ORIGINAL SCIENTIFIC PAPER

Sensory diversity of a traditional Slovenian dry-cured sausages (Suha klobasa)

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ABSTRACT

Suha klobasa is a popular dry-cured sausage that is produced practically everywhere in Slovenia. The aim of this study was to investigate the main characteristics of *Suha klobasa* produced by different manufacturers across five different informal regions of Slovenia. Products from 31 producers, as households (11), small workshops (15) or industrial plants (3) were analysed for pH value, moisture, protein, fat, and ash, as well as for their sensory parameters, according to assessments of four profiles: appearance, texture, smell and aroma. Technological production procedures were evaluated on the basis of a survey. In average Slovenian *Suha klobasa* pork is used, also *Suha klobasa* is characterized by slow ripening and smoking or without smoking but overgrown with mould. It is always filled in a small diameter casings (32-34 mm) of the pig small intestine or permeable casings, formed in two equal-length-halves and on one side (open side) looped around, often with a wooden stick. According to the regions of Slovenia, several types of *Suha klobasa* can be distinguish that are defined by sausage length and surface colour, mosaic and porousness on the one hand, and acid, smoke, mould, rancid smell/aroma on the other. *Suha klobasa* originated from different manufacturing practices differ in visual characteristics of product (size, equality and mould), in cross-section (mosaic, porousness and glassines), and texture (hardness, toughness and integrity) but not in olfactory and aroma profile.

Keywords: meat products, dry-cured sausages, Slovenia, manufacturing practices, sensory properties

Introduction

Suha klobasa (fermented salami) is one of the most original and popular Slovenian meat products. It is a family of thin, dry-cured sausages usually with two parts (two ends), typically made of pork or a mixture of pork and other meats, slow ripened (without additives for acceleration of manufacturing processes, starter cultures or glucono-delta-lactone, and preservatives) at low temperatures (12 to 16 °C), smoked or not smoked and overgrown with mould (Rules on the Quality of Meat Products and Meat preparations, 2017.). *Suha klobasa* is usually produced from 50 % to 80 % medium/coarse high quality minced pork (meat grinder plate hole, 12 mm), often also with minced beef (10-25 %) for binding, combined with 20 % to 25 % solid back fat (meat grinder plate hole, 8-10 mm).

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The meat has to be salted (kitchen salt, 1.8 %-2.2 %), the meat-fat mixture has to be seasoned with pepper (0.2-0.3 %) and garlic (dehydrated, 0.3-0.6 %), and is usually filled in pig small intestine (i.e., hog casing), rarely also permeable natural or artificial casings of small diameter (32-34 mm). A length of casing is stuffed with the mixture to reach the weight of 200 g to 250 g; two 8 to 20 cm-long halves are formed and on one side (open side) the hog casings between them is looped around, often a wooden stick (špila) (Fig. 1a,b). These halves are then hung for the cold smoking process (temperature is around 25 °C) with beech wood chips, until they turn a red-brown colour. After the smoking process, the raw sausage is dried and matured for approximately 1 month.
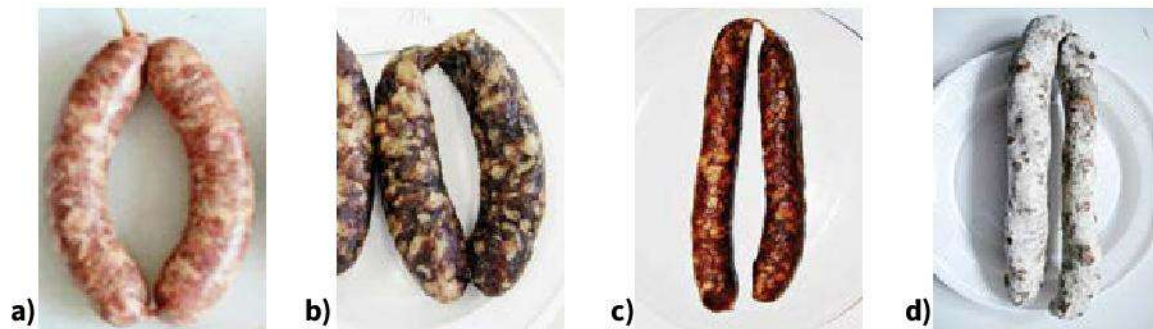
Figure 1 *Suha klobasa* before smoking (a), with a wooden stick (a,b), smoked and without a wooden stick (c), overgrown with mould and without a wooden stick (d)

