter, fat and protein between the sausages with 0.8% and 1.2% addition of bear garlic. The samples did not significantly differ ( $p > 0.05$ ) in NaCl content.

**Table 4** Chemical analysis (dry matter, fat, protein, NaCl) of sausages with kitchen garlic (KG) and bear garlic (BG) on day 1 after production

Variation of sausages	Dry matter	Fat	Protein	NaCl
	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )	( $\bar{x} \pm SD$ )
1. KG 0.4%	47.81 <sup>a</sup> ± 1.98	28.66 <sup>a</sup> ± 0.40	18.60 <sup>ab</sup> ± 0.18	2.00 <sup>a</sup> ± 0.05
1. KG 0.8%	45.02 <sup>ab</sup> ± 1.75	25.00 <sup>ab</sup> ± 0.47	17.47 <sup>b</sup> ± 0.22	2.23 <sup>a</sup> ± 0.06
1. KG 1.2%	44.52 <sup>b</sup> ± 1.58	22.53 <sup>b</sup> ± 0.50	19.37 <sup>a</sup> ± 0.21	2.26 <sup>a</sup> ± 0.09
1. BG 0.4%	43.77 <sup>ab</sup> ± 1.48	22.62 <sup>ab</sup> ± 0.43	18.88 <sup>ab</sup> ± 0.23	2.23 <sup>a</sup> ± 0.07
1. BG 0.8%	45.02 <sup>a</sup> ± 1.63	24.41 <sup>a</sup> ± 0.37	17.60 <sup>b</sup> ± 0.20	2.11 <sup>a</sup> ± 0.04
1. BG 1.2%	42.44 <sup>b</sup> ± 1.55	21.71 <sup>b</sup> ± 0.49	19.31 <sup>a</sup> ± 0.18	2.23 <sup>a</sup> ± 0.06

Note: Different indices in a column indicate statistically significant differences at the  $p < 0.05$  significance level

**Chemical analysis of sausages made with kitchen and bear garlic of different concentrations on the day 14 after production**

Table 5 shows the values of the chemical analysis of the sausages with kitchen garlic and bear garlic on the day 14 after production. The slight differences in the chemical analysis could occur due to the inhomogeneity of the mixing work. Statistically significant ( $p < 0.05$ ) differences in dry matter and fat content were observed between the sausages with 0.4% and 0.8% addition of kitchen garlic. The protein content was statistically ( $p < 0.05$ ) different between the sausages with 0.8% and 1.2% added kitchen garlic. The differences occurred mainly in dry matter

and fat content between sausages with 0.4% and 0.8% added kitchen garlic. The difference in the content of protein was observed between the sausages with 0.4% and 0.8% added kitchen garlic. No significant difference ( $p > 0.05$ ) was reported in NaCl content. For the sausage variant with bear garlic, the statistically significant difference ( $p < 0.05$ ) in dry matter content was between the sausage with 0.4% and 0.8% addition. The fat content was significantly ( $p < 0.05$ ) different between sausages with 0.8% and 1.2% addition of bear garlic. The significant difference ( $p < 0.05$ ) was observed in protein content of sausages with 0.4% and 0.8% of bear garlic, but no difference was shown ( $p > 0.05$ ) in the content of NaCl.

**Table 5** Chemical analysis (dry matter, fat, protein, NaCl) of sausages with kitchen garlic (KG) and bear garlic (BG) on day 14 after production

