DRYING CHARACTERISTICS OF TRADITIONAL DRY-FERMENTED SAUSAGE *PETROVSKÁ KLOBÁSA* AS INFLUENCED BY DIFFERENT ENVIRONMENTAL CONDITIONS

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Abstract - The influence of different environmental conditions on drying characteristics of traditional dry-fermented sausage (*Petrovská klobása*) was evaluated. For that purpose, two batches of sausages were dried in different environments, a traditional room (TR) and a controlled industrial ripening room (RR). The environmental conditions in TR were characterised by low air temperature and high relative humidity, while the conditions in RR were set to imitate conditions present in traditional practice, but also to enable faster processes of fermentation and drying. The obtained results for sausage moisture content, water activity (aw) and diameter reduction indicated slower drying process in TR than in RR (90 vs. 60 days). Beside the environmental conditions, this phenomenon was also determined by pH, which was lower in RR sausages ($P<0.05$). The third degree polynomial equation was used for estimation of the experimental average moisture content versus drying time ($r^2>0.992$). The use of industrial room for the drying of *Petrovská klobása* seems to be a potential technological improvement to shorten the drying period and to extend the production season of this traditional sausage.

Key Words – moisture content, traditional room, industrial ripening room

I. INTRODUCTION

Traditional production process of dry-fermented sausages is very time consuming. Thus, shortening of drying and ripening period would result in a reduction of the drying facilities, storage time, capital and labour, and would increase the profit margin and competitiveness of the product. The drying rate can be sped up by increasing the temperature and reducing the air relative humidity [1].

Petrovská klobása is a dry-fermented sausage manufactured in municipality of Bački Petrovac (Vojvodina, Northern Serbia). Due to its production (smoking, intensive drying) and sensory characteristics (aromatic and spicy-hot taste, dark red colour and hard consistency) it represents a transitional type between the Mediterranean and Northern or Central European fermented sausages [2, 3]. *Petrovská klobása* is produced in traditional manner, according to original recipe, without use of chemical additives and microbial starters. In small household enterprises this sausage is made during winter (usually December), when temperatures are around 0°C or lower. Thus, it undergoes slow drying and ripening processes (90 days at least) [4, 5, 6].

In order to investigate the possibility to shorten the drying period and to extend the production season of *Petrovská klobása*, drying characteristics of sausages ripened in different environmental conditions (traditional room vs. controlled ripening room), were determined in this study.

II. MATERIALS AND METHODS

Sausage preparation

Petrovská klobása sausages were made from a mixture of lean pork (80%) and pig fat (20%). After grinding the meat and the fat (10 mm), raw materials were mixed with seasonings (red hot paprika powder, salt, raw garlic paste, caraway and crystal sugar). The seasoned batter was immediately stuffed in collagen casings (55 mm in diameter) and raw sausages were dried in different environments, a traditional room (TR) and a controlled industrial ripening room (RR). The environmental conditions in TR were characterised by low air temperature (≈7°C) and

high relative humidity (RH) (≈83%) (Fig. 1(a)). On the other hand, environmental conditions in RR were set to imitate conditions present in traditional practice (low temperature, ≈11°C), but also to enable faster processes of fermentation (higher temperature in first 10 days, ≈15°C) and drying (low air relative humidity, ≈76%) (Fig. 1(b)).

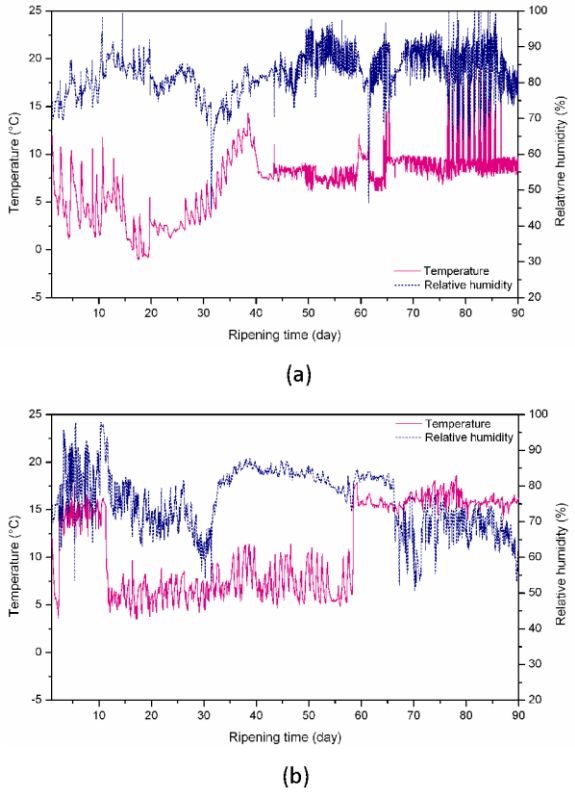

Figure 1. Environmental conditions recorded during drying of *Petrovská klobása* in TR (a) and RR (b)

