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Effect of technology differences on chemical and sensory properties of Dalmatinska pečenica (pgI)

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Abstract

In the registration process of the protected geographical indication (PGI) of *Dalmatinska pečeni-ca*, a research was conducted to determine the impact of differences in technology on the final product's chemical composition and sensory properties. Therefore, in three facilities in three Dalmatian counties, 35 samples of *Dalmatinska pečenica* were produced and divided into 7 groups, which differed in the initial weight of raw materials, composition, and amount of salting/brining mixture and the length of individual technological phases. After the processing phase, the samples were taken from each group, and the proportion of fat, protein, ash, water and NaCl was determined. A professional panel of 11 members assessed the sensory profile of *Dalmatinska pečenica* by descriptive sensory analysis. Chemical analysis determined the following average basic chemical composition of *Dalmatinska pečenica*: 5.68 % fat, 41.60 % protein, 44.80 % water and 7.63 % ash, and an average of 6.17 % represented NaCl. *Dalmatinska pečenica* produced from heavier raw meat (initial weight ≥3.5 kg) contained more intramuscular fat and water (P <0.05) and less proteins (P <0.05). The lower the initial weight of the raw *pečenica* and the higher the salt/brine consumption per kg of raw meat, the higher the NaCl content in the mature *pečenica*, with the length of the salting/brining phase not significantly increasing the NaCl content in the *pečenica*. The sensory analysis determined the sensory profile and typical sensory properties of *Dalmatinska pečenica*, including characteristic cylindrical shape and colour, firm and elastic consistency, compact structure, uniform red cross-section, slightly salty taste, softness and solubility when chewed as well as an aroma characteristic of dry-cured pork products with a slightly expressed smoke aroma. The *pečenica* produced from heavier raw materials (≥3.5 kg) using a mixture of sea and nitrite salt with spices and antioxidants, increased content of intramuscular fat and mild salinity, was rated with the highest average score (5.88 out of a possible 6), and all individual indicators of sensory properties were also rated with the highest score compared to other groups (P <0.05). The correlation coefficient (r) showed that the higher the content of intramuscular fat in the *pečenica*, the higher the evaluation of the cross-sectional appearance (r = 0.48), odour (r = 0.37), texture (r = 0.39), taste and aroma (r = 0.44), overall impression (r = 0.36) and mean score (r = 0.30). These data confirm the positive effect of intramuscular fat content (marbling) on the sensory properties of *Dalmatinska pečenica*. The examined differences in processing technology had a statistically significant effect on the parameters of chemical composition and sensory properties of *Dalmatinska pečenica*.

Keywords: *Dalmatinska pečenica*, protected geographical indication (PGI), chemical composition, sensory profile

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Introduction

Dalmatinska pečenica is a widely known and appreciated traditional, dry-cured meat product whose technology and name have recently been protected by a geographical indication (PGI) at the European Union level. The protection of the geographical origin of *Dalmatinska pečenica* is based on the reputation and traditional method of production in a defined geographical area (Krvavica et al., 2018.). The specific geographical conditions of Dalmatia, especially the unique climate and frequent wind changes and the practical skills and knowledge of the local population that has been improved and perfected over the centuries from generation to generation, have given rise to many specific traditional dry-cured meat products such as *Dalmatinska pečenica*, by which Dalmatia has become very famous. These facts were the basis for initiating and completing a protected geographical indication (PGI) registration at the EU level.

Although the technology of *Dalmatinska pečenica* is described in detail in the document "Product specification of *Dalmatinska pečenica* - Protected geographical indication" (Udruga proizvođača Drniškog pršuta, 2019.), the fact is that some technological processes differ from producer to producer, which is not prohibited by this Specification. Such differences in technology certainly affect the properties of the final product, but not so much that they are to the detriment of standardization and quality, but on the contrary, they contribute to the quality of the final product by giving it a flair of "domestic" production. Modern technology today enables the controlled production of durable dried meat products throughout the year. However, traditional products such as *Dalmatinska pečenica*, according to the Specification, must, whenever weather conditions allow, be exposed to natural air circulation (external atmosphere), given that the specific climatic conditions of the geographical area affect the microclimatic conditions in facilities as well as biochemical processes and enzymatic activity in the tissues of the liver, thus creating conditions for achieving specific sensory properties of the final product (Krvavica et al., 2018.). In addition to climatic and microclimatic production conditions (temperature, humidity and airflow rate), the quality (chemical and sensory properties) of the final product is influenced by numerous other factors (Krvavica, 2006.), which can gene-

rally be classified as internal, related to differences in properties (Hoz et al., 2007.; Seong et al., 2015.) and external, related to differences in technological production processes (Lušnic Polak et al., 2018.; Lorenzo and Purriños, 2013). Górska et al. (2017.) state that the quality of a product (primarily determined by its taste and aroma) largely depends on the quality of the raw meat, processing technology and ripening length, emphasizing that the specific aroma of dried meat produced during processing (especially during ripening) is the result of numerous biochemical changes through which proteins and lipids pass, as the main constituents of meat.

Therefore, the aim of this research, conducted as part of the registration procedure for the protected geographical indication (PGI) of *Dalmatinska pečenica*, was to determine how,, among other things, differences in technology such as starting weight of raw meat, method of salting/brining (brine composition and amount of salt/brine consumed per kg raw meat) and the length of individual technological phases (salting/brining, smoking/drying and ripening), affect the chemical composition and sensory properties of the final product. Given that the sensory properties of *Dalmatinska pečenica* have probably not been investigated so far (no data available), the aim was also to determine its specific sensory profile.