The production of *Suha klobasa* has historically been closely linked to the slaughtering of pigs on farms and processing them into products, this day has been named *koline*. Nowadays, these products are not produced only in winter; they are made throughout the whole year in industrial plants and small workshops. As a result, recipes originated from traditional household production were adapted to industrial technology. Recipes for home-made *Suha klobasa* vary, with large differences between regions, sometimes even between households (Renčelj, 2008.).

In production of *Suha klobasa* are pepper and garlic usually used. In addition, in Istria rosemary, marjoram, laurel, nutmeg, cloves and cumin are also used and ground red pepper in Pomurje. Methods for the garlic preparation are interesting and vary. For example, in Primorska, the peeled garlic branches are first cooked, manually ground in lukewarm water and evenly poured through a strainer onto the prepared sausage stuffing. In some regions, garlic is cooked in white wine (Vipava valley). It is a widespread habit to soak crushed garlic in white wine or water and then squeezed in a cloth so garlic juice is squeezed onto the sausage stuffing. Some also squeeze crushed garlic pods in the cloth without soaking (Renčelj, 2008.).

The main aim of this study was to determine the sensory profile of *Suha klobasa* prepared by different manufacturers from different regions of Slovenia. Such definition of the sensory characteristics is the first step towards the recognition of this nowadays relatively little-known product. In addition, a short comparison of technological production procedures on the basis of survey and interview was carried out.

Material and methods
Samples
The samples of *Suha klobasa* were collected from 31 producers, as households (11), small workshops (15) or industrial plants (3). These producers were from four regions in Slovenia; Dolenjska (5 producers), Gorenjska, including the capital Ljubljana (7), Primorska (9), Stajerska (7) and Pomurje (3). A total of three samples were randomly selected from each producer, transported to the laboratory in refrigerated boxes at 4 °C, and then used for the sensory analysis. Manufacturers received a survey of *Suha klobasa* production technology either personally or in advance by mail.

Sensory analysis
To evaluate the sensory qualities, a panel of four qualified and experienced panellists in the field of meat products was appointed. The analytical-de-

scriptive test (Golob et al., 2005) was performed by scoring the sensory attributes according to a non-structured scale from 1 to 7 points, where a higher score indicated greater expression of a given property. Exceptions here were for the sausage size, proportion of fat and saltiness, which were evaluated by scoring on a structured scale of 1 to 4 to 7 (1-4-7). Here, a score of 4 points was considered optimal, with scores of 4.5 or more indicated greater (to excess) expression of a property (too big, too much fat, or too salty), and those of 3.5 or less indicated insufficient expression of a property (too small, too little fat, or not salty enough). The sensory profile of the *Suha klobasa* consisted of 30 descriptors that were grouped into four blocks. The first block related to the visual attributes of sausage, such as size, equality of length, surface wrinkleless, surface colour and surface mouldiness, as well as attributes of cross section, such as mosaic, colour of meat particles, proportion of fat, glassines of fat particles and porousness. The second block related to the texture, including crispness of the fattiness, hardness, integrity of slice and toughness. The third block related to the olfactory attributes, like acid, smoke, mould, rancid, frowst and harmony in the smell. The last block related to the evaluation of the flavour attributes, such as saltiness, acid, rancid, bitter, smoke, mould, and odd aroma, and the intensity and harmony of the aroma.

For the sensory evaluation, the samples were cut as 2-mm-thick and 2-cm-thick (longitudinal section of the product) slices for the panellists to evaluate. To neutralise the taste, the panel used the central dough of white bread.