Variation of sausages	Dry matter ( $\bar{x} \pm SD$ )	Fat ( $\bar{x} \pm SD$ )	Protein ( $\bar{x} \pm SD$ )	NaCl ( $\bar{x} \pm SD$ )
14. KG 0.4%	70.11 <sup>ab</sup> ± 1.61	37.17 <sup>ab</sup> ± 0.33	28.74 <sup>ab</sup> ± 0.23	3.24 <sup>a</sup> ± 0.05
14. KG 0.8%	68.87 <sup>b</sup> ± 1.54	37.07 <sup>b</sup> ± 0.36	26.44 <sup>b</sup> ± 0.25	3.39 <sup>a</sup> ± 0.03
14. KG 1.2%	71.73 <sup>a</sup> ± 1.59	38.00 <sup>a</sup> ± 0.41	29.02 <sup>a</sup> ± 0.15	3.56 <sup>a</sup> ± 0.07
14. BG 0.4%	68.66 <sup>a</sup> ± 1.37	35.31 <sup>ab</sup> ± 0.49	29.85 <sup>a</sup> ± 0.21	3.47 <sup>a</sup> ± 0.05
14. BG 0.8%	65.87 <sup>b</sup> ± 1.43	33.54 <sup>b</sup> ± 0.41	25.76 <sup>b</sup> ± 0.23	3.25 <sup>a</sup> ± 0.06
14. BG 1.2%	67.28 <sup>ab</sup> ± 1.41	35.53 <sup>a</sup> ± 0.51	26.63 <sup>ab</sup> ± 0.23	3.30 <sup>a</sup> ± 0.03

Note: Different indices in a column indicate statistically significant differences at the  $p < 0.05$  significance level

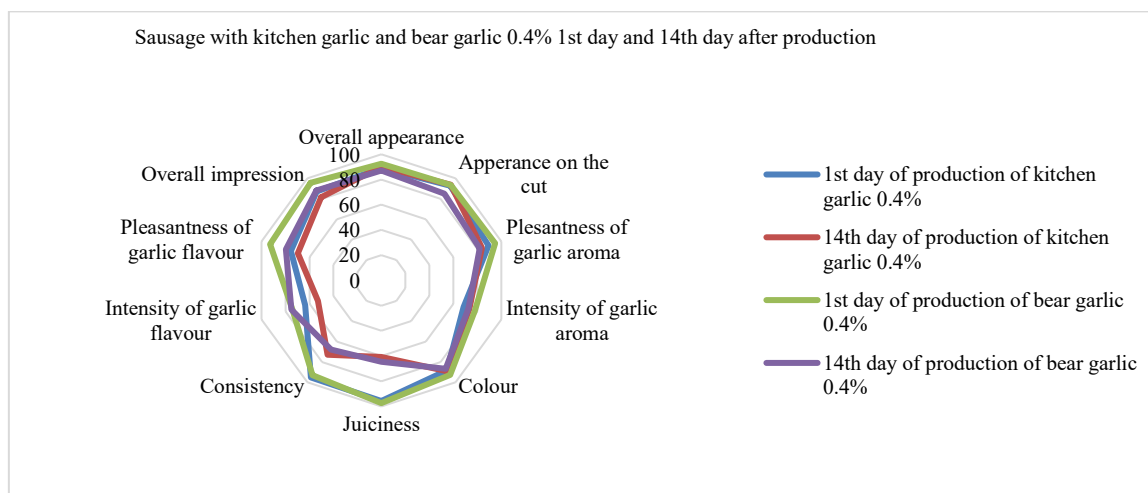
**Sensory analysis**

Samples of sausages with bear and kitchen garlic on days 1 and 14 after production were evaluated by 6 trained tasters. A total of 10 descriptors were assessed: overall appearance, appearance on the cut, pleasantness of garlic aroma, intensity of garlic aroma, colour, juiciness, consistency, intensity of garlic flavour, pleasantness of garlic flavour and overall impression. The resulting values from the sensory analysis are shown in the individual figures (Figures 1-3).

**Comparison of sensory characteristics of sausages with the same addition of kitchen and bear garlic between days 1 and 14**