Meat and methods

Production of *Dalmatinska* *pečenica* – For the purpose of the research, 35 *Dalmatinska pečenicas* were produced in three processing facilities (A, B and C) in three Dalmatian counties (Zadar, Šibenik-Knin and Split-Dalmatia counties), and divided into 7 different groups as shown in Table 1. Differences in technology by facilities and groups referred to the initial weight of raw *pečenica* (<3.5 and ≥3.5), the composition of the salting/brining mixture (sea salt; sea salt + nitrite salt; sea salt + nitrite salt + mixture of spices and antioxidants), its consumption per kg of raw meat (from 0.05 to 0.08 kg), the length of individual processing stages, and, thus, the total length of the process (facility A - 52 days, facility B - 62 days, facility C - 71 days). The salting/brining process was not performed using a predetermined amount of salt/brine, but its consumption was determined by weighing, i.e. determining the difference between the amount of salt/brine at the beginning and end of salting/brining for each
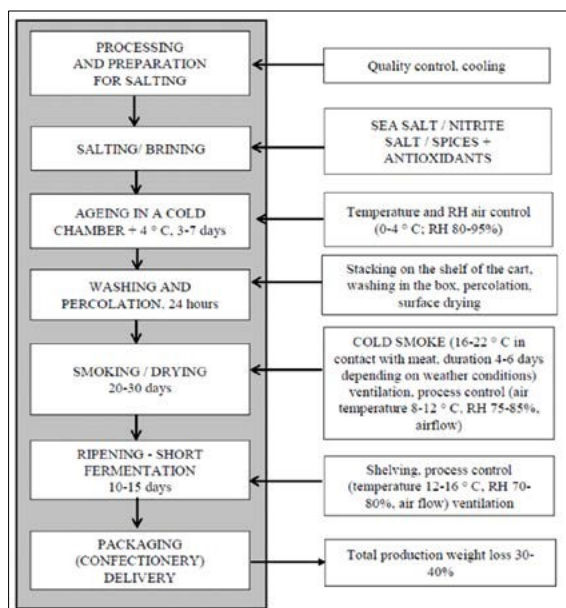
raw *pečenica*.

The production of *Dalmatinska pečenica* was carried out following traditional Dalmatian technology, i.e. according to the Product Specification "*Dalmatinska pečenica*" - Protected geographical indication (Udruga proizvođača Drniškog pršuta, 2019.). For the production of *Dalmatinska pečenica*, 35 shaped long back muscles of pigs (*m. longissimus thoracis et lumborum*) were subjected to salting/brining, cold smoking, drying and ripening procedures following the technological differences

Table 1 Division of *Dalmatinska pečenica* into groups according to technological differences

FACILITY	Group label	Processing stages	DF	Raw meat mass kg	Salting procedure	Consumption of salt / brine per kg of meat	
						kg	%
A	A1	Salting/Brining	3	≥3,5	MS	0,05	5,14
	A2	Drying/Ripening	45	<3,5	MNS	0,08	7,61
		Cold smoking	4				
B	B3	Salting/Brining	7	≥3,5	MNS	0,06	5,90
	B4				MNSZ		
	B5	Drying/Ripening	49	<3,5	MNSZ	0,06	5,61
	B6	Cold smoking	6		MNS		
C	C7	Salting/Brining	3	≥3,5	MS	0,06	6,29
		Drying/Ripening	64				
		Cold smoking	4				

DF- phase length in days; MS – sea salt; MNS – sea salt + nitrite salt;
MNSZ – sea salt + nitrite salt + mixture of spices and antioxidants

Figue 1 Diagram of the technological course of production of *Dalmatinska pečenica*

listed in Table 1 and the technological flow diagram is shown in Figure 1.

Sampling – For the needs of sensory analysis of *Dalmatinska pečenica*, on the day of analysis, the *pečenica* samples were taken from each object in such a way that one *pečenica* was taken from each group (Table 1; facility A - two, facility B - four, facility C - one). Sensory analysis of the external appearance was performed on a sample of cleaned and arranged whole *pečenica*.

For the evaluation of other sensory properties, the samples were prepared by cutting the *pečenica* into plates approximately 2 mm thick. After the sensory analysis, the samples for chemical analysis were taken. Thus, 5 samples of *pečenica* were taken from each group (facility A - 10 samples, facility B - 20 samples, facility C - 5 samples; a total of 35 samples) so that a sample weighing approximately 200 g was cut from the middle of each *pečenica*. The samples were vacuumed and frozen at -18 °C until

analysis was performed. Immediately before the chemical analysis, the frozen samples were homogenized in a commercial electric meat grinder.

Chemical analysis – The water content of *Dalmatinska pečenica* samples was determined gravimetrically (ISO 1442:1997.), the total fat content by Soxhlet method (HRN ISO 1443:1999.), the protein content by Kjeldahl method (HRN ISO 1871:1999.), the ash content by dry incineration of the sample (ISO 936:1998.), and the NaCl content by the modified Mohr method (Pavlinić, 2015.).

Sensory profile determination and sensory analysis – A review of the available literature did not reveal written data on the sensory properties of *Dalmatinska pečenica*, so it can be assumed that the assessment of sensory properties of *Dalmatinska pečenica* has not been the subject of scientific interest. Therefore, before performing the subject assessment, the sensory profile of *Dalmatinska pečenica* was determined by an appropriate descriptive method. For this purpose, a simple descriptive method of sensory analysis was used according to the general instructions for determining the sensory profile (HRN EN ISO 13299:2016.). An expert panel trained for sensory evaluation of dry-cured meat products determined the external appearance, cross-sectional appearance (colour, marbling), odour, consistency (strength, softness, texture, dryness, juiciness, solubility) and aroma
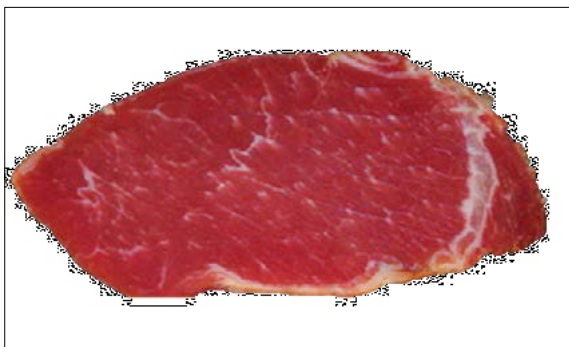
Slika 2. Cross-section of a mature *Dalmatian pečenica*

and taste of *Dalmatinska pečenica* (Table 2).
The assessment of the sensory properties of the studied *Dalmatinska pečenica* was carried out by a trained panel composed of 11 members with previous experience in implementing sensory assessment of dry-cured meat products. All panel members were educated in detail about the method of assessing sensory properties and the established sensory profile of *Dalmatinska pečenica*.