Physicochemical analysis

Eight optimal samples of *Suha klobasa* (different producers) were selected from all analysed samples according to the results of sensory analysis and were used for the physicochemical analysis. The water content of *Suha klobasa* was determined according to AOAC 950.46 (Official Methods of Analysis, 1997.), the total protein content (crude protein, $N \times 6.25$) was determined by the Kjeldahl method (according to AOAC 928.08; Official Methods of Analysis, 1997), and the ash content was determined according to AOAC 920.153 (Official Methods of Analysis, 1997.). The fat content was determined by the method described as AOAC Official Method 991.36. Fat (crude) in Meat and Meat Products (Official Methods of Analysis, 1997). Data from the

chemical analyses were expressed on a wet matter basis. The pH values were measured in water extract using a combined glass-gel spear electrode (type 03, Testo pH electrode) with a thermometer (type T, Testo penetration temperature probe) connected to a pH meter (Testo 230, Testo).

Data analysis

The differences according to the regions and manufacturing practices of the samples were analysed through a general linear model (GLM) procedure and least squares mean (LSM) test (SAS/STAT), with a 0.05 level of significance. Multivariate analysis included factor analysis and linear discriminant analysis (LDA). Statistical analysis was performed using SPSS version 15.0 for Windows, as the evaluation version (SPSS Inc., Chicago, IL, USA).

Results and discussion

Technological production procedures evaluated on the basis of survey

The survey was made with the help of a questionnaire that was sent by mail or delivered in personally by visiting household, workshop or plant. Shortly, this questionnaire addressed raw material (pork type, slaughter age, fat quantity, etc.), ingredients (sugar, salt, pepper, garlic, etc.), additives (starter cultures, KNO_3, etc.), processing technologies (fermentation, drying, ripening etc.) and is summarized as follows in Table 1.

Study articles on similar traditional dry sausages/salami from other European countries were made, there are a few comparisons regarding the production technology and sensory quality (Casaburi et al., 2006.; Rason et al., 2007.; Braghieri et al., 2016; Alamprese et al., 2016.; Cenci-Goga et al., 2018).

Italian salami production consists of the following steps: grinding and mixing of pork (shoulders, flank (70 %), in some cases belly and trimmings of ham, hind fat (20–30 %) and all ingredients (salt 18–30 g/kg, sucrose, dextrose 10 g/kg, spices (pepper 5 g/kg, garlic 2 g/kg, ground sweet red pepper and wild fennel seeds, red vine), sodium ascorbate, natural aromas, sometimes (often in industrial plants) potassium nitrate and sodium nitrite), stuffing in natural casings or artificial casings (36–42 mm of diameter), fermentation/drying for

Table 1 Manufacturing characteristics of *Suha klobasa* according to survey

Raw material	The answer or comment
Pork breed	Pietrain, Krškopolje pig (autochthonous breed), Landrace × Large White × Duroc
Live weight of animal	From 120 kg to 250 kg, on average 130 kg; heavy pork used only in households and small workshops
Beef	Yes, usually frozen
Fat/lean separated	Yes
Fat	Hind fat, in some cases belly and trimmings of ham
Temperature of raw material	4 °C to 10 °C, in industrial plants -10 °C to 2 °C
Proportion of fat and meat in the batter	1:4
Proportion of pork and beef	9:1
Ingredients	
Salt	1.8-2.2 %
Nitrite salt (salt + $NaNO_2$)	Rarely
Pepper	0.2-0.3 %
Garlic, dehydrated	0.3-0.6 %
Other spices	Nutmeg, cumin, rosemary, marjoram, laurel, cloves, ground red peppers, pimento, also vine and spirits (rum, cognac…)
Sugar	Yes
Na ascorbate	Rarely
Starter culture	Not used in households and workshops, used in industrial plants
Manufacturing process	
Mincing/cutter	Mincing, cutter in one industrial plant
Mincing/diameter of plates	Pork 8-26 mm, beef 3-4 mm and fat 8-10 mm or by hand with a knife
Mixing/temperature of batter	From 6 °C to 12 °C; in industrial plants from -1 °C to 4 °C
Filling	Fill exclusively in pig small intestine (i.e., hog casing), rarely also permeable natural or artificial casings of small diameter (32-34 mm); manual filler or machine (vacuum option)
Size and mass of pair	From 8 cm to 20 cm, usually about 15 cm; weight from 200 g to 400 g, on average about 250 g.
Formation/ wooden stick	Two equal long halves were formed and on one the open side the casing between them is looped around with a wooden stick
Surface drying	24 h/ around 12 °C
Smoking	Yes, except in Primorska region (mould on the surface)
Smoke	Cold smoking (20-25 °C) with beech wood chips, until surface turn a red-brown colour; open firing, smoker generator (chips) and friction generator (log of beech wood)
Dryer type	Natural climate; drying/ripening chambers allow setting and controlling parameters (temperature, humidity, air circulation)
Drying temperature and relative humidity	A temperature of 8 °C to 18 °C, a relative humidity of 90 % to 70 %
Drying length	Approximately 30 days
Storing and packing	Vacuum packaging technology or bulk; storing temperature from 4 °C to 8 °C