When comparing the sausages with 0.4% addition of kitchen and bear garlic between days 1 and 14 after production, a statistically significant difference ( $p < 0.05$ ) was in the descriptor of the pleasantness of garlic aroma in the sausage with added bear garlic. The highest mean value ( $95 \pm 5$ ) was measured for the sausage with the addition of bear garlic on day 1 after production. The lowest mean value ( $89 \pm 6$ ) was measured for the sausage with the addition of kitchen garlic on day 1 after production. Furthermore, there was a statistically significant difference ( $p < 0.05$ ) in the juiciness between the sausage with the addition of kitchen garlic on the day 1 after production, the sausage with the addition of kitchen garlic on the day 14 after production and the sausage with the addition of bear garlic on the day 14 after production. There was also a statistically significant difference ( $p < 0.05$ ) between sausage with the addition of kitchen garlic on the day 14 after production

and the sausage with the addition of bear garlic on the day 1 after production. A statistically significant difference ( $p < 0.05$ ) was found between the sausages with the addition of bear garlic on the day 1 and 14 after production. The highest mean value ( $97 \pm 6$ ,  $97 \pm 3$ ) was measured for the sausages with the addition of kitchen garlic on day 1 after production and the sausage with the addition of bear garlic on day 1 after production. The lowest mean value ( $65 \pm 30$ ) was measured for the sausage with the addition of bear garlic on the day 14 after production. There was a statistically significant difference ( $p < 0.05$ ) in the consistency between the sausage with bear garlic on the day 14 after production and the sausage with kitchen garlic on the day 1 after production. The highest mean value ( $95 \pm 7$ ,  $93 \pm 8$ ) was measured for the sausage with the addition of kitchen garlic on the day 1 after production and for the sausage with the addition of bear garlic on the day 1 after production. The lowest mean value ( $68 \pm 28$ ) was measured for the sausage with the addition of bear garlic on the day 14 after production. Another statistically significant ( $p < 0.05$ ) descriptor was the pleasantness of garlic flavour between the sausage with the addition of kitchen garlic on the day 14 after and the sausage with the addition of bear garlic on the day 1 after production. The highest mean value ( $93 \pm 10$ ) was measured for the sausage with the addition of bear garlic on the day 1 after production. The lowest mean value ( $76 \pm 7$ ) was measured for the sausage with the addition of kitchen garlic on the day 1 after production. The results of the evaluation are shown in Figure 1. The other descriptors did not show statistically significant differences. It can therefore be concluded that the concentration of 0.4%, the different type of garlic and the storage time did not have a significant effect on the evaluation of the other descriptors.



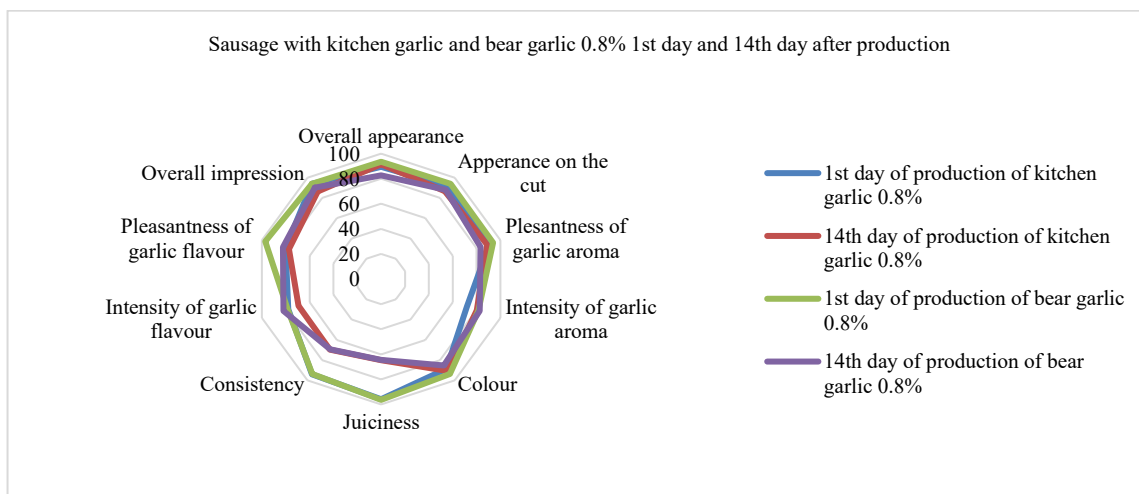
**Figure 1** Sensory evaluation of sausages with 0.4% added kitchen garlic and bear garlic on days 1 and 14 after production