Slika 3. Evaluation sheet for the evaluation of sensory properties of *Dalmatinska pečenica*

The evaluation of sensory properties was performed according to the model shown in Table 2 and the General Instructions for Sensory Analysis (HRN ISO 6658:2017.) using the Evaluation Sheet shown in Figure 3. The evaluation of sensory properties of *Dalmatinska pečenica* was performed on samples from all groups (Table 1), that is, on a total of 7 samples from 3 facilities. Sensory analysis of the external appearance of the *pečenica* was performed on a cleaned and arranged *pečenica* sample. For evaluating other sensory properties, samples were prepared by cutting the *pečenica* into slices (Figure 2) approximately 2 mm thick and served to panel members on a white plate.

Statistical data processing – was performed using the software package XLSTAT (Microsoft, USA). Descriptive statistics of the researched indicators were calculated using the Summary statistics procedure. Assessment of the effect of technological differences on the chemical composition and sensory properties of *Dalmatinska pečenica* was performed using factor analysis of variance (ANOVA), and the results were expressed as mean ± standard deviation (SD). Differences were accepted as statistically significant if the probability of the null hypothesis (absence of facility and group effect) was less than 5 % (P <0.05). Correlation coefficients (r) between individual examined indicators were determined using the Correlation matrix, Pearson (n). Conclusions on the value of correlation coefficients r were made with a probability level of at least 95 % (P <0.05).

Results and discussion

Chemical composition of *Dalmatinska pečenica*

Analysis of the chemical composition of *Dalmatinska pečenica* samples grouped in 7 diffe- rent groups from three different objects (Table 1) showed that *pečenica* contains an average of 5.68 % fat, 41.60 % protein, 7.63 % ash, 44.80 % water and 6,17 % NaCl (Table 3).

Table 2 Table for determining the sensory profile of *Dalmatinska pečenica*

Sensory properties	Definition	Descriptive grade range 1 to 6
1. APPEARANCE		A rate of 1 to 6 evaluates acceptability rather than intensity of the property*
Product shape	Correctness of shape	Regular to extremely irregular
Presence of notches and irregularities	Appearance of the outer surface (the presence of notches and dent, level and uniformity of dehydration)	No cuts or imperfections to extremely uneven; Slightly to excessively or unevenly dried
Exterior surface color	Intensity and uniformity of the colour of the outer surface	Light to extremely dark; Uniform to extremely uneven
The presence of mold	The presence of mold	No mold until very covered with mold
2. CROSS-SECTION		
Yellow colour fat tissue	Yellow fat tissue intensity	White to intense yellow
Pink colour of fat tissue	The intensity and distribution of pink fat tissue	Completely white to predominantly pink
Surface gloss (oily surface)	Fat dissolution level in cross section	Completely dry to very oily
Red colour of muscle tissue	The intensity of red colour of muscle tissue in cross-section	Pink to dark red
Colour uniformity	Uniformity of muscle tissue colour	Uniform to very uneven
Colour clarity	The intensity of colour clarity in cross-section	Blurry to very clear
Marbling	Visible intramuscular fat level	Completely fat-free to very marbled
3. ODOUR		
Odour intensity	The strength of the overall odour before tasting	Odourless to very intense odour
The presence of a specific odour	The intensity of specific odour for that type of product	Very weak to very intense
Presence of smoke odour	Intensity	Very weak to very intense
The presence of odours by spices	Intensity	Very weak to very intense
Presence of foreign odour	Intensity	Very weak to very intense
Characteristic odour (rancidity)	Intensity	Very weak to very intense
4. TEXTURE		
Fat tissue firmness	Resistance to fat tissue bite by front teeth	Extremely soft to very firm
The softness of muscle tissue	Resistance to muscle tissue bite and chewing	Extremely soft and gentle to very firm and hard
Fibre	To what degree is felt fibrous when chewed	No expressed fibrosity to very expressed Very dry to very humid
Dryness juiciness solubility	The amount of juice in the mouth at the first bites Feeling of lubrication during chewing	Dry to very juicy
5. TASTE AND AROMA		
Salty	Intensity	Unsalted to very salty
Sweet	Intensity	Not sweet to extremely sweet
Bitter	Intensity	Not bitter to very bitter
Taste and aroma left in the mouth	Intensity and retention time of taste after ingestion	Without to very intense
Taste and aroma specific for permanent dry-cured meat products	Intensity of typical taste	Very weak to very intense
Taste and aroma of smoke	Intensity of smoke aroma	Very weak to very intense
Characteristic taste (rancidity)	Intensity	Very weak to very intense
The totality of flavours and aromas	Intensity	Weakly expressed to very intense taste and aroma

Each of the 5 sensory properties is evaluated with a rating from 1 to 6 based on the acceptability of individual characteristics of the evaluated property

Table 3 Average chemical composition of *Dalmatinska pečenica* (all 35 samples),%

Parameter	Max	Min	SV	SD	CV, %
Fat, %	9,33	2,68	5,68	1,95	34,31
Proteins, %	46,33	35,89	41,60	2,65	6,37
Ash, %	8,49	6,98	7,63	0,39	5,10
Water, %	46,76	41,99	44,80	1,27	2,83
NaCl, %	7,25	5,49	6,17	0,46	7,50

Max – maximum; Min – minimum; SV – mean value;
SD – standard deviation; CV – coefficient of variation

As shown in Table 4, the samples from group C7 (facility C) contained the most fat (7.94 %), the samples from group B5 (facility B) contained the most protein (44.80 %), the samples from group A2 (facility A) contained the most ash (8.11 %) and NaCl (7.05%), and samples from group B3 (facility B) contained the most water (45.95%). The fat content varied the most, both for all samples (CV 34.31 %) and by groups (CV from 13.27 % to 19.12 %).

