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Quality and safety standardization of traditional fermented sausages*

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A b s t r a c t: Traditional meat products, dry fermented sausages, which are coming from particular geographic areas of Serbia, are mainly produced in rural households, according to experience and traditional technology. The quality of final products is under the influence of numerous factors. Variability of this quality restricts the possibility for achieving higher production rates and availability of these products on foreign markets.

This paper presents the specificness of the production process and requirements for traditional dry-fermented sausages (Petrovská klobása) which have to be accomplished during standardization of production in controlled conditions, aiming to preserve specific properties and superior quality. In order to achieve this goal it is necessary to fully understand physical-chemical, biochemical and microbiological changes occurring during spontaneous fermentation of these products in traditional manufacturing process and to transfer the perceived models of fermentation, drying and ripening to controlled production conditions.

***Key words**: traditional products, protected designation of origin, dry fermented sausages, quality standardization.*

Introduction

Fermentation and drying of meat products are probably the most ancient ways of preservation known to man. In Europe, natural fermented sausages have a long tradition. Preparation of various sausages was a common practice throughout the Roman State, in Europe, and Mediterranean region, well before the time of Caesars and continued to be after the decline of Rome (*Incze,* 1998; *Savić and Savić*, 2002; *Comi et al.*, 2005). Thus all European countries have cultural traditions linked with specific dry-fermented meat products (*Jordana*, 2000).

Distinct cultural and social backgrounds of the populations and the environmental/climatic conditions in different geographical regions greatly determine the physical and sensory properties of each country style dry-fermented meat product. Thus, a great variety of fermented sausages are produced in European countries and many of them have been granted PDO (Protected Designation of Origin) and PGI (Protected Geographical Indication) labels (*Casaburi et al.,* 2007; *Roseiro et al.*, 2008). The famous traditional dry sausages are Italian (*Salame Piacentino, Salame di Varzi, Ciauscolo…)*, Spanish (*Androlla*, *Botillo, Salchichón, Chorizo…),* Portuguese (*Chouriço Grosso de Estremoz e Borba*, *Painho de Portalegre*…) and Hungarian (*Szegedi szalámi*). A lot of fermented sausages are also produced in our country, but only few of them have specific quality and characteristics which can be attributed to their geographical origin. One of them is *Petrovačka kobasica (Petrovská klobása)*, fermented meat product which is a part of Slovaks' gastronomic heritage. It is produced in rural households on the territory of the municipality of Bački Petrovac, according to the experience and traditional technology.

Dry-fermented sausages are traditional products prepared since the earliest civilizations to preserve meat. The manufacturing of these products is more an art depending on the skill and experience

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of the meat manufacturer rather than a process fully based on scientific and technological means. Although nowadays meat can be preserved by freezing, refrigeration and thermal processing, the traditional dry-fermented meat products are still produced in large quantities because they have a unique and much appreciated flavour. Traditional processes are time consuming, production batches are small, capital turnover is slow and product competitiveness is low (*Arnau et al.,* 2007). However, European consumers are willing to pay up to 20% higher prices for traditional products with geographical indications, as it is shown in EC study from 2003 (*Thual,* 2005). These products are a significant element of the European cultural heritage. Their production and sale provide a decisive economic input to many regions. However, due to changes in lifestyle, the question is how to make these products more sustainable and more accessible to a wider food market. The solution requires modernization of all aspects, as well as improvement of competitiveness and safety and ensuring of high product quality. Since, production of traditional products significantly affects the sustainable rural development and growth, employment and social welfare, the EU has recognized the importance of this problem and offered support through the Framework Programmes FP6 and FP7 (*Gasparik-Reichardt et al.,* 2005; *European Commission,* 2006). As traditional food is both a knowledge resource and part of cultural heritage, continued funding and support leads to information about their specific characteristics, the relationship between consumption of such products and health and provides promotion of high quality food and food from certain regions, with the aim of ensuring sustainable economic development and improvement of each manufacturer. Mentioned facts clearly indicate the actuality of this problem in the EU, as well as the importance of research which can offer solutions and improve microbiological quality of traditional sausages in accordance with the principles of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) or HACCP system.

Importance of research related to traditional products has been also recognized in our country, and was initiated by numerous studies of protection and quality standardization, especially for several types of autochthonous cheeses, and more recently for several dry fermented sausages. In order to preserve specific properties and high quality of dry fermented sausages (*Petrovačka kobasica*) during production in controlled conditions, process characteristics and demands which have to be fulfilled will be presented in this paper.

Defining the quality parameters and criteria in the protection of traditional fermented sausages *(Petrovská klobása)*

In our country the protection of geographical designations and indications is regulated by national legislation „Official Journal of RS“, No. 18/2010 and in the European Union by Council Regulation (EC) No. 510/2006. ZZ „Kulen“ was formed in Bački Petrovac in 2005 in the context of protection of geographical indication of *Petrovačka kobasica* and afterward improved production of this sausage of required standard and recognizable quality.