When comparing sausages with 0.8% addition of kitchen and bear garlic between day 1 and day 14, there was a statistically significant difference ( $p < 0.05$ ) for the descriptor overall appearance between the sausage with the addition of bear garlic on the day 14 after production and on day 1 after production. The highest mean value ( $94 \pm 6$ ) was measured for the sausage with bear garlic added on the day 1 after production. The lowest mean value ( $83 \pm 7$ ) was measured for the sausage

with the addition of bear garlic on the day 14 after production. A statistically significant difference ( $p < 0.05$ ) was found in the juiciness between the sausage with the addition of kitchen garlic on the day 1 after production, the sausage with the addition of kitchen garlic on the day 14 after production and the sausage with the addition of bear garlic on the day 14 after production. The highest mean value ( $96 \pm 7$ ,  $96 \pm 3$ ) was measured for the sausage with the addition of kitchen garlic

on the day 1 after production and for the sausage with the addition of bear garlic on the day 1 after production. The lowest mean value ( $64 \pm 29$ ) was measured for the sausage with the addition of bear garlic on the day 14 after production. There was a statistically significant difference ( $p < 0.05$ ) in the descriptor pleasantness of kitchen garlic flavour between the sausage with the addition of kitchen garlic on the day 1 of production and the sausage with the addition of bear garlic on the day 1 after production. There was a statistically significant difference ( $p < 0.05$ ) between the sausage with the addition of kitchen garlic on the day 14 after production and the sausage with the addition of bear garlic on the day 1 after production and the sausage with the addition of bear garlic on the day 1 after

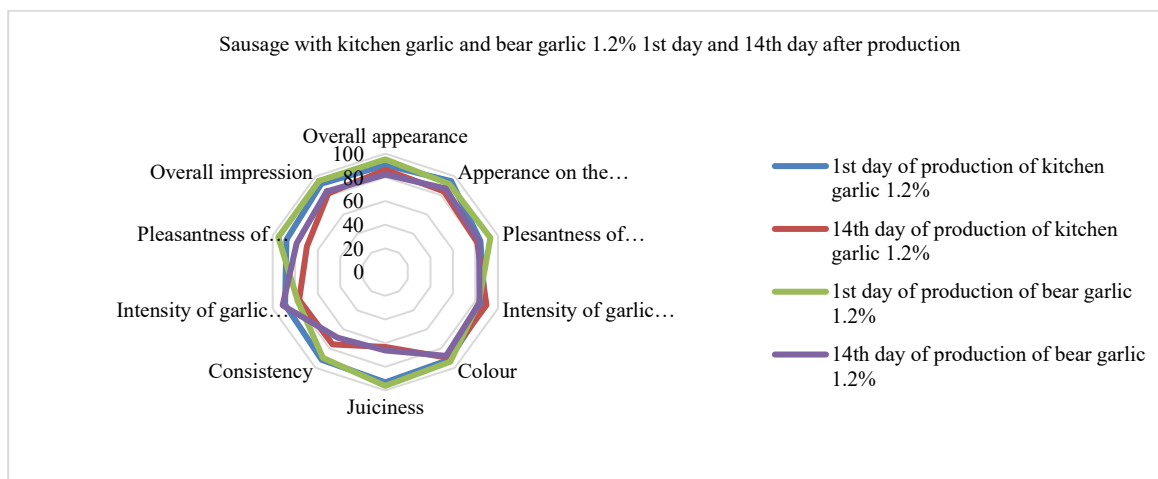
production, and between the sausage with the addition of bear garlic on the days 1 and 14 after production. The highest mean value ( $97 \pm 4$ ) was measured for the sausage with the addition of bear garlic on the day 1 after production. The lowest mean value ( $77 \pm 15$ ) was measured for the sausage with kitchen garlic on the day 14 after production. The results of the evaluation are shown in Figure 2. The other descriptors did not show statistically significant differences. It can therefore be concluded that the concentration of 0.8%, the different type of garlic and the storage time did not have a significant effect on the evaluation of the other descriptors.