The analysis of chemical properties of the studied samples determined the average basic chemical composition and NaCl content of *Dalmatinska pečenica* (5.68 % fat, 41.60 % protein, 7.63 % ash, 44.80 % water and 6.17 % NaCl; Table 3), which mostly coincides with the results of research by other authors. Thus Pateiro et al. (2015.) found that dry loin produced from the indigenous Spanish pig breed Celta contains an average of 41.46 % water, 10.68 % fat, 73.04 % proteins and 8.86 % NaCl. Investigating differences in some traits of dried pork loin 4 different genotypes of Iberian pig (indigenous breed), Muriel et al. (2004.) found that after 60 days of processing, it contained 32.97 % to 35.66 % water and 6.77 % to 10.22 % intramuscular fat. In both cases, they are indigenous primitive breeds of pigs, whose meat contains a higher amount of fat, so the proportion of fat in dry loin was higher than in the studied samples of *Dalmatinska pečenica* (from 2.68 to 9.33 %; Table 3). The fat content is usually a more variable ingredient in meat and meat products, as it depends on several factors, most notably the breed and fattening of the animal, which is noticeable in the studied *pečenica*, given that the coefficients of variation, both for all samples (CV 34.31 %) and by groups (CV from 13.27 % to 19.12 %), were the highest for fat content in the samples. In pork, the proportion of fat in the carcass can vary from 1 % in highly meaty pigs with PSE meat syndrome (pale, soft, exudative) to 40 % in primitive breeds (Uremović and Uremović, 1997.). The high-fat content in samples A1 (7.64%), B3 (6.28),

B4 (6.51 %) and C7 (7.94 %) is probably due to the higher slaughter mass of pigs, as the initial masses of raw *pečenica* were ≥3.5 kg, in contrast to others with initial weights <3.5 kg. According to Lušnic Polak et al. (2018.), the basic chemical composition of dried pork loin produced from commercial raw meat (initial weight 2.57 to 2.85 kg) in industrial conditions after 12 weeks of the procedure was as follows: 39.37 % water, 10.45 % fat, 40.02 % proteins, 9.01 % ash and 4.70 % NaCl. A lower proportion of water and consequently a higher proportion of dry matter, i.e. other ingredients, concerning *Dalmatinska pečenica* result from much longer processing and a smaller initial mass of *pečenica*. Aliño et al. (2009) found that dried loin from Spanish commercial production (thawed raw meat weighing 2.8 ± 0.2 kg; process duration 60 days) contained approximately 45 % water, 45 % protein, 14 % fat and 4.1 % NaCl, which are somewhat different results than in this study, but also than the results of other authors. It is possible that the use of thawed raw meat results in a higher processing weight loss, and thus a lower proportion of water and consequently a higher proportion of dry matter ingredients. The initial mass of raw meat has similar consequences on the loss of mass in processing (kalo) and water activity (a_w) of *Dalmatinska pečenica* (Krvavica et al., 2016).

The highest proportion of fat (7.94 %) was found in group C7, the highest proportion of proteins (44.80 %) in group B5, the highest proportion of ash (8.11 %) and NaCl (7.05 %) in group A2, and the largest share of water (45.95 %) in group B3 (Table 4). By testing the differences between the groups (Table 4), it was found that the fat content in group C7 was not statistically higher than that in group A1 (7.64 %). Furthermore, the fat contents in group A2 (4.31 %) and group B5 (3.62 %) were also similar to those in groups B3 (6.28 %) and B4 (6.51 %) and groups A1 and B4. These relationships follow the conclusion that *pečenica* produced from heavier raw meat

(groups A1, B3, B4 and C7) had a significantly higher fat content than those produced from lighter raw meat (groups A2, B5 and B6). By testing the differences in water contents, it was found that the share of water in group B3 (45.95 %) was not significantly higher than in groups A1 (45.82 %) and C7 (44.92 %).

Furthermore, similar water proportions were found in groups A2 (44.32 %), B5 (43.83 %), B6 (43.65 %), but also in group C7 (44.92 %). Groups A2 and B3, as well as A2 and B5, also had statistically similar water proportions. However, regardless of the deviations, it is still evident that the proportion of water in *pečenica* produced from heavier raw meat was higher than in those produced from the lighter ones. Since heavier *pečenica* contained more intramuscular fat than the lighter one, this could be the reason for slower dehydration with a higher initial mass and a minor weight loss of *Dalmatinska pečenica* (Krvavica et al., 2016), including a higher water content in the final product. The proportions of proteins and ash in the tested samples of *pečenica* are closely related to the fat and water content (Table 5) since the correlation coefficients confirm a strong negative correlation between fat and proteins content (r = - 0.91, P <0.001) and between proteins content and water (r = - 0.79, P <0.001), a medium-strong positive correlation between fat and water content (r = 0.51, P <0.01), and a slightly weaker correlation between fat and ash content (r = - 0.40, P <0.05). By testing the differences in NaCl proportions by groups (Table 4), significant statistical differences were found between group A1 (5.67 %) with the lowest salt content and group A2 (7.05 %) with the highest salt content. These groups were different in initial weight and composition and consumption of salt/brine (Table 1). The NaCl contents in all groups

from facility B (B3, B4, B5 and B6) were similar, although these are groups different in the initial mass of the raw meat and the composition and consumption of salt/brine. The NaCl content in group C7 was different from all other groups (as well as the NaCl content in group A2). The lowest NaCl was found in group A1 (5.67 %), in which the consumption of salt per kg of raw meat was the lowest (5.14 %), and the highest in group A2 (7.05 %) in which the consumption of brine per kg of raw meat was the most prominent (7.61 %). The difference between these groups was also statistically very significant (P <0.001). Since salting/brining was not performed using a predetermined amount of salt/brine, but its consumption was determined as the residue after salting, significantly higher consumption of brine for samples from group A2 (7.61 %) and a significantly higher proportion of NaCl in mature *pečenica* in the same group A2 (7.05 %), could be a consequence of the poorer quality of raw meat from group A2, given that excess surface water of poorer quality pork results in faster melting of salt on the surface and accelerated diffusion of salt into the meat, and thus increased salinity of the final product (Toldrá, 2002). It was to be expected that the NaCl content in mature *pečenica* decreases with increasing water and fat content. However, only a very weak (r = - 0.24, P <0.05), statistically insignificant negative correlation between these indicators was found.

