Colour characteristics of vacuum packed fermented sausage during storage

S Skaljac1, M Jokanovic1, V Tomovic1, M Ivic1, B Sojic1, P Ikonic2 and T Peulic2

1 University of Novi Sad, Faculty of Technology Novi Sad, Novi Sad, Serbia
2 University of Novi Sad, Institute of Food Technology, Novi Sad, Serbia

E-mail: snezana.savatic@tf.uns.ac.rs

Abstract. The effect of vacuum packaging on colour (instrumental and sensory characteristics) of dry fermented sausage (Petrovská klobása) during storage period was examined. Sausages were dried under controlled conditions and stored unpacked (C) or packed under vacuum (V). The instrumental colour characteristics (CIE L*a*b* system: lightness – L*; redness – a*; yellowness – b*; hue angle – h and chroma – C*), sensory evaluation of colour, pH, water activity and moisture content were determined at the end of the drying period (day 0 of storage) and after 30 and 60 days of storage. Vacuum packed sausages had significantly (P<0.05) lower L* and a* on day 30 and 60 of storage compared with L* and a* values determined at day 0 of storage; however, other instrumental colour characteristics were not statistically different (P>0.05). Sausages packed under vacuum had significantly higher (P<0.05) a* value on day 30 of storage and significantly higher (P<0.05) L* value on day 60 of storage compared with unpacked sausages. Also, on both examined storage days, the colour of vacuum packed sausages was more acceptable sensorially than that of unpacked sausages. According to the results obtained in this study, vacuum packaging had a positive impact on colour characteristics (instrumental and sensory) of dry fermented sausages produced in controlled conditions.

1. Introduction
Consumers often estimate the quality of meat and meat products based on colour. Colour of meat products is an important parameter in acceptability of products and influences consumers’ acceptance of meat products. Oxygen together with illumination cause discoloration of meat products during storage. Therefore, colour formation and colour stability are important quality indicators of fermented dry sausages [1-3].

Petrovská klobása is a dry fermented sausage with designation of origin (PDO) according to Serbian legislation because of its specific and distinctive qualities. This sausage is produced without additives or starter cultures. The intense red colour is one of the important characteristics of Petrovská klobása, and makes it distinctive from other products of the same type. This pleasing colour is formed thanks to the use of red paprika [4].

In order to prevent undesirable oxidation processes and enhance the colour stability of meat products, selected food additives with suitable functional properties, such as nitrates and nitrites, are used in controlled conditions [2, 5]. Since, Petrovská klobása is produced without artificial additives...
for enhancing colour characteristics, vacuum packaging could be a suitable packaging method to preserve desirable colour characteristics during longer storage periods [5-7].

Therefore, the aim of this study was to determine effect of vacuum packaging on colour characteristics (instrumental and sensory) of dry fermented sausage (Petrovská klobása) during storage.

### 2. Materials and Methods

#### 2.1. Preparation of dry fermented sausages

The sausages were produced from minced lean pork meat, pork fat and seasonings (home-made red hot paprika powder, salt, caraway, crushed garlic and sugar). The sausage mixture was stuffed into collagen casings (55 mm diameter). After a rest day, sausages were smoked in by a registered meat processor in Laćarak (near Sremska Mitrovica, Serbia). The smoking process lasted 24 h in controlled conditions. Smoke was produced by a smoke generator using beech wood. Smoking and subsequent drying and ripening processes were performed in an industrial chamber. The average temperature in the industrial ripening room was 7°C, while average relative humidity ranged from 90% to 65%. After smoking, drying and ripening processes were continued until the moisture content was below 35.0%, which occurred day 60 of production. After that, sausages were divided in two groups. Control sausages were unpackaged (C), while other sausages were packed in vacuum (V). All sausages were stored under controlled conditions until day 120 of production (day 60 of storage).

#### 2.2. Samples

Samples for analyses were taken on day 0 of storage, i.e. at the end of the drying period (C); day 30 (C1 unpacked and V1 vacuum packed sausages), and; day 60 (C2 unpacked and V2 vacuum packed sausages).