**Figure 2** Sensory evaluation of sausages with 0.8% added kitchen garlic and bear garlic on days 1 and 14 after production

When comparing sausages with 1.2% addition of kitchen and bear garlic between day 1 and day 14 after production, there was a statistically significant difference ( $p < 0.05$ ) in the juiciness descriptor between the sausage with added kitchen garlic on the day 1 and day 14 after production. In addition, the statistically significant difference ( $p < 0.05$ ) was found between the sausage with added kitchen garlic on day 14 after production and the sausage with added bear garlic on the day 1 after production. There was also a statistically significant difference ( $p < 0.05$ ) between the sausage with bear garlic added on the day 1 after production and the sausage with bear garlic added on the day 14 after production. The highest mean value ( $93 \pm 6$ ) was obtained for the sausage with the addition of kitchen garlic on the day 1 after production. The lowest mean value ( $66 \pm 28$ ) was measured for the sausage with the addition of bear garlic on the day 14 after production. There was a

statistically significant difference ( $p < 0.05$ ) in the descriptor garlic flavour pleasantness between the sausage with the addition of kitchen garlic on the day 14 of production and the sausage with the addition of bear garlic on the day 1 after production. The highest mean value ( $95 \pm 6$ ) was measured for the sausage with the addition of bear garlic on the day 1 after production. The lowest mean value ( $70 \pm 17$ ) was measured for the sausage with the addition of kitchen garlic on the day 14 after production. The results of the evaluation are shown in Figure 3. The other descriptors did not show statistically significant differences. It can therefore be concluded that the concentration of 1.2%, the different type of garlic and the time of evaluation did not have a significant effect on the evaluation of the other descriptors.



**Figure 3** Sensory evaluation of sausages with 1.2% added kitchen garlic and bear garlic on days 1 and 14 after production

**DISCUSSION**

**Instrumental colour measurement**

Consumers consider the appearance and colour of a meat product as a key criteria when choosing a product. Consumers associate colour with the freshness of the meat. A study by **Tapp et al. (2011)** investigated the relationship between instrumental measurements of fresh meat colour and the palatability of cooked meat. Several factors influence the individual measured colour values of meat samples, such as the light source and the instrument used to measure the colour. A study by **Holman et al. (2016)** investigated the relationship between colour acceptability and instrumental assessment of beef colour. Previous research has demonstrated that consumers are willing to pay a higher price for cherry red beef. If the colour does not meet consumer requirements and expectations, discounting

often occurs or the meat is added to mince. The study concluded that  $L^*$  and  $b^*$  values reflect differences in consumer acceptance of beef colour. According to the study by **Holman et al. (2017)**, the value  $a^*$  indicates the acceptability of the meat colour by the consumer. If  $a^*$  values were less than 14.5, the colour of the meat was considered unacceptable. The optimum value for the acceptability of meat colour is 14.5 and above. The results of this study can be compared with a study that evaluated the relationship between consumer ratings of lamb colour and objective measures of colour (**Khlijji et al., 2010**). In this study (**Khlijji et al., 2010**), the  $a^*$  was considered acceptable if it was greater than 14.5. Values of  $a^*$  close to 14.5 (considered acceptable) were also measured on the surface of sausages in our work. It can be concluded that the  $a^*$  values in our work were not higher than 14.5, which could be due to the fact that this is a meat product made from both beef and pork.

Our results can be compared with the study of Šmiecnińska *et al.* (2022), where were investigated the effects of garlic (*Allium sativum* L.) and bear garlic (*Allium ursinum* L.) on the physicochemical and sensory properties of rabbit meat burgers. Variant with the addition of garlic (0.35 g/100 g) in the oven-roasted burger had the following values:  $L^* = 70.06$ ,  $a^* = 3.98$ ,  $b^* = 19.79$ . For raw burgers, the results from the colour analysis were different ( $L^* = 55.35$ ,  $a^* = 11.50$ ,  $b^* = 17.32$ ).