Considering the numerous statistically significant differences in the chemical composition among the 7 investigated groups of *Dalmatinska pečenica*, it may be concluded that the technological differences between the groups (differences in the initial mass of raw meat, composition and consumption of salt/brine and duration of individual processing phases

Table 4 Influence of technological differences on chemical properties of *Dalmatinska pečenica* (SV±SD)

Facilities Grups	Parameters (SV±SD)				
	Fat, %	Proteins, %	Ash, %	Water, %	NaCl, %
A1	7,64±1,21[AE]	38,35±1,50[A]	7,82±0,14[A]	7,27±0,20[C]	5,67±0,18[A]
A2	4,31±0,64[B]	43,01±1,11[B]	8,11±0,14[B]	44,32±0,78[BCD]	7,05±0,15[B]
B3	6,28±0,83[C]	40,25±1,16[CD]	7,29±0,12[C]	45,95±0,68[A]	5,95±0,22[C]
B4	6,51±1,05A[C]	40,82±1,11[D]	7,37±0,18[C]	45,09±0,61[C]	5,97±0,21[C]
B5	3,62±0,64[BD]	44,80±1,33[E]	7,44±0,25[C]	43,83±1,07[D]	6,05±0,14[C]
B6	3,45±0,66[D]	44,42±2,11[BE]	8,08±0,25[B]	43,65±1,68[D]	6,02±0,17[C]
C7	7,94±1,16[E]	39,55±0,79[AC]	7,27±0,20[C]	44,92±1,29[ACD]	6,51±0,22[D]
RZ	*	*	*	*	*

*SV – mean value; SD – standard deviation; Different letters within the same line (A, B, C, D, E) indicate significant differences between groups; RZ – significance level (*P < 0.05)*

Table 5 Correlation coefficients (r) between the parameters of the chemical composition of *Dalmatinska pečenica*

Parametar	Bjelančevine	Pepeo	Voda	NaCl
Mast	**-0,91*****	-0,40*	**0,51****	-0,17
Bjelančevine	1	0,27	**-0,79*****	0,22
Pepeo	-	1	-0,29	0,22
Voda	-	-	1	-0,24
NaCl	-	-	-	1

*Values in **bold** are different from zero (*P<0.05; **P<0.01; ***P<0.001)*

as well as whole process) significantly affected the chemical composition of the mature *pečenica*.

Sensory analysis and sensory profile of *Dalmatinska pečenica*

Sensory analysis conducted by an expert panel composed of 11 members determined the sensory profile, or typical sensory properties of *Dalmatinska pečenica*: the external appearance of the product is oblong-cylindrical, surface free of cuts and other damage; the colour of the outer surface is light brown to dark brown with or without light yellow to light brown surfaces covered with fat tissue; the product is easy to cut, has a firm and elastic consistency and compact structure, and the cross-section is a uniform red colour that can be dark red to dark brown at the edges with or without parts of white to light yellow or light brown fat tissue; the product has a slightly salty taste, soft, soluble and juicy in the mouth, and the aroma is characteristic of the aroma of dry-cured pork products, with a slightly expressed aroma of smoke.

By assessing the sensory properties of *Dalmatinska pečenica* from 7 different groups (Table 1), the same expert panel rated the *pečenica* from group

B4 with the highest average grade (5.88; Table 6), with all individual sensory properties also rated the highest (from 5.82 to 6.00). Judging by the content of intramuscular fat, *pečenica* from group B4 (6.51 %) was among those with the highest fat content (only group C7 contained a higher amount of fat), so it is to be assumed that permeation of muscle with adipose tissue (marbling) in *pečenica* with a higher proportion intramuscular fat was higher (Muriel et al., 2004.). The evaluation of the cross-sectional appearance largely (along with the colour) depends on the degree of marbling (good but not excessive marbling is desirable), so the cross-sectional appearance of *pečenica* with a higher proportion of intramuscular fat was rated higher, which confirms the correlation coefficient between these two properties (r = 0.48, P <0.05; Table 8). The positive effect of intramuscular fat content on colour (lighter) and the degree of marbling is also confirmed by research by other authors on dried pork loin (Muriel et al., 2004.) and other products such as prosciutto (Jurado et al., 2003., cit. Muriel et al., 2004.; Ruiz et al., 2000.). Moreover, these sensory properties (colour and marbling) positively affect consumer preferences (Ruiz et al., 2002.). The cross-sectional appearance of group B4

Table 6 Influence of technological differences on sensory properties of *Dalmatinska pečenica*

Facilities Grups	Sensory properties (SV±SD)						
	Appearance	Cross-section	Odour	Texture	Taste and aroma	Overall impression	Mean grade
A1	5,64±1,14[A]	5,36±1,03[AB]	5,64±0,50[AD]	5,55±0,69[AB]	5,45±0,93[ACD]	5,36±1,03[AB]	5,50
A2	5,09±0,50[A]	5,36±0,67[B]	5,18±0,60[BC]	5,27±0,65[AD]	5,00±0,45[AB]	5,27±0,47[AD]	5,20
B3	5,27±0,65[A]	5,27±0,65[B]	5,18±0,60[BC]	5,09±0,83[ACD]	4,82±0,60[B]	4,82±0,60[BE]	5,03
B4	5,91±0,30[BC]	6,00±0,00[C]	5,82±0,40[D]	5,82±0,40[B]	5,82±0,40[C]	5,91±0,30[C]	5,88
B5	5,82±0,60[C]	5,64±0,50[B]	5,36±0,50[AB]	5,36±0,67[AD]	5,36±0,50[D]	5,36±0,50[A]	5,48
B6	5,64±0,67[AC]	4,36±0,67[D]	5,09±0,83[BC]	4,82±0,75[C]	4,09±0,70[E]	4,45±0,69[E]	4,74
C7	5,36±0,67[AC]	5,64±0,67[B]	5,09±0,70[BC]	5,00±0,77[C]	5,00±0,77[ABD]	5,18±0,75[ABD]	5,21
RZ	*	*	*	*	*	*	

SV – mean value; SD – standard deviation; Different letters within the same line (A, B, C, D, E) indicate significant differences between groups; RZ – significance level (*P< 0.05)

Table 7 Correlation coefficients (r) between the indicators of sensory properties

Properties	Cross-section	Odour	Texture	Taste and aroma	Overall impression	Mean grade
Appearance	0,21	**0,71****	**0,50***	**0,42***	**0,39***	**0,55****
Cross-section	1	**0,54****	**0,74****	**0,91*****	**0,91*****	**0,87*****
Odour	-	1	**0,91*****	**0,80*****	**0,82*****	**0,88*****
Texture	-	-	1	**0,93*****	**0,92*****	**0,95*****
Taste and aroma	-	-	-	1	**0,96*****	**0,98*****
Overall impression	-	-	-	-	1	**0,97*****
Mean grade	-	-	-	-	-	1

*Values in **bold** are different from zero (*P<0.05; **P<0.01; ***P<0.001)*

was rated the highest (6.00), statistically significantly higher than all other groups (P <0.05; Table 6). This is probably due to synergy of the higher initial mass of raw meat, meat quality and good marbling, the use of nitrite salt and a mixture of spices (nitrites fix the colour of muscle tissue and ensure its uniformity, and a mixture of spices with antioxidants prevents adverse oxidation processes; Krvavica et al. 2016) including optimal microclimatic conditions and length of individual phases, as well as the entire processing. Furthermore, the proportion of NaCl (5.97 %) in the mature *pečenica* of group B4 was among the lowest (only in group A1 a lower proportion of NaCl was found; Table 4), and salinity was expected to affect the taste and aroma properties. However, only a slight negative correlation (r = - 0.17, P <0.05) was found between these two properties (Table 7), although the differences in NaCl content between the groups were significant (Table 4). Likely, the differences in salinity between the groups were not so significant to affect the taste considerably.

