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Product Quality and Safety

Effects of lycopene on the colour and sensory characteristics of cooked sausages

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Abstract. *Research was conducted in order to determine the effect of tomato lycopene addition and reduction of included nitrites on the chemical composition, residual nitrite quantity, muscle pigment oxidation processes, colour characteristics and overall sensory evaluation of cooked perishable sausages. Experimental samples with three lycopene concentrations and different nitrite quantities, and a reference sample with standard and reduced sodium nitrite content were prepared. It was found that the increase in the included lycopene quantity was accompanied by an increase in the values of the red a* and yellow b* component of the experimental sample colour. The best colour characteristic and colour stability of the cut surface was observed with the samples made using 100 mg.kg^{-1} and 50 mg.kg^{-1} of sodium nitrite and 40 mg.kg^{-1} of lycopene. The sausages made only with the addition of lycopene and 100 mg.kg^{-1} sodium nitrite and 80 mg.kg^{-1} lycopene had lower sensory evaluation compared to the samples with standard (100 mg. kg^{-1}) or reduced (50 mg.kg^{-1}) nitrite and lycopene quantity.*

Keywords: lycopene, sausages, colour, nitrite

Introduction

The quality of meat and meat products is a complex evaluation comprising their nutritional qualities and organoleptic, technological, sanitary and hygienic indices. Nevertheless, sensory characteristics are still of greatest importance to consumers. It is the colour of meat products that makes the first impression and is often the basis of its selection or rejection (Cornforth and Jayasingh, 2004; Deda et al., 2007; Hamm, 2007). The colour formation process in cooked meat products is mainly affected by the nitrites added. Apart from their role in the colour formation processes, nitrites also affect meat product flavour and oxidative changes, demonstrating a certain antioxidant effect, in combination with different technological factors they have an effect on microbiological safety, and they enter into chemical reactions with the carbohydrates and lipids in meat batter (Morrissey and Tichivangana, 1985; Honikel, 2004; Sebranek and Bacus, 2007; Honikel, 2008). Along with the technological effects mentioned, nitrites are also associated with health risks for consumers (Devcich et al., 2007). The quantity of nitrites included in meat products is of extreme importance in view of the fact that the rate of secondary amine nitrosation is directly proportional to the quantity of nitrites added to the meat batter. Although the nitrite/nitrate content in vegetables largely exceeds that in meat and meat products, the antioxidants contained in them (ascorbic acid, α-tocopherol, etc.) can react with nitrosating agents and consequently demonstrate a protective effect as regards nitrosamine formation (Honikel, 2008).

Lycopene is a natural pigment synthesised by plants and microorganisms, having a generally recognized GRAS status, and showing antioxidant properties (Kong et al., 2010). Interest in lycopene has grown significantly in the past several years owing to the data gathered on its biologically active role in the prevention of a number of major diseases, such as breast cancer, cervical cancer, cardiovascular problems, osteoporotic fractures, cataract, and lung, pancreatic, prostate, skin and stomach cancer (Khachik et al., 2002; Choski and Joshi, 2007; Kavanaugh et al., 2007).

In this aspect, the evaluation of the effect of lycopene addition and the technological possibility of nitrite reduction on the development of colour and sensory characteristics of meat products may become the trend for the creation of meat products which have improved quality indices and chemical safety.

Material and methods

Studies were made using structureless sausage according to the BDS 127-83 recipe and technological instruction for the production of Strandzha frankfurters: 30% lean pork, 70% semi-fat pork, 2.2% sodium chloride, 0.2% sugar, 0.4% white pepper, 0.1% nutmeg, 0.01% sodium nitrite. The samples were prepared at the Training and Production Facility of the Meat and Fish Technology Department. Boned refrigerated pork bought at retail stores and having active acidity pH = 6,13 ± 0,15 was used for the purpose of the study. Tomato extract having 10% lycopene content (according to the specification) was used as lycopene source. The sausages were prepared by placing the chopped meat in a meat cutter and processing them, adding the auxiliary materials until fine, homogenous meat mass was obtained. During cutting, flaky ice was added in a quantity equal to 25÷30% of the meat mass weight. Figure 1 shows a schematic representation of the experimental setup.