Variant with the addition of bear garlic (0.35 g/100 g) in the oven baked burger had the following values:  $L^* = 71.04$ ,  $a^* = 3.14$ ,  $b^* = 20.19$ . For raw burgers, the results from the colour analysis were different, ( $L^* = 56.77$ ,  $a^* = 8.12$ ,  $b^* = 18.64$ ). The results of our work can be compared rather with the variant raw burgers, whose values were closer to the sausages with the addition of bear and garlic than the roasted burger variant. It can be assumed that the different values with this study were due to the different type of meat and the different concentration of and bear garlic.

### Chemical analysis

The results of our work can be compared with the study of Kurčubić *et al.* (2023), which added bear garlic to burgers. In this study, bear garlic was used in the form of freshly squeezed bear garlic extract. The average protein content of each sample in the study was 20 g, which is comparable to our work, where protein values ranged at the same level around 19 g. The fat values in our work differed slightly from this study, were higher than 17 g. The average fat content determined in the study was 17 g. We assume, that when comparing our work with this study, the values may be different, for example, by using different form of bear garlic, quantity and type of meat product.

This study also found that bear garlic was very effective in preserving hamburgers when stored in the refrigerator.

The optimum concentration of bear garlic extract was found to be 10% w/vol. The highest antioxidant activity was observed at this concentration.

The result shows that the storage time of the sausages had an effect on dry matter, fat content, protein and salt. For the variants of sausages with kitchen and bear garlic, which were evaluated on the day 14 after production, all chemical analysis results increased compared to the results of analyses conducted on the day 1 after production. The increase in values could be due to evaporation of water or because the sausages were not wrapped. Slight differences in the chemical analysis could also be due to inhomogeneity of the product in the mixing process.

### Sensory analysis

Our results can be compared with the study of Kurčubić *et al.* (2023), where the properties of burgers enriched with bear garlic extract. Variant with the addition of bear garlic, the burger with the bear garlic extract was higher rating in colour, texture and overall acceptability than the control without the addition of bear garlic. From the sensory evaluation of our results, it can be concluded that the sausage with the addition of bear garlic achieved higher ratings than the sausage with the addition of kitchen garlic.

The results can also be compared with the study of Šmiecnińska *et al.* (2022), where the effects of kitchen and bear garlic on the physicochemical properties of and sensory properties of rabbit meat burgers were investigated. For roasted burgers, the variant with bear garlic had higher values for appearance, juiciness, texture and overall acceptability than the bear garlic variant. In our work, the sausages with the addition of bear garlic scored higher on these descriptors than the sausages with added garlic, especially on the day 1 after production.

### CONCLUSION

The aim of this study was to investigate the effect of the addition of bear garlic on the sensory quality of meat product in comparison with kitchen garlic. By instrumental colour measurements, it was found that in the vast majority of trials, sausages with the addition of kitchen garlic were lighter on the surface and cut and also redder than sausages with the addition of bear garlic. On the other hand, the sausages with the addition of bear garlic were more yellow than the sausages with the addition of kitchen garlic in most of the evaluations, which could be due to, for example, the pigments contained in the bear garlic.

Based on the results of the chemical analysis can be concluded that the differences between day 1 and 14 after the production of the sausages with bear garlic and kitchen garlic were insignificant. The small differences in chemical composition could be due to inhomogeneity of the product during mixing. There was no statistically significant ( $p > 0.05$ ) difference in salt content between samples in any variant. There was an increase in dry matter, fat, protein and salt values between day 1 and day 14 after production of the sausages with the addition of both bear and kitchen garlic. The results from the day 14 after production were relatively higher than the values from the day 1 after production. The increase in the values may have been caused by evaporation of water.

From the results of the sensory analysis can be concluded that the most significant difference was in the descriptor pleasantness of garlic flavour, where the sausage with the addition of bear garlic was rated better. The sausage with the addition of bear garlic on the day 14 after production had a lower score in the descriptor of juiciness and consistency compared to the other variants, which was probably due

to the fact that bear garlic has more water and fiber. The sausages with the addition of bear garlic on the day 1 after production had predominantly higher score in the descriptors of juiciness, pleasantness of garlic aroma, pleasantness of garlic flavour and overall impression than the sausages with the addition of kitchen garlic.

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