Samples

Samples taken at distinct processing stages, included raw batter prior to stuffing (0) and three randomly selected sausages after 2, 6, 15, 30, 60, and 90 days of drying. Physico-chemical analyses were carried out at these sampling times. In order to determine moisture content in central and peripheral layer, each sausage was subdivided in two concentric fractions, the more internal one with 25.4 mm in diameter and the external circular crown with the rest to full diameter of sausage.

Physico-chemical analysis

In order to determine diameter reduction, two measures were taken at each sample sausage at the beginning and after previously mentioned periods of the drying process. The difference in diameter, expressed as percentage of the initial measure, represents the value of diameter reduction (%).Water activity (aw) of samples was determined using Testo 650 measuring instrument with a pressure-tight precision humidity probe (Testo AG, USA). The pH was measured using the portable pH meter (Consort T651, Turnhout, Belgium) equipped with an insertion glass combination electrode (Mettler Toledo Greifensee, Switzerland). Moisture content was determined by drying the samples at 103±2°C to constant weight (ISO 1442:1997).

Modeling drying kinetics

The experimental data obtained for the moisture content versus time (known as the batch drying curve) was fitted to cubic polynomial, as suggested by Kemp et al. [7] and Guiné [8], in the form:

$$M = a_0 + a_1 t + a_2 t^2 + a_3 t^3 \quad (1)$$

where M is the dry basis moisture content and t is the drying time in days.

The adequacy of the models has been evaluated by the coefficient of determination (r^2), which should be close to one.

Statistical analysis was performed using Statistica 10.1 software (StatSoft, Tulsa, Oklahoma, USA).

III. RESULTS AND DISCUSSION

During drying period, higher percent (%) of diameter reduction was registered for RR sausages (Fig. 1).

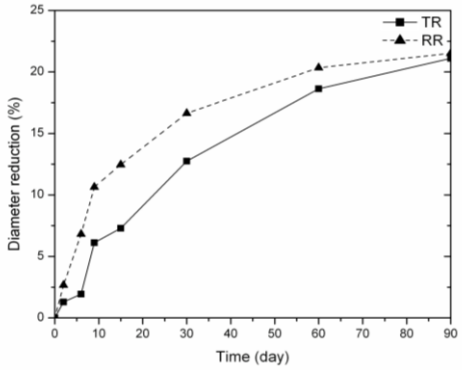

Figure 2. Diameter reduction (%) of *Petrovská klobása* during drying in TR and RR

Obviously, processing time and different environmental conditions significantly (P<0.05) affected shrinkage of sausages, mostly reflected

as diameter reduction. Due to pH drop during fermentation, solubilised proteins coagulate and form a gel, while their water holding capacity decreases. Thus, both gel formation (condensation structure) and water evaporation, caused by syneresis and drying, result in the shrinkage of sausages which is reflected in a significant diameter reduction [9, 10]. This process was particularly pronounced in RR sausages, where the higher initial temperature (Fig. 1(b)) caused rapid and intensive pH drop (Table 1), and consequently easier dehydration and homogenisation of sausage.

The fermentation process was considerably faster in RR sausages, where the pH had fallen below 5.0 after only 6 days (4.99) (Table 1).