The lycopene was added to the meat batter and further cut for 3 ÷ 5 more revolutions of the cutter. The meat batter was stuffed into artificial polyamide casings, and individual pieces were shaped by turning. The shaped sausages were heat-treated at 95 ÷ 80°C for 60 ÷ 70 min. Sausage cooking was conducted at 76 ÷ 78°C until the temperature inside the sausage reached 72°C. The cooked sausages were cooled under running water for 10 ÷ 15 min until the

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temperature of individual sausages was equal to the ambient temperature. The studies towards evaluation of the residual nitrite quantity were made using a M550 Double Beam Scanning UV/VIS spectrophotometer (Camspec Ltd, United Kingdom). The residual nitrite quantity in the investigated samples was determined on the 1st day of refrigerated storage of the sausages according to BDS EN 12014-3.

Objective determination of color characteristics of the cut surface of samples tested sausage was made by Minolta Chroma Meter (model CR 410, Osaka, Japan) in the system CIE Lab, 1976; *L**– brightness, *a** – red component of color and *b** – yellow component of color. The measurement was conducted using illuminant C and 2° standard observation angle. All measurements were taken five times in non-overlapping zones, and the mean values and standard deviation were calculated. The data related to *a** and *b** were used for the calculation of colour saturation *h** according to the formula

$$h^* = \tan^{-1}(b^*/a^*) \times (180/\pi)$$

and the colour of hue C according to the formula

$$C = \sqrt{a^{*2} + b^{*2}}$$ (Cardarelli et al., 2008).