#### 2.3. Instrumental determination of colour characteristic

Instrumental colour measurements were performed on fresh cut sausages samples at least 3 cm thickness, using the colorimeter Chroma Meter (CR-400), with aperture of 8 mm in the measuring head and standard additions to measure CR-A33b (Konica Minolta, Japan). Lighting D-65 and standard observer angle of 2° were used. Before each set of measurements, the instrument was calibrated using a white ceramic tile (CR-A43). Sausage colour characteristics were expressed by the CIE \( L^*a^*b^* \) system (lightness – \( L^* \), redness and greenness – \( a^* \); yellowness and blueness – \( b^* \)) [8]. Hue angle (h) and chroma (\( C^* \)) were calculated using CIE \( L^*a^*b^* \) values [9]. Data presented are means of 10 measurements.

\[
h = \tan^{-1}\left(\frac{b^*}{a^*}\right)
\]

\[
C^* = \sqrt{a^{*2} + b^{*2}}
\]

#### 2.4. pH, water activity (\( a_w \)) and moisture content determination

\( pH \) and moisture content in Petrovská klobása were determined according to respective methods recommended by the International Organization for Standardization [10, 11]. Water activity (\( a_w \)) in Petrovská klobása samples was determined using a Testo 650 instrument with a pressure-tight precision humidity probe (Testo AG, USA). All determinations were made in triplicate.
2.5. Sensory analysis of colour
Colour characteristics were also evaluated sensorially on a fresh cut of the sausage samples. Sensory analysis was conducted by a group of six experienced evaluators of different ages, according to a point system for analytical descriptive tests, using a scale from 1 to 5 (5 – optimal colour characteristic; 1 – atypical colour characteristic).

2.6. Statistical analysis
Results are presented as mean value±standard deviation. One way ANOVA procedure in Statistica (version 12, StatSoft, Tulsa, USA) was used to compare means. Means were also compared by Duncan’s test at the 5% level of significance.

3. Results and Discussion
The effect of storage period on the pH, a<sub>w</sub> and moisture content of V and C sausages is shown in Table 1. At the beginning of the storage period, pH, a<sub>w</sub> and moisture content were 5.38, 0.907 and 34.30%, respectively. During the 60 day storage period, pH, a<sub>w</sub> and moisture content significantly decreased (P <0.05) in both groups of sausages, but V sausages had significantly (P<0.05) higher values of these parameters compared to C sausages. Perea-Sanz et al. [5] reported the same trends for a<sub>w</sub> and pH during storage of vacuum packed dry fermented sausages. They concluded the slight but continuous pH decrease which occurred during the storage period could be due to the metabolic activity of lactic acid bacteria, which are likely still active although to a lesser extent. Piras et al. [12] connected lower pH with lipid oxidation in meat products and they also showed that vacuum packaging prevents oxidative processes in dry cured sliced ham. Our results are in agreement with these studies, because during storage, our V sausages had minor changes of the examined parameters (pH, a<sub>w</sub> and moisture content) compared to our C sausages.

Table 1. pH, water activity (a<sub>w</sub>) and moisture content (means±standard deviations) in dry fermented sausage (Petrovská klobása) during storage

| Parameters                  | 0 day | 30 days of storage | 60 days of storage |
|-----------------------------|-------|--------------------|--------------------|
|                             | C     | C1                 | V1                 | C2     | V2     |
| pH                          | 5.38±0.02 | 5.29±0.02         | 5.25±0.01          | 5.16±0.03 | 5.28±0.01 |
| Water activity (a<sub>w</sub>) | 0.907±0.003 | 0.873±0.002     | 0.910±0.002       | 0.830±0.001 | 0.877±0.001 |
| Moisture content (%)        | 34.30±0.25 | 23.03±0.62        | 30.28±0.16        | 20.13±0.83 | 28.45±0.33 |

In the same row different letters signify values are significantly different (P < 0.05)

In this study, colour characteristics of dry fermented sausages (Petrovská klobása) produced in controlled conditions were determined during 60 days storage. Instrumental colour characteristics were measured on fresh cuts of V and C sausages (days 0, 30 and 60 of storage) (Table 1). During the storage period, L*, a*, b*, h and C* values significantly (P<0.05) decreased in C sausages. V sausages had significantly (P<0.05) lower L* and a* on days 30 and 60 of storage compared with these values on day 0 of storage. However, other instrumental colour characteristics were not statistically different (P>0.05). Böhner et al. [3] reported that change of b* value during storage can be related to the intensity of the oxidation process, and higher oxidation changes lead to increased yellowness, while decreased a* could be explained by the reaction of light-induced oxidation of the colour pigments and formation of metmyoglobin. This pigment is grey-brown and likely caused the decreased a* on the cut surfaces of our sausages. V sausages had significantly higher (P<0.05) a* value on day 30 of storage and significantly higher (P<0.05) L* value on day 60 of storage than did C sausages. Also, at both examined storage periods, V sausages were more sensorially (colourwise) acceptable than were C sausages (day 30 – C1=4.13 and V1=4.50; day 60 C2=3.89 and V2=4.29) (Figure 1). According to these results, vacuum packaging had a positive impact on colour characteristics (instrumental and
sensory) of dry fermented sausages produced in controlled conditions. Similar results were found by other authors. They confirmed the positive impact of vacuum packaging on colour characteristics of meat products during storage [5, 12].