The correlation coefficients between individual sensory properties (Table 8) confirm that all assessments of individual sensory properties of *Dalmatinska pečenica* were in a positive correlation with each other, and in most cases in a very strong (P <0.001) or strong correlation (P <0.01). Very strong correlations between odour and taste and aroma, as well as cross-section and texture, and connection of all sensory properties with the overall impression and mean grade, are understandable and expected (Górska et al., 2017.). However, the positive correlation between appearance and odour and taste and aroma, cannot be explained so simply. The assessment of appearance of the outer surface of *pečenica* depends on uniformity of trimming (presence of notches), degree and uniformity of dehydration and color (Table 2). Also, coverage of adipose tissue also play an important role, as well as mold presence. The correlation between texture and degree of dehydration is expected, as well as impact of adipose tissue coverage and mold presence on odor, aroma and taste, and texture. In any case, very high and high positive correlations among individual sensory properties are understandable, which is confirmed by research by other authors (Ruiz et al., 2000.; 2002.; Kos et al., 2019.).

According to the results from Table 6, the *pečenicas* from group B6 were rated with the lowest mean score (4.74), with individual scores being the lowest for cross-sectional appearance (4.36), texture (4.82), taste and aroma (4.09) and the overall impression (4.45). In addition, the lowest grade for external appearance was given to group A2 (5.09), and the lowest grade for fragrance, group B3 (4.91). The *pečenicas* from group B6 were produced from lighter

Table 8 Correlation coefficients (r) between chemical and sensory properties

Parameters	Appearance	Cross-section	Odour	Texture	Taste and aroma	Overall impression	Mean grade
Fat	-0,07	**0,48***	**0,37***	**0,39***	**0,44***	**0,36***	0,30
Proteins	0,15	**-0,38***	-0,22	-0,29	**-0,40***	-0,29	-0,24
Ash	-0,22	**-0,65****	-0,04	-0,20	**-0,44***	-0,34	**-0,38***
Water	-0,18	**0,36***	0,14	**0,36***	**0,40***	0,24	0,22
NaCl	**-0,69****	0,07	**-0,38***	-0,26	-0,17	0,01	-0,09

*Values in **bold** are different from zero (*P<0.05; **P<0.01; ***P<0.001)*

raw meat (<3.5 kg), and the share of intramuscular fat compared to other groups was the lowest (3.45 %; P <0.05; P <0.001; Table 4), which could be the main reasons for the worst average score, but also the appearance of the cross-section, texture and overall impression. From the data analysis (Table 6), it is impossible to determine the influence of the initial mass of *pečenica* on the evaluation of external appearance regardless of the lowest evaluation of this property for group A2 (5.09) produced from lighter raw meat. Namely, by testing the differences, it was found that this rating did not differ statistically from the ratings of the external appearance of *pečenica*s in groups A1, B5, B6 and C7, produced from heavier raw meat. Other indicators of external appearance (regularity of shape and surface, intensity and uniformity of colour, etc.) had a decisive influence on assessing the external appearance of *pečenica*. However, judging by the grade for the cross-sectional appearance in group B6 (4.36), rated with the lowest grade compared to other groups (P <0.01 and P <0.001) and containing the lowest fat content (3.45 %; P <0.05 and P <0.001; Table 4), the cross-sectional appearance very likely depends significantly on the proportion of intramuscular fat, i.e. marbling, which is confirmed by other authors (Muriel et al., 2004.; Ruiz et al., 2000.). This claim is also favoured by the established positive correlation between the cross-sectional appearance and intramuscular fat content (r = 0.48, P <0.05; Table 7). It is known that the quality of raw meat has a crucial effect on the sensory properties of dry-cured meat products, including mature *pečenica*. Thus Lušnic Polak et al. (2018.), examining the impact of iodised salt in the production of dry-cured loin, state that the identified differences in sensory properties between groups are probably due to differences in raw meat quality as the crucial factor of ripe *pečenica* quality. One of the important indicators of the overall quality of meat is the degree of marbling, especially when it comes to dry-cured meat products. Namely, the optimal amount of intramuscular fat, in addition to the cross-sectional appearance, also contributes to the development of desirable biochemical processes, especially in the ripening phase of products, which result in the creation of desirable odour, aroma and taste (Toldrá, 2002.). This is confirmed by the positive correlations (Table 8) between the proportion of fat, taste and aroma (r = 0.44, P <0.05) and the proportion of fat and odour (r = 0.37, P <0.05) found in this study, as well as the high proportion of intramuscular fat in samples of group B4. Furthermore, given

the differences in smoking length between *pečenicas* in facility B and other 2 facilities (all *pečenicas* in facility B were smoked 6 times, compared to others smoked 4 times during the smoking phase), no significant difference in assessment was found between them considering odour, taste and aroma. Moreover, the odour, taste and aroma of group B4 were rated the highest (Table 6), which confirms that moderate and mild smoking with cold smoke provides *Dalmatinska pečenica* is characterised by mild odour and aroma of smoke and basically has a positive effect on sensory properties. According to Pham et al. (2008.) smoked dry-cured ham products have higher consumer acceptability in comparison to non-smoked ones.