two to seven days (at 15–20 °C and 65–88 % relative humidity) and ripening for fifteen days to one month (at 10–18 °C and 75–-85 % relative humidity). Smoke is not applied (Casaburi et al., 2006; Braghieri et al., 2016.; Alamprese et al., 2016; Cenci-Goga et al., 2018.).

The manufacturing characteristics of the traditional French dry sausages investigated by Rason et al. (2007.) are as follows: use of pork (heavy pork, porker and sow), pork fat (8–20 %) or without additional pork fat, use of salt (22–30 g/kg), pepper (1–2 %),vine (without or 5–50 g/kg), sugar (without or 3–8 g/kg), garlic (without or 2–4 g/kg) and very rarely KNO3 (0.2 g/kg), as well as regarding manufacturing process: use of mincing or cutter, without starter

culture, dripping (6-96 h/11–13 °C), no fermentation period or short period (16–20 °C/1–5 days), drying in natural or conditioned dryer at 10–13 °C and 80–82% relative humidity for 5 to 12 weeks.

The traditional types of Spanish dry fermented sausages are `salchichón', `chorizo' and `fuet' (Edwards et al., 1999.). `Salchichón' is a product manufactured from a mixture of chopped pork and/or beef, lard, curing agents (salt, nitrate, nitrite, sugar and ascorbates) and spices (whole or ground black pepper). The product, after mixing and casing, is subjected to fermentation (20–24 °C, 48 h, relative humidity 90–95 %) and ripening (12–15 °C) for about 1 to 8 months. This product has a minimum diameter of 20 mm although usually its diameter is greater than 30 mm. `Salchichón' is characterized by attributes, such as for appearance luminance, presence of crust, fat/lean connection and exudate, for odour black pepper, lactic acid, mould and other spices, for texture hardness and initial juiciness, and for flavour black pepper aroma, mould aroma, other spices aroma, acid taste and salty taste (Ruiz Pérez-Cacho et al., 2005.).`Fuet' is a similar product as `salchichón', with a diameter between 20 and 40 mm but it is fermented and ripened at 14–15 °C and 80–85 % relative humidity for a total time of 15–20 days. `Chorizo' has a similar composition and diameter to `salchichón'; the major differences are the replacement of black pepper with garlic and paprika. The ripening period may vary from about 15 days to several months (Edwards et al., 1999.). Industrial standardization of fermented meat products requires starter culture, e.g. Asturian Chorizo microbiota is represented mainly by *Lactobacillus plantarum*, with secondary contributions from *L. sakei* and *L. futsai* (Prado et al., 2019.).

Basic chemical composition of *Suha klobasa*

On average, *Suha klobasa* collected in these survey contained water at 29.42 ±4.6 g/100 g, protein at 32.61 ±4.4 g/100 g, fat at 31.75 ±6.3 g/100 g, and ash at 5.70 ±0.6 g/100 g. These data are not precisely in agreement with those of Golob et al. (2006), who reported for *Zimska salama* lower protein (26.0 g/100 g), water (24.5 g/100 g) and ash content (5.56 g/100 g) and higher fat content (44.9 g/100 g). When compare products in this study with those for Italian, Spain and Greek sausages, data are not precisely in agreement again. Italian ripened/fermented sausages (Demeyer et al., 2000.; Moretti et al., 2004.) contained water at 23-34 g/100 g, protein at 22-40

g/100 g, and fat at 26-32 g/100 g, meanwhile Spain dry fermented sausages (Hoz et al., 2004) contained protein at 24.26 g/100 g, and fat at 32.96-38.61 g/100 g, and traditional Greek sausages (Papadima and Bloukas, 1999) protein at 28 g/100 g, and fat at 29.86 g/100 g.