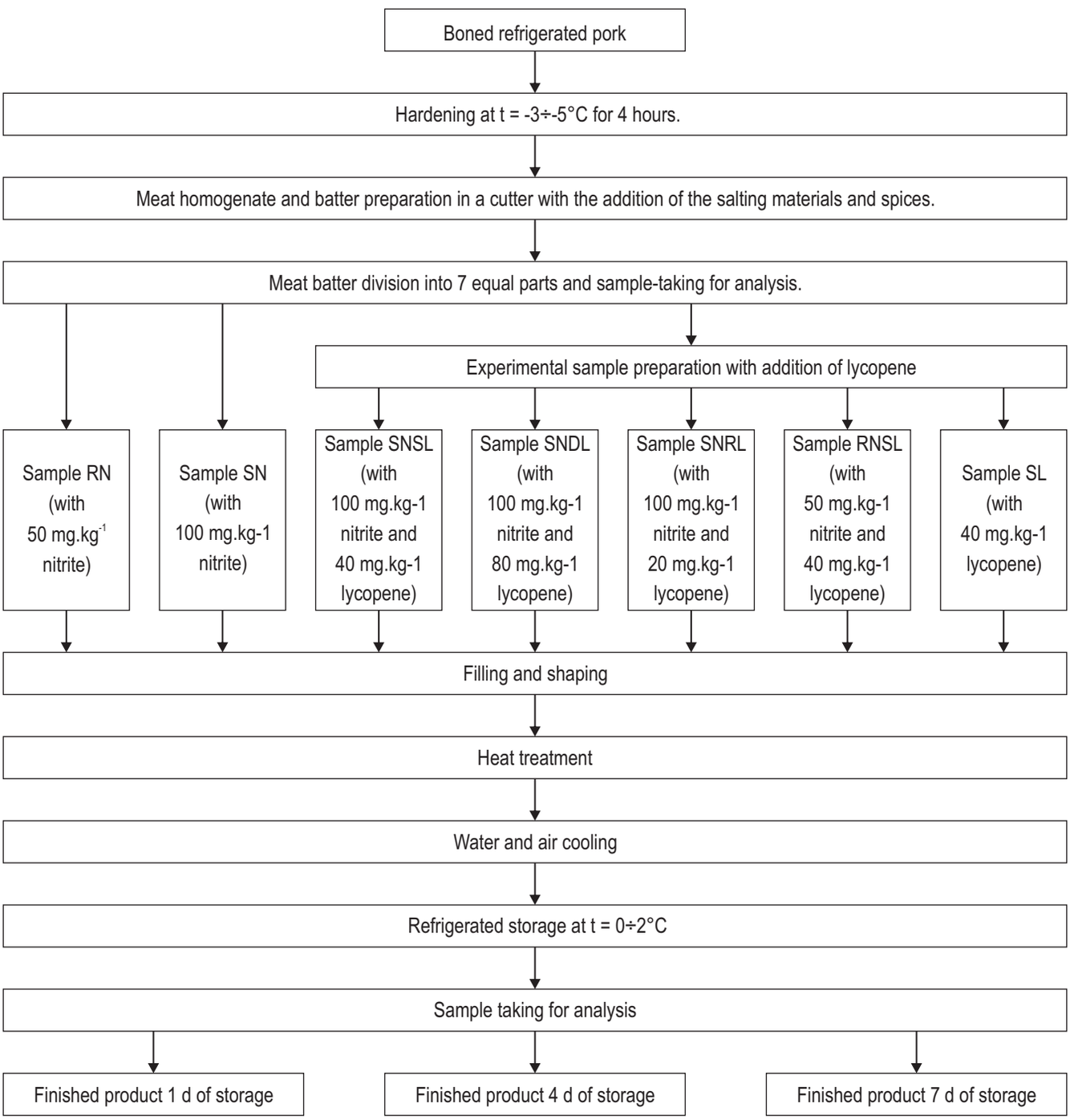


Figure 1. Experimental setup

For evaluation of the colour stability of the cut surface on the 4th day of storage, the samples were cut and left for 2 hours under normal conditions. The measured values of *L**, *a** and *b** before and after exposure to light and atmospheric oxygen, were used for the calculation of the total colour change in the samples studied. The calculations were made according to the formula

$$\Delta E_{0-n} = (\Delta L^{*2}_{0-n} + \Delta a^{*2}_{0-n} + \Delta b^{*2}_{0-n})^{1/2}$$

where ΔL^*, Δa^* and Δb^* are the differences between the *L**, *a** and *b** values at the beginning and at the 2nd hour (Luciano et al., 2009).

The sensory evaluation of the samples was made on the 4th day of refrigerated storage at a temperature of 0 ÷ 4°C. The sensory analysis was performed by a five-member tasting panel along a hedonic scale. For each of the indices evaluated, i.e. appearance, cut colour, taste, smell and texture, a scale of 1 to 5 was used, 1 being the dislike extremely, and 5 the like extremely evaluation of the respective index.

Results and discussion

The results of the studies for residual nitrite quantity evaluation in the samples have been presented in Table 1. The data show that residual nitrite was found in all cooked sausage samples produced with addition of sodium nitrite on the 1st day of storage. As a result of the studies conducted, a trend toward a decrease in the residual nitrite quantity in the finished product after lycopene addition to the meat batter was identified.

Table 1. Residual nitrite quantity in the samples studied in relation to the sodium nitrite and lycopene quantities added

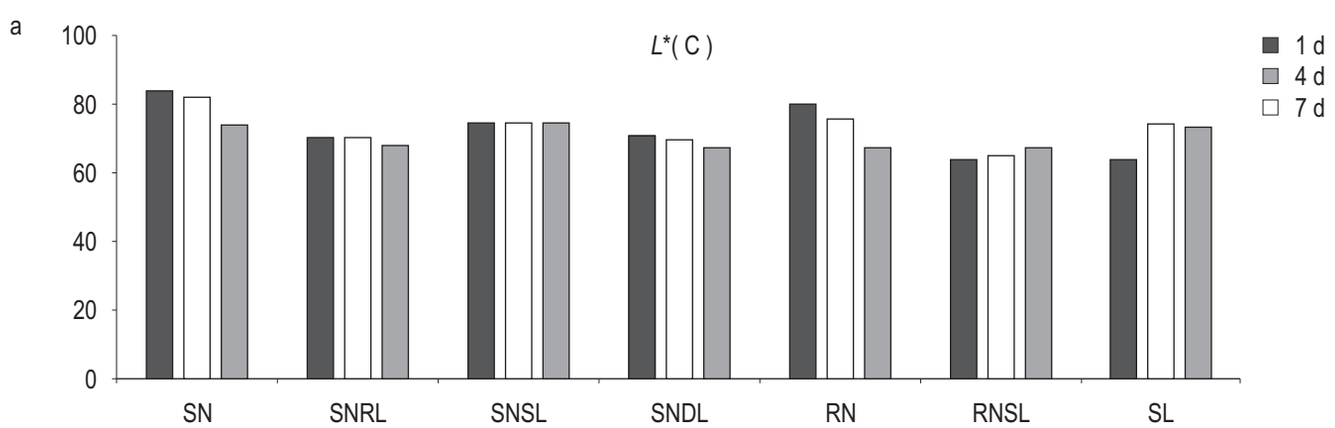
Sample	Added sodium nitrite	Added lycopene	Residual nitrite	
	mg.kg-1	mg.kg-1	Mean	SD
SN	100	-	32.97	0.18
SNRL	100	20	28.43	0.31
SNSL	100	40	26.56	0.25
SNDL	100	80	25.12	0.13
RN	50	-	18.81	0.83
RNSL	50	40	12.03	0.28
SL	-	40	Not Detected	