In village households, this sausage is made end of November and mid December. This is when temperatures are around 0^{o} C or lower. *Petrovačka kobasica* is produced from cold (cca 24h p.m.), or hot deboned (cca 4h p.m.) lean pork meat and fat. Pork meat and fat are grounded to a 10 mm particle size and mixed with powdered red hot paprika (2.50%), salt (1.80%), crushed garlic (0.20%), caraway (0.20%) and sugar (0.15%), approximately 15-30 minutes by using traditional techniques. The mixture is stuffed into natural casings, pig intestine (rectum), around 35-40 cm long and near 4,5-5,0 cm in diameter. After stuffing it undergoes smoking process for about 10 to 15 days with pauses, using specific kinds of wood (cherry wood). Subsequently, it is left to dry and ripen at dry and well ventilated place for a period of up to 4 months, until it achieves optimum quality. Thus, *Petrovačka kobasica* is produced without the use of nitrate/nitrite, glucono delta-lactone (GDL) and microbial starters and at the end of ripening *Petrovská klobasá* is characterized by specific savoury taste, aromatic and spicy-hot flavour, dark red colour and hard consistency.

Aiming to establish quality standard and to protect designation of origin, the traditional process of manufacturing and gross characteristics of *Petrovská klobasá* have been investigated during three production seasons in five rural households. Some physical-chemical and sensory properties of sausages as well as climate parameters registered in production season, when most of products achieved high overall quality, are presented in this paper. Based on the properties of the best rated sample sausages the parameters of optimal quality for this traditional dry-fermented sausage were defined (*Petrović et al.,* 2007).

It should be noted that drying process, for most of the sausages in this season, was completed between 80 and 90 days (water content < 35%) and ripening process at 120th day (the best sensory quality). Quality parameters determined at the end of the ripening process for the best sausages (manufacturers

D and E) were taken as quality criteria for protection of geographical indications.

As it can be seen from results shown in table 1, after 120 days of drying and ripening, protein content established in A sausages was the highest (29.79%) and the lowest in C sausages (23.36%). Final values of protein content in *Petrovská klobása* samples were higher with respect to the reported values of this parameter for the majority of different fermented sausages (*Žlender and Renčelj*, 1990**;** *Tojagić*, 1997; *Stamenković et al*., 1998; *Lorenzo et al*., 2000; *Comi et al*., 2005; *Salgado et al*., 2006; *Vuković et al*., 2009), as well as of the minimal content of meat protein (16%) required for that type of sausages according to Serbian Regulations (2004). In addition, this regulation defines for *Kulen*, fermented dry sausage similar to *Petrovská klobása*, minimal meat protein content of 22%.

Free fat content after 120 days of drying and ripening ranged from 34.09% in E sausages to 46.01% in C sausages. Although significant differences ($p < 0.05$) in fat content (up to 12%) of sausages from different manufacturers were observed, the value for this parameter even in the fattiest sausage (C) was slightly lower or similar to the registered values for Sremska kobasica, dry *Kraška kobasica* or some traditional Spanish sausages (*Žlender and Renčelj*, 1990; *Tojagić,* 1997; *Lorenzo et al.*, 2000; *Salgado et al.*, 2006). Fat content in A, B, D and E sausages was similar with those, which were found in Italian sausage of *Felino* type (*Bianchi et al.,* 1974).

Table 1. Physicochemical and biochemical properties of traditionally produced *Petrovská klobása* (A, B, C, D, E) at the end of drying and ripening (120th day)

Tabela 1. Fizičko-hemijska svojstva petrovačkih kobasica izrađenih na tradicionalan način kod pet proizvođača (A, B, C, D, E) na kraju sušenja i zrenja (120. dan)

Property / Ispitana svojstva	**Manufacturer / Proizvođač**				
	A	**B**	**C**	**D**	**E**
Protein content (%) / Sadržaj proteina (%)	29.79 ± 0.30^{ab}	29.62 ± 0.57^{a}	23.36 ± 0.42^{c}	27.52 ± 0.58^{d}	30.43 ± 0.62^{b}
Fat content (%) / Sadržaj masti (%)	41.39 ± 1.19^{a}	41.48 ± 0.79^{a}	46.01 ± 0.56^{d}	37.71 ± 0.52^{c}	34.09 ± 1.15^{b}
Moisture content (%) / Sadržaj vlage (%)	22.14 ± 1.00^{a}	23.19 ± 0.47^{b}	25.05 ± 0.72^{c}	27.53 ± 0.49^{d}	29.11 ± 0.47^{e}
Ash content (%) / Sadržaj min. materija (%)	4.87 ± 0.13^{b}	3.87 ± 0.21^{a}	3.99 ± 0.13^{a}	5.26 ± 0.13^{c}	4.74 ± 0.15^{b}
NaCl content (%) / Sadržaj NaCl (%)	3.01 ± 0.10^{a}	3.28 ± 0.14^{a}	3.01 ± 0.29^{a}	3.15 ± 0.14^{a}	2.99 ± 0.20^{a}
RCCTP[1] (%)	4.74	5.85	7.88	7.27	6.70
Weight loss (%) / Gubitak mase (%)	45.71	40.83	44.82	42.92	40.33
pH	5.31	5.36	5.09	5.14	5.42
Lightness (L*) / Svetloća (L*)	31.78 ± 3.51^{a}	34.09 ± 1.64^{ab}	36.38 ± 2.55^{b}	35.18 ± 2.03^{ab}	34.37 ± 1.76^{ab}
NPN (g/100g)	0.64 ± 0.01^{b}	0.67 ± 0.01^{c}	0.62 ± 0.01^{a}	0.72 ± 0.01^{d}	0.74 ± 0.01^{e}
NH2-N (g/100g)	0.239 ± 0.045^{b}	0.353 ± 0.047^{a}	0.278 ± 0.049^{b}	0.372 ± 0.020^{a}	0.362 ± 0.008^{a}
%NPN in TN[2]	13.43	14.14	16.59	16.35	15.20
Sensory quality / Ukupni senzorni kvalitet	3.94	4.18	4.27	4.64	4.74
Firmness (N) / Čvrstoća (N)	14.48 ± 1.04^{a}	10.38 ± 2.01^{c}	6.18 ± 0.48^{b}	13.04 ± 1.16^{a}	13.53 ± 0.82^{a}