Table 1. Evolution of pH and aw during drying of *Petrovská klobása* in TR and RR

Sample		TR		RR	
Parameter		pH	aw	pH	aw
Time (day)	0	$5.55^{ab,A}$ ±0.03	$0.97^{a,A}$ ±0.01	$5.55^{c,A}$ ±0.03	$0.97^{c,A}$ ±0.01
	2	$5.54^{ab,A}$ ±0.03	$0.97^{a,B}$ ±0.01	$5.55^{c,A}$ ±0.01	$0.97^{bc,AB}$ ±0.00
	6	$5.58^{b,A}$ ±0.05	$0.97^{a,B}$ ±0.00	$4.99^{d,C}$ ±0.02	$0.96^{ab,A}$ ±0.01
	9	$5.51^{a,D}$ ±0.03	$0.96^{b,B}$ ±0.00	$4.87^{a,B}$ ±0.06	$0.95^{a,AB}$ ±0.00
	15	$5.26^{e,D}$ ±0.03	$0.95^{b,A}$ ±0.01	$4.89^{ab,B}$ ±0.05	$0.94^{g,A}$ ±0.00
	30	$5.04^{c,C}$ ±0.04	$0.93^{e,B}$ ±0.01	$4.93^{b,A}$ ±0.02	$0.92^{f,A}$ ±0.01
	60	$5.03^{c,B}$ ±0.03	$0.90^{d,B}$ ±0.01	$5.09^{e,C}$ ±0.04	$0.87^{e,A}$ ±0.09
	90	$5.15^{d,A}$ ±0.03	$0.86^{c,B}$ ±0.00	$5.22^{f,B}$ ±0.03	$0.81^{d,A}$ ±0.01

[a-g] Means within the same column with different superscript letters are different ($P < 0.05$).
[A-D] Means within the same row with different superscript letters are different ($P < 0.05$).

Also, the pH drop was higher in RR products (0.7 units), compared to TR (0.5 units), confirming the other studies regarding the influence of processing conditions on pH evolution [11, 12, 13]. After reaching the minimal value pH started gradual increase in both sample sausages, due to degradation of proteins and liberation of non-protein nitrogen compounds, as it was proposed by Kaban and Kaya [14] and Spaziani et al. [15].

Further, sausages produced under different environmental conditions presented close a_w values for the same drying and ripening periods analysed, with differences being noticeable ($P<0.05$) after 30, 60 and 90 days of processing, when a_w values were significantly lower in RR sausages (Table 1). After 90 days of drying, water activity ranged ($P<0.05$) between 0.86 and 0.81, in TR and RR sausages, respectively. This data indicate very intensive drying process in industrial ripening room, which was actually finished after 60 days, when a_w registered in RR sausages was 0.87 (Table 1). These aw values (0.86-0.87) were in agreement with those generally found in a number of European dry-fermented sausages [15, 16].

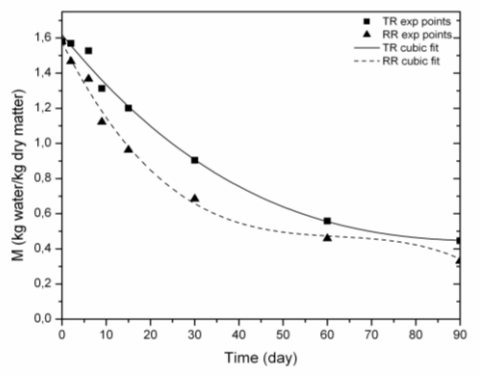

Figure 3. Drying curves for the *Petrovská klobása* sausages with cubic decay fit

The experimental data obtained by determining the moisture content in TR and RR sausages along the processing period were used to test the cubic decay function for describing the drying behavior of *Petrovská klobása.* The adequacy of the models has been evaluated by the coefficient of determination, and its high values (0.992, 0.994, respectively) indicate good fit of experimental data. In Figure 3 the curves obtained with cubic decay fit are presented together with the experimental points, for sausages dried in different environmental conditions. It can be seen that the greater water evaporation occurred for sausages dried in RR. In fact, after two months of drying (60 days) these sausages lost about 50% (wet basis) of their initial water content (result not shown), fulfilling the requirements of Serbian legislation considering the allowed content of water in dry-fermented sausages ready for consumption (<35%) [17]. Hence, drying process in RR was finished after 60 days, being 30 days shorter compared to traditional practice.

IV. CONCLUSION

From the present work, it can be concluded that drying of *Petrovská klobása* sausages in industrial ripening room, with different environmental conditions, resulted in different drying characteristics compared to those dried in traditional room. Higher diameter reduction (%) and lower a_w and moisture content indicated 30 days shorter drying period in RR conditions. The batch drying data for the examined sausages are well described by the cubic polynomial function (r^2>0.992).

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