The results of the objective studies of the colour characteristics of the samples showed that lycopene addition to the meat batter for cooked perishable sausages resulted in a number of changes in the fraction of pigments which had a significant effect on the finished product colour (Figure 2). The colour brightness *L** values in the experimental and reference samples on the first day of their storage varied in a wide range: from 65.86 to 82.35. During storage, the colour brightness *L** of the reference samples (SN) and the samples with reduced nitrite content (RN) tended to decrease, as has also been reported by other authors (Eyiler and Oztan, 2011). In the samples to which lycopene was added (SNRL, SNSL, SNDL, RNSL), the values of the index determining colour brightness remained relatively stable during the 7-day storage period, whereas the sample to which only lycopene and no nitrite was added (SL) showed a slight increase in colour brightness *L** on the fourth day, then it was stable again (Figure 2a).

The results of the studies related to the changes in the red colour component *a** for the samples made with the addition of sodium nitrite, i.e. SN and RN, varied within a relatively narrower range (Figure 2b). It is interesting to note that the reduction of the added sodium nitrite quantity from 100 mg.kg^{-1} to 50 mg.kg^{-1} did not lead to a significant decrease in the *a** values. This means that the addition of sodium nitrite in 50 mg.kg^{-1} quantity was sufficient for the normal run of the colour formation processes and for the accumulation of the necessary amount of nitrosomyoglobin, precursor of nitrosohaemochromogen, the substance which imparts the characteristic colour to cooked sausages.

It was found that in samples SNSL, SNDL, and SNRL, lycopene addition was an important factor in the *a** increase in relation to the SN and RN samples. It is worth mentioning that the *a** mean values of the three experimental samples were statistically different ($p<0.05$) and could be arranged in the following order: *a** SNDL > *a** SNSL > *a** SNRL.

Figure 2b shows that in sample RNSL, the reduction in the sodium nitrite quantity added did not lead to any significant changes in *a** compared to the samples made with the standard sodium nitrite quantity and the same quantity of lycopene added (SNSL). At the same time, the values of the red colour component of sample RNSL were significantly higher ($p<0.05$) than those of samples SNRL and SL, by 19.15 % and 25.55% respectively. It was found that throughout the seven-day storage of the sausages, the *a** values remained stable for all samples. The data on the changes in the yellow colour component *b** values in the samples studied were similar to the changes observed in the red colour component *a**