[1]Relative content of connective tissue protein / Relativni sadržaj proteina vezivnog tkiva u proteinima mesa

[2]Share of non-protein nitrogen (NPN) in the total nitrogen (TN) / Udeo neproteinskog azota u ukupnom azotu

[a-e]Means within the same row with different superscript letters are different ($p < 0.05$) / Različita slova u istom redu ukazuju na statistički značajno različite vrednosti ($p < 0,05$)

The lowest moisture content after 120 days of drying and ripening was stated in A sausages (22.14%). The highest moisture content after the same period of time was found in E sausages (29.11%). The examined samples of *Petrovská klobása* have, therefore, values for the moisture content slightly higher than those stated for *Sremska kobasica* (*Tojagić,* 1997), similar to values found in Italian sausages of *Felino* type and dry *Kraška kobasica* (*Bianchi et al.,* 1974; *Žlender and Renčelj*, 1990), but lower if compared with traditional Spanish sausages *Androlla*, *Botillo* and *Chorizo de cebolla* (*Lorenzo et al.*, 2000; *Salgado et al.,* 2006).

Further, content of mineral substances (ash) after drying varied between 3.87% (B) and 5.26% (C). These values for ash content in samples of *Petrovská klobása* are similar or somewhat lower compared to some previously studied fermented sausages (*Bianchi et al.,* 1974; *Žlender and Renčelj,* 1990; *Tojagić,* 1997; *Stamenković et al.,* 1998; *Lorenzo et al.,* 2000; *Comi et al.*, 2005; *Salgado et al*., 2006).

In the finished product, salt content varied from 3.01% in A and C sausages, up to 3.28% in B product. Therefore, values for the NaCl content in *Petrovská klobása* were determined to be in a very narrow interval, being lower than in the majority of determined values for different fermented sausages (*Žlender and Renčelj*, 1990; *Tojagić*, 1997; *Gasparik-Reichardt et al.,* 2005). Similar NaCl contents were found in the Spanish traditional sausage *Botillo* and in Italian sausage from the region of Friuli Venezia Giulia (*Lorenzo et al.*, 2000; *Comi et al.,* 2005), but somewhat lower values were reported in Croatian fermented sausage (*Gasparik-Reichardt et al.,* 2005) and in Spanish sausages *Androlla* and *Chorizo de cebolla* (Lorenzo et al., 2000; Salgado et al., 2006).

Relative content of connective tissue proteins (RCCTP), after 120 days of production, was the lowest in A sausages, amounting to 4.74%, and the highest in C sausages (7.88%). Nevertheless, all determined values were by far lower than the maximal allowable level of the RCCTP (20%), indicating that for production of *Petrovská klobása* mostly 1st category meat was used, which is in concordance with request of the Serbian Regulations (2004) for that group of products.

It is evident that values for weight loss of sausages from all five production lots after 120 days of manufacturing were more than 40 percent (Table 1). The highest weight loss during the manufacturing process was observed in A sausages, which in average lost 45.71% of their initial weight. The E sausages had the lowest average weight loss, amounting to 40.33%. Determined values of weight losses during the production process were similar to those reported for dry *Kraška kobasica* (*Žlender and Renčelj,* 1990), and higher than those which were measured for Italian sausage type *Felino* (*Bianchi et al.,* 1974).

Initial pH values of B and E sausages were 5.50 and 5.56, respectively. During the first 15 days of production, pH values in those sausages dropped to 5.06 and 5.10. After that period, pH values have started their gradual increasing, reaching, after 120 days, values 5.36 and 5.42, respectively (Table 1). Such changes of pH values are in line with findings of other authors that have investigated physicochemical properties of fermented dry sausages (*Savić et al*., 2001; *Gasparik-Reichardt et al*., 2005). During the first couple of days the increasing of pH was observed in C and D sausages, reaching 5.78 in product of manufacturer D. After that initial increase, in the following period up to 80th day, decreasing of pH was observed in these sausages, to 5.06 and 5.02, respectively. Subsequently, gradual increasing of pH in C and D sausages was observed, so that on the day 120 values of 5.09 and 5.14 were registered (Table 1). In A sausages, after a very low initial pH value (5.26), significant variations of pH during manufacturing process were observed, reaching, on the 120th value of day 5.31 (Table 1).