Table 2. Instrumental colour characteristics (CIE L*a*b* system) of dry fermented sausage (Petrovská klobása) during storage period; means±standard deviations

| Colour characteristic | 0 day | 30 days of storage | 60 days of storage |
|-----------------------|-------|--------------------|--------------------|
|                       | C     | C1 V1              | C2 V2              |
| Lightness (L*)        | 39.32±2.20 | 34.39b±2.75 | 36.54h±1.35 | 32.02a±2.92 | 36.48b±2.88 |
| Redness (a*)          | 25.23b±2.34 | 21.87±2.28 | 25.25b±1.82 | 22.19a±3.81 | 23.87ab±1.40 |
| Yellowness (b*)       | 25.82b±3.32 | 22.09±4.99 | 20.54±2.02 | 21.11±3.83 | 21.96±3.25 |
| Hue angle (h)         | 45.55±2.22 | 44.74±4.74 | 41.08±2.23 | 43.49±4.32 | 42.38±3.59 |
| Chroma (C*)           | 36.12b±3.81 | 31.17±4.90 | 32.57ab±2.41 | 30.70a±4.91 | 32.49ab±2.89 |

In the same row different letters signify values are significantly different (P<0.05)

Figure 1. Sensory analysis of colour characteristics

4. Conclusion
During the storage period, L*, a*, b*, h and C* values significantly (P<0.05) decreased in unpacked sausages. Vacuum packed sausages had significantly lower L* and a* on days 30 and 60 of storage compared with L* and a* values determined on day 0 of storage. However, other instrumental colour characteristics were not statistically different (P>0.05). Also, at both examined storage periods, vacuum packed sausages were more sensorially acceptable (colourwise, to a trained panel of evaluators) than were unpacked sausages. In conclusion, vacuum packaging had positive impacts on colour characteristics (instrumental and sensory) of dry fermented sausages produced in controlled conditions.

Acknowledgement
The research in this paper was financed by the Ministry of Education and Science of the Republic of Serbia (Project No. TR 31032).

References
[1] Bozkurt H and Bayram M 2006 Meat Sci. 73 344–50
[2] Gøtterup J, Olsen K, Knochel S, Tjener K, Stahnke L H and Møller J K S 2008 Meat Sci. 78 492–501
[3] Böhner N, Rieblinger K, Danzl W 2014 Food Packaging Shelf 1 131–9
[4] Petrović Lj, Džinić N, Tomović V, Ikonić P and Tasić T 2007 Intellectual Property Office Republic of Serbia, Decision No. 9652/06 G-03/06
[5] Perea-Sanz L, Montero R, Belloch C and Flores M 2019 Meat Sci. 147 100–7
[6] Summo C, Caponio F and Pasqualone A 2006 Meat Sci. 74 249–54
[7] Rubio B, Martínez B, García-Cachán M D, Rovira J and Jaime I 2008 Meat Sci. 80 1182–7
[8] Škaljac S, Jokanović M, Tomović V, Ivić M, Tasić T, Ikonić P, Šojić B, Džinić N and Petrović Lj 2018 LWT - Food Sci. Technol. 87 158–62
[9] Ledesma E, Laca A, Rendueles M and Diaz M 2016 LWT - Food Sci. Technol. 65 164–72
[10] International Organization for Standardization 1999 Measurement of pH; 2917: 1999 ISO: Geneva
[11] International Organization for Standardization 1997 Determination of Moisture Content; 1442: 1997 ISO: Geneva
[12] Piras F, Fois F, Casti D, Mazza R, Consolati S G and Mazzette R 2016 J. Food Process. Pres. 40 1223–8