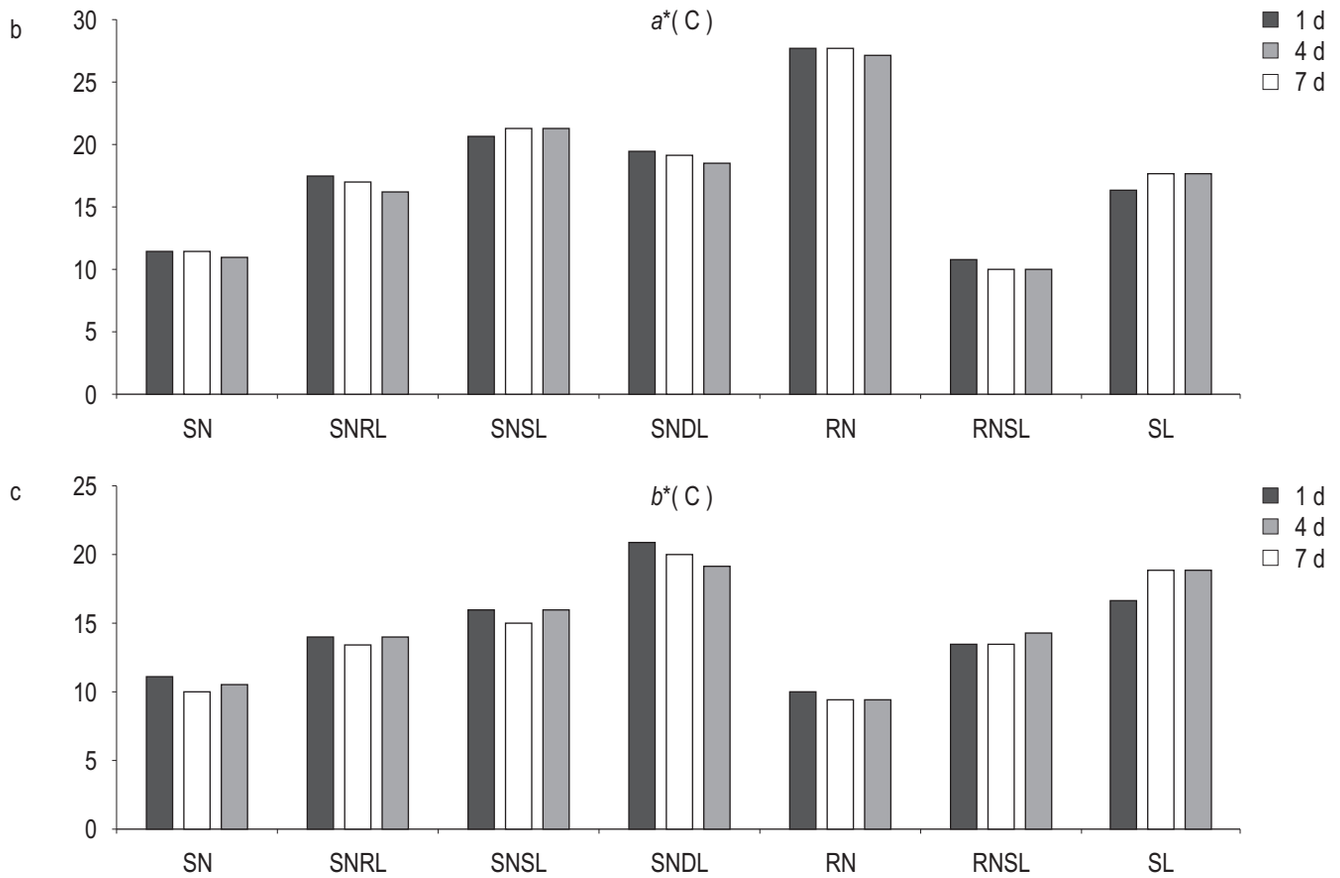


Figure 2. Effect of treatment (nitrite and lycopene) and time of storage (days 1, 4 and 7) on (a) *L** values, (b) *a** values and (c) *b** values of the cooked sausages samples.