After 120 days of drying and ripening the highest value of %NPN in TN (Table 1) was found in C sausages, being 16.59%. Somewhat lower values of %NPN in TN were found in D (16.35%) and E (15.20%) sausages. This indicates on the fact that during production processes of C, D and E sausages intensive proteolytic processes occurred. Results shown in the Table 1 agree with findings of various other authors that investigated this matter and indicate that proteolysis process during the fermentation and ripening effects with the increasing of the non-protein nitrogen contents in sausages occurred (*García de Fernando and Fox*, 1991; *Beriain et al.,* 2000; *Lorenzo et al.*, 2000; *Hughes et al*., 2002; *Salgado et al*., 2006; *Dalmış and Soyer*, 2008). Therefore, *García de Fernando and Fox* (1991) recorded the increase of %NPN in TN from the initial value of 8 to the final value of 15, after 41 day of production of sausages obtained from pork. Similar increase of NPN share in the total N was registered by *Beriain et al.* (2000) in the Spanish traditional sausage *Salchichon*, from initial 9.40 to the final 15.95%, after 30 days of manufacturing. Average NPN content in Spanish traditional sausage *Androlla,* after 60 days of drying and ripening, was 0.57 g/100g of sample (*Lorenzo et al.,* 2000), what corresponds with results registered for *Petrovská klobása* in similar period of manufacturing.

Mean values of α-amino acidic nitrogen content (NH_2-N) during the traditional manufacturing process of *Petrovská klobása,* shown in Table 1, are higher than those published for Spanish traditional sausag-

es *Androlla* (0.096 g/100g), *Botillo* (0.095 g/100g) and *Chorizo de cebolla* (0.136 g/100g), (*Lorenzo et al*., 2000; *Salgado et al,* 2006). However it must be remembered that ripening of *Petrovská klobása* lasts longer.

After 120 days of drying and ripening, the highest value of lightness L* was measured on the cut surface of C sausages (36.38) and the lowest on cut surface of A sausages (31.78). Such registered L* values of the cut surface of *Petrovská klobása* are in concordance with those reported for traditional Greek sausage, which indicate that products with higher fat tissue contents tend to have higher L*values. On the other hand, with high weight loss, during drying and ripening, lightness decreases and sausage is becoming darker (*Papadima and Bloukas,* 1999).

At the end of production, based on the measured penetration force, it is possible to conclude that A sausages were the firmest (14.48 N). Somewhat less firm were E sausages (13.53 N) and extremely low firmness was established in C sausages (6.18 N).

After 120 days of drying and ripening, it was estimated, by the manufacturers themselves, that sausages have reached high sensory quality. That quality was partly confirmed with scores from five experienced panellists, being between 3.94 and 4.74 (Table 1), indicating optimal, typical quality with, occasionally, smaller deviations and deficiencies just for D (4.64) and E (4.74) sausages.

Climate characteristics recorded during the observed period of traditional manufacturing process

Geographic location of Bački Petrovac and especially local climatic conditions exert significant effects on drying, fermentation and ripening process of homemade *Petrovská klobása.* The values of climatic parameters (air t °C and rH%) in the region of Bački Petrovac, registered during analyzed manufacturing period, when the elements for standardisation of manufacturing process and quality of *Petrovská klobása* were investigated, were in good correlation with multi-annual averages of these climatic parameters registered in the region concerned (*Petrović et al*., 2007).

The quality of sausages largely depends on such climatic circumstances, which can not be significantly influenced. However, manufacturers of *Petrovská klobása* have great experience and knowledge how to adapt production process to current conditions.

The analyzed manufacturing season provided almost ideal climatic conditions during whole process of drying and ripening. Average daily temperatures in the first decade of December were 0.2–8.8°C and relative air humidity was about 65%. Such climatic (processing) parameters enabled slow development of the desirable microflora (predominantly lactic acid bacteria) (*Vuković,* 2006; *Vesković-Moračanin and Obradović*, 2009), fermentation and onset of internal and external water diffusion in B and E sausages. In the same period A, C and D sausages behaved differently to certain extent. Having in mind that the average daily temperatures during the first 10 days reached up to ~9°C, it is possible to assume that in sausages of these manufacturers, because of the somewhat poorer microbiological quality of raw materials and/or poorer sanitary conditions during preparation of raw sausage mixtures (environment – desks, knives, machines) the growth and development of aerobic, Gramm-negative, psychotropic proteolytic bacteria started (*Vesković-Moračanin and Obradović*, 2009). These undesirable microorganisms nevertheless, were not able to prevail in sausages of manufacturers A, C and D, because the next 20 days of December were characterized with very low temperatures (in average 1.1°C). At the same time, by harmonizing process of smoking with the external climate factors, the majority of manufacturers have successfully prevented negative effects of such low temperatures and relative air humidity during the period in which water content in sausage mixtures still was so high, that it easily could be frozen.