Conclusive remarks

The research shows that the basic chemical composition of the studied *Dalmatinska pečenica* consists of 5.68 % fat, 41.60 % protein, 44.80 % water and 7.63 % ash, and an average of 6.17 % represents NaCl. Furthermore, the *pečenica* produced from heavier raw meat (initial weight ≥3.5 kg) contained more intramuscular fat and water (P <0.05) and less proteins (P <0.05). At the same time, the NaCl content increased with decreasing initial mass of the raw *pečenica* and with an increase in the consumption of salt/brine per kg of raw meat in the salting/brining phase (the smallest share was determined in group A1 - 5.67 %, and the largest in group A2 - 7.05 %). The sensory analysis determined the sensory profile and typical sensory properties of *Dalmatinska pečenica*, of which, in addition to the characteristic cylindrical shape and colour, firm and elastic consistency, compact structure, uniform red cross-section, slightly salty taste, softness and solubility when chewed, and characteristic aroma of dry-cured pork products with a slightly expressed smoke aroma stand out. The investigated differences in processing technology (initial mass of raw meat, composition and consumption of salt/brine, duration of individual processing phases, duration of the entire process) had a statistically significant effect on the chemical composition and sensory properties of *Dalmatinska pečenica*. The intramuscular fat content (marbling) had a positive effect on several sensory properties of *Dalmatinska pečenica* (cross-sectional appearance, smell, texture, taste and aroma, overall impression and average grade), which confirms its positive effect on the overall quality of dry-cured meat products.

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Einfluss von technologischen unterschieden auf chemische und sensorische eigenschaften der Dalmatinska pečenica

Zusammenfassung

Im Rahmen des Registrierungsprozesses der geschützten geografischen Angabe (g.g.A.) von Dalmatinska pečenica wurde eine Untersuchung durchgeführt, um den Einfluss von Unterschieden in der Technologie auf die chemische Zusammensetzung und die sensorischen Eigenschaften des Endprodukts zu bestimmen. Dazu wurden in drei Betrieben in drei dalmatinischen Gespanschaften 35 Proben der Dalmatinska pečenica hergestellt und in 7 Gruppen eingeteilt, die sich im Ausgangsgewicht der Rohstoffe, der Zusammensetzung und der Menge der Salz-/Pökelmischung sowie in der Länge der einzelnen technologischen Phasen unterschieden. Nach der Verarbeitungsphase wurden Proben aus jeder Gruppe entnommen und der Anteil von Fett, Eiweiß, Asche, Wasser und NaCl bestimmt. Ein professionelles Panel aus 11 Mitgliedern bewertete das sensorische Profil der Dalmatinska pečenica durch eine deskriptive sensorische Analyse. Die chemische Analyse ermittelte die folgende durchschnittliche chemische Grundzusammensetzung der Dalmatinska pečenica: 5,68% Fett, 41,60% Eiweiß, 44,80% Wasser, 7,63% Asche und 6,17% NaCl. Die Dalmatinska pečenica, die aus schwereren Rohstoffen (Ausgangsgewicht ≥3,5 kg) hergestellt wurde, enthielt mehr intramuskuläres Fett und Wasser (P <0,05) und weniger Proteine (P <0,05). Je geringer das Ausgangsgewicht der rohen Pečenica und je höher der Salz-/Pökellakeverbrauch pro kg rohes Fleisch war, desto höher der NaCl-Gehalt in der reifen Pečenica, wobei die Länge der Salz-/Pökelphase den NaCl-Gehalt in der Pečenica nicht signifikant erhöhte. Die sensorische Analyse ermittelte das sensorische Profil und die typischen sensorischen Eigenschaften der Dalmatinska pečenica, einschließlich der charakteristischen zylindrischen Form und Farbe, der festen und elastischen Konsistenz, der kompakten Struktur, des gleichmäßigen roten querschnitts, des leicht salzigen Geschmacks, der Weichheit und Löslichkeit beim Kauen sowie eines für haltbare geräucherte Schweinefleischprodukte charakteristischen Aromas mit einem leicht ausgeprägten Raucharoma. Die Pečenica, die aus schwereren Rohstoffen (≥3,5 kg) unter Verwendung einer Mischung aus Meer- und Nitritsalz mit Gewürzen und Antioxidantien hergestellt wurde, mit einem erhöhten Gehalt an intramuskulärem Fett und mildem Salzgehalt, wurde mit der höchsten Durchschnittsnote (5,88 von möglichen 6) bewertet, und auch alle einzelnen Indikatoren der sensorischen Eigenschaften wurden im Vergleich zu den anderen Gruppen mit der höchsten Note bewertet (P <0,05). Der Korrelationskoeffizient (r) zeigte, dass je höher der Gehalt an intramuskulärem Fett in der Leber, desto höher die Bewertung des querschnittsaussehens (r = 0,48), des Geruchs (r = 0,24), der Textur (r = 0,28), des Geschmacks und des Aromas (r = 0,44), des Gesamteindrucks (r = 0,36) und der Durchschnittsnote (r = 0,30). Diese Daten bestätigen den positiven Einfluss des intramuskulären Fettgehalts (Marmorierung) auf die sensorischen Eigenschaften von Dalmatinska pečenica. Die untersuchten Unterschiede in der Verarbeitungstechnologie hatten einen statistisch signifikanten Einfluss auf die Parameter der chemischen Zusammensetzung und der sensorischen Eigenschaften der Dalmatinska pečenica.

Schlüsselwörter: Dalmatinska pečenica, geschützte geografische Angabe (g.g.A.), chemische Zusammensetzung, sensorisches Profil

Efecto de las diferencias tecnológicas en las propiedades químicas y sensoriales de la carne rostizada Dalmatinska pečenica