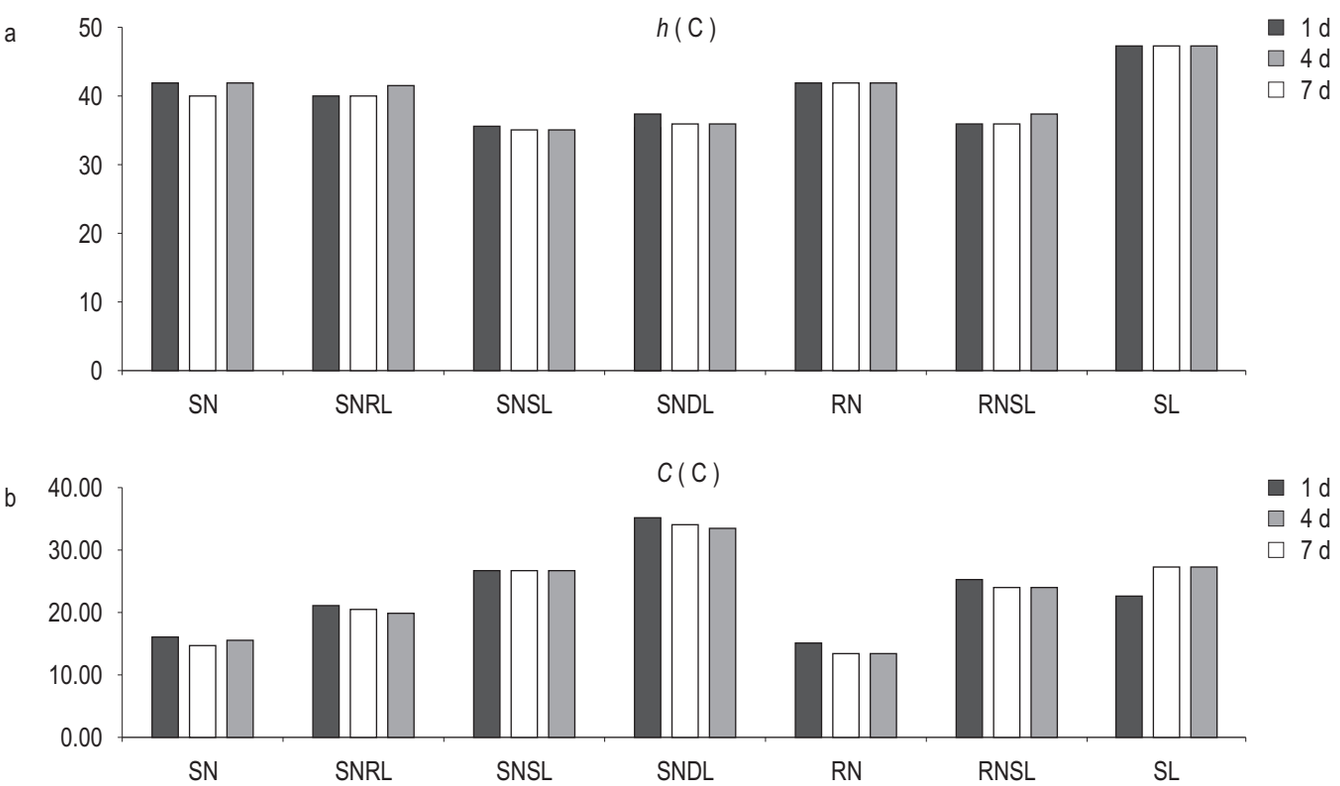


Figure 3. Effect of treatment (nitrite and lycopene) and time of storage (days 1, 4 and 7) on (a) *h* values and (b) *C* values of the cooked sausages samples. The lower *h* values indicated a colour shift towards the redder end, whereas the higher *C* values indicated more intense colouring.

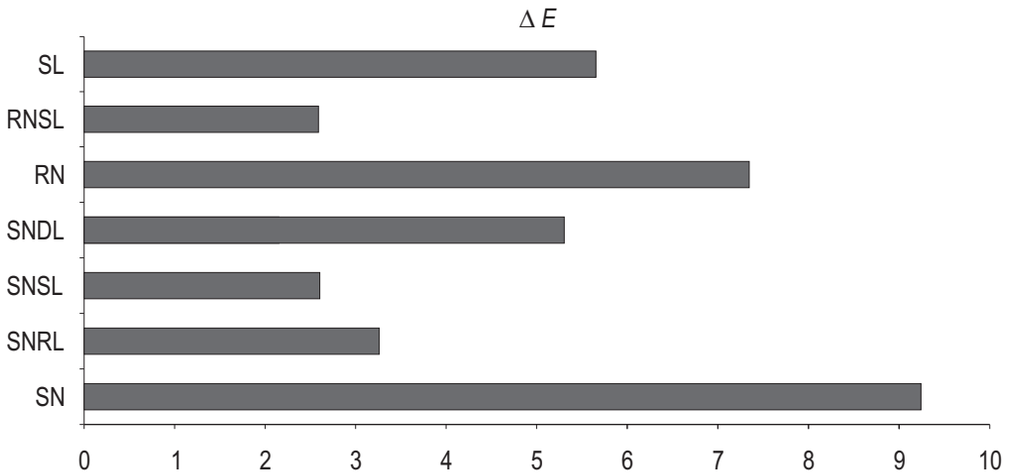


Figure 4. Colour changes expressed as ΔE values of the cut surface for a period of 2 hours