By further analysis of the effects of climatic conditions (t°C, relative humidity) on drying dynamics during the month of January, it is possible to notice that low air temperatures (in average –1.3°C) with somewhat lower relative air humidity (63.5%) are convenient for slow drying and ripening of sausages. Continuation of this process was enabled also during the third month of processing (February), when the average values of climatic parameters had approximately similar levels (0.7°C, 62.2% rH). During the month of March, the 4th month of sausage processing, when drying was largely finished, dominates intensive ripening process, homogenizing a sausage mixture to the form of firm content, possible to cut and completing the taste and odour (*Vuković*, 2006), the average air temperature still was not higher than 10°C and relative air humidity was, in average, a little bit lower, being 56.9%.

Therefore, owing to the very favourable climatic conditions in all four months, after 120 days of processing, majority of manufacturers had high quality sausages, with smaller defects which were result of nonstandard raw mixture composition and inadequate sanitary conditions in the traditional conditions of manufacturing.

By comprehensive analysis of obtained results from all three observed seasons, the parameters of optimal quality for this traditional dry-fermented sausage were defined. These parameters are presented in

Code of Practice of this product with geographical indication (P*etrović et al.*, 2007) as a quality standard which has to be satisfied in future production.

Quality parameters

pH > 5,4
Moisture content < 35%
Meat protein content > 25%
Free fat content < 35%
RCCTP < 15%
NaCl content < 3,5%
%NPN in TN > 15%
Lightness (L*) = 32-37
Firmness = 10–15N
Sensory quality > 4,5

Fermentation, drying and ripening model defining the quality and safety of traditional fermented sausages for the purpose of standardisation (*Petrovská klobása)*

Production of fermented sausages is a complex process which depends on a wide range of factors and despite the exceptional skills and experience of *Petrovská klobása* manufacturers, variations in product quality are possible. Based on the investigations on basic raw materials, production methods and overall quality of sausages, both in a process of registration of designation of origin and within the project "Development of drying and fermentation technology of *Petrovačka kobasica* (*Petrovská klobása* – geographical indication of origin) under controlled conditions", (funded by Ministry of Science and Technological Development, 2008–2011), the optimal model of production in traditional conditions had been found. By using this model manufacturers are able to modify the production process properly in order to get high quality product in traditional and controlled conditions.

Aiming to the define mentioned model, a number of experimental sausages (models) have been made according to traditional (protected) recipe and under influence of following variable factors: pig race for meat production, hot boned vs. cold meat, natural vs. artificial casing, intensity and duration of smoking, type of wood for smoking, duration of drying and ripening. These variable factors were the cause of quality variations and disagreement between manufacturers. In the same time a selected model of drying/ripening was applied and followed in controlled conditions.

In the households which are members of the cooperative „Kulen", white breed pigs and their hybrids (150–180 kg, about 9 months old) are reared for production of *Petrovská klobása.* Since the quality of meat originating from these pigs is very poor and it does not meet the requirements set in a code of practice (*Petrović et al.*, 2007), it was concluded that pigs for *Petrovská klobása* production have to be exclusively Landrace breed and meat quality has to be „normal" (*Petrović et al.,* 2009; *Džinić et al.,* 2009; Tomović et al., 2011a; 2011b; 2011c).

Traditionally, *Petrovačka kobasica* is produced from hot boned meat, but considering food safety and modern technology issues it is better to abandon this practice. Researches conducted within the mentioned Project confirmed that claim (*Tomović et al.,* 2008; *Tomović et al.*, 2009).

Very important part in *Petrovská klobása* production process is smoking procedure. It has positive influence both on preservation and sensory properties. The use of non-characteristic wood in smoking practice (cherry, apricot) leads to formation of specific red (mahogany) colour of the sausage surface which is not the case if beech wood is used. Duration and temperature throughout the smoking procedure are also very important factors. It lasts between 10 and 15 days with pauses and temperature should not be higher then 10°C (*Ikonić et al.*, 2010a). Otherwise, it may cause very fast fermentation and drop of pH to ~ 5, which has a negative effect on taste and formation of desirable colour (*Petrović et al.*, 2010a).

Sensory evaluation, expressed as the percentage of total sensory quality, of sausages produced in two seasons using different models at the end of the drying process (90. day A1, A2, B1 and B2; 45. day B3 and B4; 65. day C1, C2 and C3) and at the end of ripening period (120. day) are shown in figure 1.

As it can be seen from the results presented in figure 1, total sensory quality at the end of the drying (90. day) for sausages made from hot deboned meat (A1-A2, natural and artificial casing) and from cold meat (B1-B2, natural and artificial casing), both in the traditional manner was respectively: 84.1%, 84.7%, 99.7% and 99.7%. Then, total sensory quality for sausages made from cold meat in traditional manner, and after drying under controlled conditions for 45 days (B3-B4-natural and artificial casing) was 89.8% (B3) and 85.9% (B4).