Resumen

En el proceso de registro de la indicación geográfica (IGP) de la carne rostizada Dalmatinska pečenica, se realizó una investigación con el objetivo de determinar el impacto de las diferencias tecnológicas en la composición química y propiedades sensoriales del producto final. Por lo tanto, en tres instalaciones en el área de tres condados dálmatas, se produjeron 35 carnes rostizadas Dalmatinska pečenica, divididos en 7 grupos, que se diferenciaron en el peso inicial de las materias primas, la composición y cantidad de la mezcla de salazón / salmuera y la duración de las fases tecnológicas individuales. Después del procesamiento, se tomaron muestras de carne rostizada de cada grupo y se determinó la proporción de grasa, proteína, ceniza, agua y NaCl. La evaluación del perfil sensorial de carne rostizada Dalmatinska pečenica mediante análisis sensorial descriptivo fue realizada por un panel profesional de 11 miembros. Los análisis químicos determinaron la siguiente composición química básica media de la carne rostizada Dalmatinska pečenica: 5.68% de grasa, 41.60% de proteína, 44.80% de agua y 7.63% de ceniza, y el NaCl estuvo representado por un promedio de 6.17%. Las carnes rostizadas Dalmatinska pečenica producidas de materias primas más pesadas (peso inicial ≥3.5 kg) contenían más grasa y agua intramuscular (P <0.05) y menos proteína (P <0.05). Cuanto menor sea el peso inicial de la carne rostizada Dalmatinska pečenica y mayor el consumo de salazón / salmuera por kg de carne cruda, mayor será el contenido de NaCl en la carne rostizada Dalmatinska pečenica madura, y la duración de la fase de salazón / salmuera no aumentará significativamente el contenido de NaCl en la carne rostizada Dalmatinska pečenica. El análisis sensorial determinó el perfil sensorial y las propiedades sensoriales típicas de la carne rostizada Dalmatinska pečenica, de las cuales, además de la forma y el color cilíndrico característicos, destacan la consistencia firme y elástica, la estructura compacta, la sección transversal roja uniforme, el sabor ligeramente salado, la suavidad y la solubilidad al masticar, y el aroma característico de los productos cárnicos crudos-curados con un aroma ahumado levemente pronunciado. La carne rostizada Dalmatinska pečenica, producida de materias primas más pesadas (≥3,5 kg) utilizando una mezcla de sal marina y nitrito con especias y antioxidantes, con mayor contenido de grasa intramuscular y salinidad leve, obtuvo la puntuación media más alta (5,88 sobre 6 posibles), junto con todos los indicadores individuales de propiedades sensoriales también calificados como los más altos en relación con otros grupos (P <0.05). El coeficiente de correlación (r) mostró que cuanto mayor es el contenido de grasa intramuscular en el hígado, mayor son la evaluación del aspecto transversal (r = 0,48), el olor (r = 0,24), la textura (r = 0,28), el sabor y el aroma (r = 0,44), la impresión general (r = 0,36) y la puntuación media (r = 0,30). Estos datos confirman el efecto positivo del contenido de grasa intramuscular (el veteado) sobre las propiedades sensoriales de la carne rostizada Dalmatinska pečenica. Las diferencias examinadas en la tecnología del procesamiento tuvieron un efecto estadísticamente significativo sobre los parámetros de composición química y propiedades sensoriales de la carne rostizada Dalmatinska pečenica.

Palabras claves: carne rostizada Dalmatinska pečenica, indicación geográfica protegida (IGP), composición química, perfil sensorial

Impatto delle differenze tecnologiche sulle proprietà chimiche e sensoriali della salsiccia dalmata "Dalmatinska pečenica"

Riassunto

Durante il processo della registrazione dell'indicazione geografica protetta (in croato ZOZP=IGP) della salsiccia dalmata Dalmatinska pečenica è stata condotta una ricerca al fine di determinare l'impatto delle differenze tecnologiche sulla composizione chimica e sulle proprietà sensoriali del prodotto finale. Pertanto, in tre stabilimenti nell'area di tre contee dalmate, sono stati prodotti 35 campioni di salsicce dalmate Dalmatinska pečenica, suddivisi in 7 gruppi che differivano tra di loro per il peso iniziale delle materie prime, la composizione e la quantità di miscela per la salatura (salamoia) e la durata delle singole fasi tecnologiche. Una volta finita la fase di lavorazione, da ciascun gruppo sono stati prelevati i campioni di salsicce pečenica per determinarne la proporzione di grassi, proteine, ceneri, acqua e NaCl (sale da tavola), mentre la valutazione del profilo sensoriale di Dalmatinska pečenica è stata eseguita mediante un'analisi sensoriale descrittiva da un gruppo professionale composto da 11 membri. La seguente composizione chimica di base (media) della Dalmatinska pečenica è stata determinata tramite le analisi chimiche: 5,68% di grassi, 41,60% di proteine, 44,80% di acqua e 7,63% di ceneri, mentre NaCl era presente in quantità media del 6,17%. Le salsicce pečenice prodotte da materie prime pesanti (peso iniziale ≥3,5 kg) avevano un maggiore contenuto di grasso intramuscolare e acqua (P<0,05) e un minore contenuto di proteine (P<0,05). Più basso il peso iniziale della pečenica cruda e maggiore il consumo di sale/salamoia per kg di carne cruda, maggiore era il contenuto di sale (NaCl) nella pečenica matura, mentre la durata della fase di salatura/salamoia non ha avuto un impatto significativo sul contenuto di sale (NaCl) nella pečenica. Mediante un'analisi sensoriale sono stati determinati il profilo sensoriale e le proprietà sensoriali tipiche della salsiccia Dalmatinska pečenica, di cui, oltre alla caratteristica forma cilindrica ed il colore, spicca la consistenza soda ed elastica, una struttura compatta, la sezione trasversale di color rosso uniforme, un sapore leggermente salato, carne morbida e facile da masticare con un aroma caratteristico dei prodotti a base di carne di maiale stagionato a lunga conservazione e con una nota leggermente affumicata. La salsiccia pečenica prodotta da materie prime più pesanti (≥3,5 kg) usando una miscela di sale marino e nitrito con spezie e antiossidanti, di un maggior contenuto di grasso intramuscolare e leggermente salata, è stata valutata con il voto medio ed un punteggio massimo di 5,88 (su un massimo di 6 punti attribuibili), insieme a tutti i singoli indicatori delle proprietà sensoriali, i quali sono altrettanto stati valutati con il punteggio massimo attribuibile rispetto agli altri gruppi (P <0,05). Il coefficiente di correlazione (r) ha dimostrato che il contenuto più alto di grasso intramuscolare nella salsiccia pečenica ha conseguito anche un punteggio più alto in merito all'aspetto della sezione trasversale (r= 0,48), all'odore (r= 0,24), alla consistenza (r= 0,28), al gusto ed aroma (r= 0,44), all'impressione complessiva (r= 0,36) e alla valutazione media (r= 0,30). I dati sopra indicati confermano l'effetto positivo del contenuto di grasso intramuscolare (marmorizzazione) sulle proprietà sensoriali della salsiccia dalmata Dalmatinska pečenica. Dal punto di vista statistico, le differenze esaminate nella tecnologia di lavorazione hanno avuto un impatto significativo sui parametri della composizione chimica e sulle proprietà sensoriali della salsiccia dalmata Dalmatinska pečenica.

Parole chiave: Dalmatinska pečenica, indicazione geografica protetta, composizione chimica, profilo sensoriale