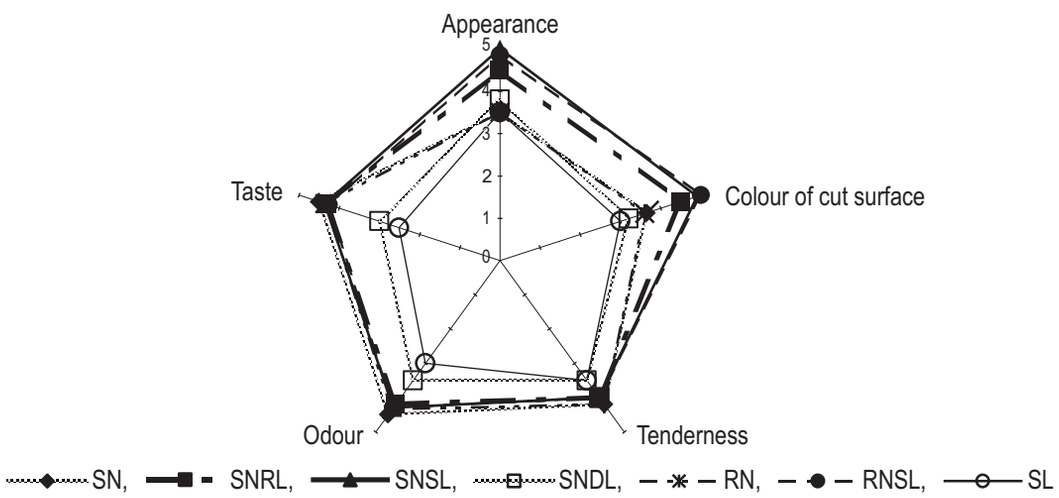


Figure 5. Effect of treatment (nitrite and lycopene) on sensory evaluation of cooked sausages.

(Figure 2c). Higher b* values were observed in the samples to which lycopene was added, and they remained relatively stable in all experimental samples after the 7th day of storage.

For a more comprehensive view of the colour formation process in the samples studied, the values of the colour saturation *h* (Figure 3a) and colour hue *C* (Figure 3b) indices were determined.

The study on the colour stability of the cut surface for a period of 2 hours (Figure 4) showed that the ΔE values reflecting the overall colour changes differed significantly between samples.

The most considerable colour changes were observed in samples SN, RN and SL. In the SNRL, SNSL, and RNSL samples these colour changes were delayed to some extent, which resulted in colour stabilisation in these samples at the second hour. This was probably due to the more expressed antioxidant effect of the lycopene-nitrite combination used. In the SNDL and SL samples lycopene probably acted mainly as prooxidant, therefore more significant colour changes were observed under the influence of light and air oxygen.

The results obtained from the sensory analysis of the experimental sausage samples showed that lycopene addition led to changes which were consistent with the data from the colorimetric study (Figure 5). The analysis of the data on the appearance and colour of the cut section of the SN and RN samples demonstrated that nitrite reduction did not result in any significant mean value differences between these two samples, but the mean values were considerably lower that the mean evaluations of the lycopene- and nitrite-containing samples. The data comparison between samples having different nitrite and lycopene concentrations showed the highest sensory evaluations of colour for the SNSL and RNSL samples. This is indicative of the significant improvement in the appearance and colour of cooked products when 40 $mg.kg^{-1}$ lycopene was added to the meat batter. The addition of lycopene only, however, as in sample SL, resulted in a lower and more unacceptable score.

The comparative analysis of the mean evaluations of the taste, smell and texture of individual samples showed that lycopene addition led to a reduction in these values. Sample SL had the lowest score on these indices. This may be due to the lack of nitrite, which has a major role in the formation of the characteristic smell and taste of meat products. No statistically different values of the smell and

taste indices were established in the samples made with 100 mg.kg^{-1} and 50 mg.kg^{-1} sodium nitrite (SN and RN). The use of a nitrite – lycopene combination for addition to the meat batter for sausages in samples SNSL, SNRL, and RNSL did not cause any significant differences in the mean evaluations of taste and smell in relation to the samples containing nitrite only (Figure 5).

Conclusion

When lycopene is added to the meat batter of perishable sausages, colour formation processes are expressed more strongly compared to the samples made without lycopene. An increase in the *a** values of cooked sausages was found, indicating that the lycopene used contributed to greater nitrosomyoglobin accumulation in combination with a reduced quantity of the sodium nitrite added, and a lower nitrite quantity in the finished product. Nevertheless, the addition of lycopene on its own or in greater concentrations resulted in a product having a non-characteristic colour, and it probably acted as a prooxidant rather than antioxidant causing deterioration of the taste and smell of cooked sausages. It was found that the addition of lycopene in a 40mg.kg^{-1} quantity could be used as an efficient means of reducing the nitrite quantity added during cooked sausage production, which is a major prerequisite for the manufacture of a finished product having improved sensory characteristics and chemical safety with regard to residual nitrites.

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Product Quality and Safety

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