Sausages from C group, produced in the second season from cold meat in traditional manner, but in registered abattoir under controlled environment (C1-hand mixed mixture, natural casing; C2-hand mixed mixture, collagen casing; C3-mechanically mixed mixture, collagen casing) and dried under controlled conditions for 65. days, had a total sensory quality of 88.7% (C1), 82.4% (C2) and 81.0% (C3). So, only sausages produced in the household B from cold meat had total sensory quality higher than

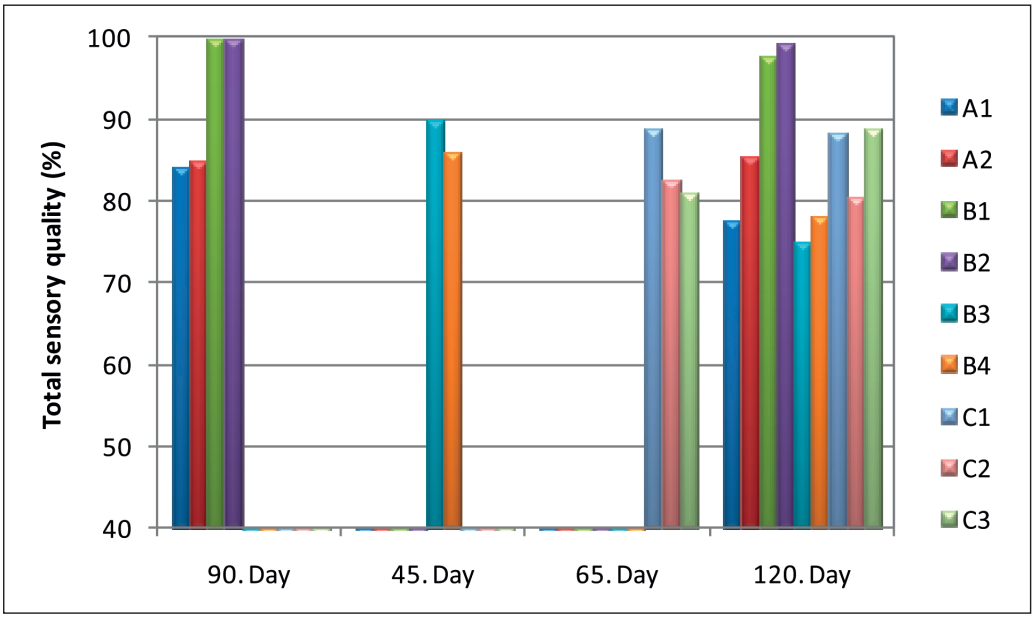

Figure 1. Sensory evaluation of sausages produced in two seasons using 9 different models, expressed as a percent of total sensory quality at the end of the drying (90, 45. and 65. day) and ripening process (120. day)

Grafikon 1. Senzorna ocena kobasica izrađenih u dve proizvodne sezone po 9 različitih modela, izražena kao% ukupnog kvaliteta na kraju procesa sušenja (90, 45. i 65. dan) i zrenja (120. dan)

90% at the end of the drying period (*Jokanovic et al*., 2009; *Jokanovic et al*., 2010a, 2010b), although according to our previous findings (*Ikonić et al*., 2010) sausages are still not ripened optimally.

Total sensory quality of sausages from all examined groups was not significantly changed till 120th day of ripening. Sausages from B1 and B2 groups still had the best sensory quality, at the level requested by criteria in Code of Practice (*Petrović et al*., 2007).

Based on total sensory quality analysis, as well as on analysis of numerous other physical-chemical and biochemical properties, the fermentation, drying and ripening model used in two mentioned groups (B1 and B2) is defined as optimal. No other model tested during production of sausages from A1, A2, B3, B4, C1, C2, C3 groups showed results in the required quality of sausages at the end of the drying, ripening and storage.

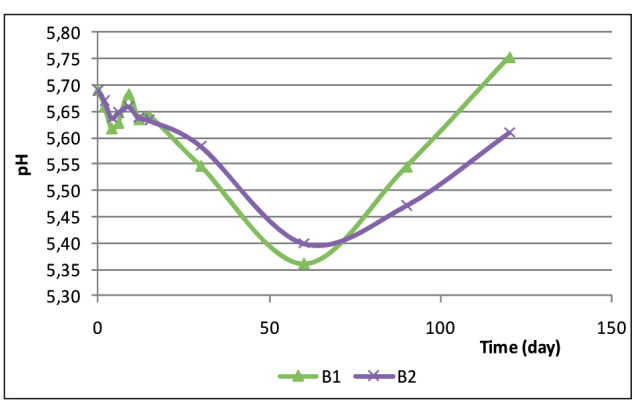

Figure 2. Changes of pH value according to optimal model of fermentation, drying and ripening of *Petrovačka kobasica* in natural (B1) and collagen (B2) casing

Grafikon 2. Promene vrednosti pH po optimalnom modelu fermentacije, sušenja i zrenja *petrovačke kobasice* u prirodnom (B1) i veštačkom (B2) omotaču

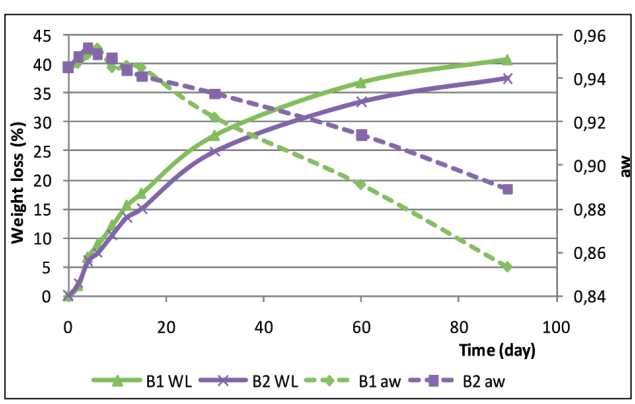

Figure 3. Changes of weight loss and aw value of *Petrovačka kobasica* in natural (B1) and collagen casing (B2) according to optimal model of fermentation, drying and ripening in traditional conditions

Grafikon 3. Promene gubitka mase (Gm) i aw vrednosti *petrovačke kobasice,* u prirodnom (B1) i veštačkom (B2) omotaču, po optimalnom modelu sušenja i zrenja u tradicionalnim uslovima

Optimal model of fermentation, drying and ripening (fig. 2, 3 and 4) should result in approximately 28% of weight loss until 30th day of production, 37% until 60th day and 40% after 90 days of production. Such drying behaviour can be described adequately by Page's regression model (*Ikonić et al.,* 2010b).

Water activity change occurs following the dynamics: from 0.95 (raw mixture) to 0.93 during first 30 days (artificial casing), from 0.930 to 0.915 in next 30 days and at the end of drying process aw should be lower than 0.89. Sausages in natural casing (unequal diameter) have a slightly

lation (figure 5.), (*Danilović et al*., 2011). *En. Durans* is detected only in sausage stuffing (0. day) accounting 43% of population, while the rest was *En. Caseliflavus* which was dominant, with 80%, on the second day of fermentation. None of these species were found in the later stages of fermentation. Also, *Ln. mesenteroides* and *Pd. Pentosaceus* were detected after second day of fermentation.

Ln. mesenteroides was isolated from all sausage samples and its presence was finally stable from 15 to 90th days. Population of *Pd. pentosaceus* non-linearly increased, during fermentation, with

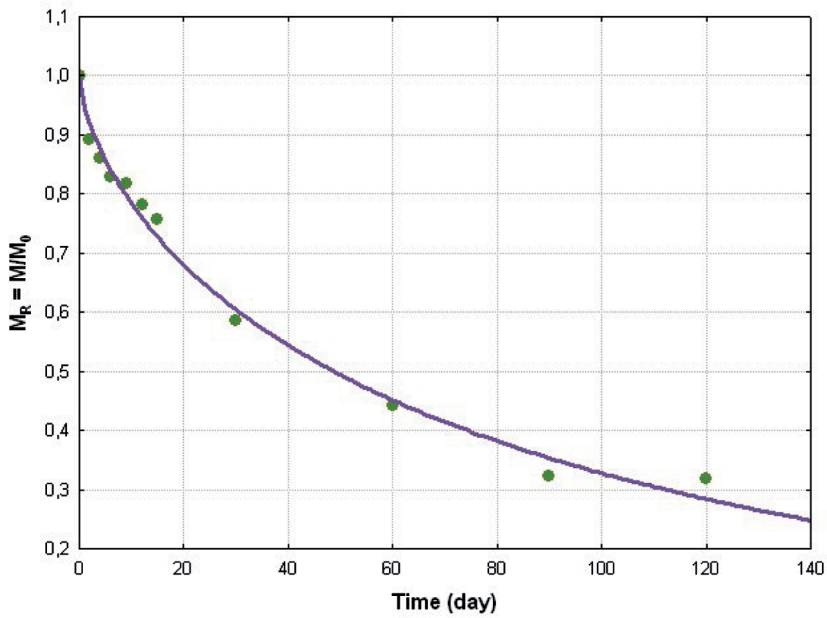

Figure 4. Experimental and predicted moisture contents, using Page's empirical model, during drying of *Petrovská klobása* in traditional conditions different change of a_w values

Grafikon 4. Eksperimentalne i na osnovu *Page-ovog* modela procenjene vrednosti sadržaja vlage u *petrovačkoj kobasici* po optimalnom modelu sušenja i zrenja u tradicionalnim uslovima

To achieve the optimal quality of *Petrovská klobása* it is essential to have a raw mixture with pH value lower then 5.8 (*Petrović et al.,* 2010b ; 2010d). After that, pH drops constantly until 60th day of production, when it reaches its minimum, being around 5.3. Faster decrease of pH and lower final value, results in some of the technological defects. After that period, pH should increase gradually, reaching, after 120 days, at the end of ripening, values higher than 5.4 (*Ikonić et al.*, 2010a), as it is registered in sausages B1 and B2 (Petrović et al., 2011).

Model of optimal fermentation and drying of *Petrovačka kobasica* produced in traditional manner in 2008/2009 season (A and B sausages), partly it is a result of changes in the microorganism popu-

a maximum value of 45% reached after 9 days. The presence of *Lb. sakei* rapidly increased from 20% to 50% after 9 days, and after that period it was isolated from all samples till the end of fermentation process. In contrast to *Lb. Sakei*, *Lb. curvatus* was found only in two samples in, much smaller quantity (6%).

Results of *Vaštag et al.* (2010), who determined the extent and progress of proteolysis in *Petrovačka* kobasica during drying and ripening, confirm the specific quality of this traditional product. The proteolysis was quantified by measuring the degree of hydrolysis (DH). DH showed a sharp increase during 48h, after which this value showed slight increase throughout whole ripening period. Proteolysis of sarcoplasmic and myofibril proteins by combined

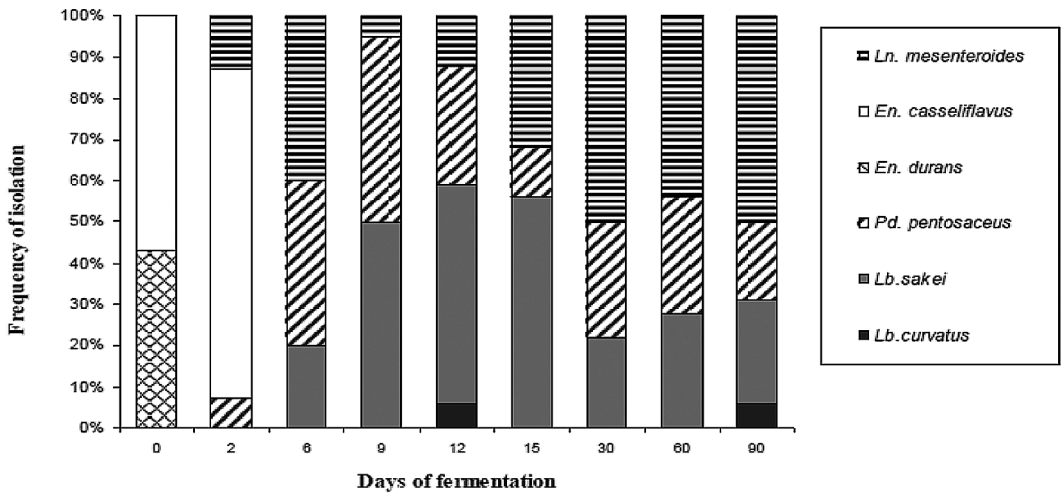

Figure 5. Changes of microorganism's population during fermentation and drying of sausages made in the traditional conditions (in season 2008/2009)

Grafikon 5. Promena populacije mikroorganizama tokom fermentacije i sušenja kobasica izrađenih u tradicionalnim uslovima (u sezoni 2008/2009)

activity of proteinases of endogenous and microbial origin resulted in peptide accumulation, precursors for biogenic amines formation. Histamine was not detected, while determined biogenic amines contributed to the overall flavour (*Tasić et al.,* 2010).

A particular finding (*Vaštag et al*., 2010) is that formed peptides formed during protealysis are biologically active, as endogenous antioxidants with direct beneficial effects on health by regulating different biochemical and/or physiological processes. But, more significant finding is the presence of ACE inhibitors. It is known that their role is to inhibit enzyme responsible for converting angiotensin I to angiotensin II, which leads to narrowing of blood vessels, on the one hand and retention of salt and water at the kidneys, on the other hand. These two mechanisms are crucial in initiating and maintaining high blood pressure (*Vermeirssen et al.*, 2004).

Based on these findings, it could be said that *Petrovská klobása* is somehow a natural functional food, i.e. traditional production in given environment conditions results in safe and high quality product. This is one of the first findings of bioactive peptides presence in traditional sausages at all (*Obradović and Vesković-Moračanin*, 2007).

In order to ensure the safety of sausages produced in traditional conditions, monitoring of microbiological (total count of aerobic mezophil, aerobic spore bacteria, *Micrococacceae, Enterobacteriaceae* and *E. coli, Streptococcus spp.*, *Staphylococcus aureus, Pseudomonas spp.,* UB *Clostridium spp., Salmonella, Listeria monocytogenes, Proteus spp*) and physical-chemical parameters (presence of veterinary drugs, hormones, β-agonists, animal peptides, polycyclic aromatic hydrocarbons, products of lipid peroxidation-MDA values, etc.) were carried out according current legislation. Based on the obtained results it can be concluded that sausages produced during research within mentioned project, over three seasons, were safe (*Petrović et al.*, 2010c; *Petrović et al.*, 2011).

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Standardizacija kvaliteta i bezbednosti tradicionalnih fermentisanih kobasica

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R e z i m e: Tradicionalni proizvodi od mesa u tipu fermentisanih suvih kobasica, sa određenog geografskog područja Srbije, proizvode se, uglavnom, u seoskim domaćinstvima, prema iskustvu i tradicionalnoj tehnologiji. Brojni faktori utiču na kvalitet finalnih proizvoda, a varijabilnost kvaliteta ograničava mogućnost postizanja većeg obima proizvodnje i učešća ovih proizvoda na inostranom tržištu.

U ovom radu predočene su specifičnosti u izradi fermentisanih suvih kobasica („petrovačke" kobasice) i zahtevi koje treba ostvariti pri standardizaciji proizvodnje tradicionalnih kobasica u kontrolisanim uslovima, radi očuvanja karakterističnih svojstava i vrhunskog kvaliteta. Da bi se taj cilj postigao potrebno je potpuno objasniti fizičko-hemijske, biohemijske i mikrobiološke promene u toku spontane fermentacije ovih proizvoda u tradicionalnoj proizvodnji, a potom preneti uočene modele fermentacije, sušenja i zrenja u kontrolisane uslove proizvodnje.

Ključne reči: *tradicionalni proizvodi, geografsko poreklo, fermentisane suve kobasice, standardizacija kvaliteta.*

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