The pH values of all of these *Suha klobasa* analysed here were also relatively high (5.90 ±0.50), with some values around 7 (interval, 5.33-6.92). The final pH value of the Italian dry sausages was 6.18, our products have a slightly lower (5.90) values (Casaburi et al., 2006.).

Sensory analysis of *Suha klobasa according to region and manufacturing practice*

Table 2 shows the data for sensory analysis of the *Suha klobasa*, with the basic statistical parameters calculated according to the regions, manufacturing practices and as means across the regions/practices. The sensory profile of *Suha klobasa* can be divided into the assessment of four profiles: appearance, texture, smell, and flavour. On average, these *Suha klobasa* were slightly bigger than desirable (4.3), ends/parts were not equal length (5.9), surface was noticeably wrinkled (2.5), almost optimal colour of the surface (4.1), slight surface mouldiness (1.3; one of 31 samples was covered with mould), relatively uneven mosaic (5.1), but with optimal proportion of fat (4.3), noticeable glassines of fat particles (1.8) and porousness (1.4), as well as a little too bright colour of meat particles (5.3). The texture consisted of four properties, as fatness (2.5, to greasy), integrity of slice (5.1, the slices were falling apart), hardness (4.6, a markedly soft texture) and toughness (3.2, noticeable connective tissue and cartilage), all of which were not rated as optimal. In the profile of the olfactory attributes, besides the characteristic smells (such as smoke or mould), smell of frowst and acid was also detected. The relatively frequent occurrence of these odd smells affected the low average rating of the smell harmony (5.0). The relatively intense general aroma of the *Suha klobasa* (5.0) was dominated by distinctive aroma of smoke (2.6), with the rare detection of aroma of acid (1.8), rancid (1.3), bitter (1.9), mould (1.2) and undefined aromas (odd, 1.6). On average, the saltiness of the *Suha klobasa* was appropriate (4.0).

Statistical analysis of data on sensory profile was performed to classify samples of *Suha klobasa* according to production region. As the

most discriminating variables were selected visual attributes, such as equality of sausage length and surface colour of sausage, attributes related to the texture, such as mosaic and porousness, the olfactory

Table 2 A total of 28 sensory attributes of the *Suha klobasa* according to different Slovenian regions and manufacturing practices

Attribute	Value of property according to geographical region						Value of property according to manufacturing practice					Grand mean value
	I (n = 5)	II (n = 7)	III (n = 9)	IV (n = 7)	V (n = 3)	PR	H (n = 11)	SW (n =17)	P (n = 3)	Pp	SEM	
Appearance of sausage												
Sausage size (1-4-7)	4.0	4.2	4.3	4.2	4.6	Ns	4.1^B	4.4^A	4.3^A	*	0.6	4.3
Equality of sausage length (1-7)	5.6^c	6.0^{ab}	5.8^{bc}	5.9^{abc}	6.3^a	*	5.7^B	5.9^{AB}	6.3^A	*	0.7	5.9
Surface wrinkleless (1-7)	2.5	2.7	2.3	2.8	2.3	Ns	2.3	2.7	2.3	Ns	1.0	2.5
Surface colour of sausage (1-4-7)	4.2b	3.8b	3.8b	4.9a	3.8b	***	4.1	4.2	3.8	Ns	0.9	4.1
Surface mouldiness (1-7)	1.4	1.3	1.6	1.2	1.1	Ns	1.0^B	1.6^A	1.0^B	**	0.9	1.3
Cross-section												
Mosaic (1-7)	4.9^b	5.0^b	5.1^b	5.5^a	5.3^{ab}	**	4.9^B	5.2^B	5.8^A	**	0.7	5.1
Colour of meat particles (1-7)	4.6^c	5.1^b	5.5^{ab}	5.7^a	5.5^{ab}	***	5.2^B	5.2^B	6.0^A	*	0.9	5.3
Proportion of fat (1-4-7)	4.4	4.2	4.4	4.1	4.5	Ns	4.3	4.3	4.4	Ns	0.6	4.3
Glassines of fat particles (1-7)	1.8	1.9	1.6	1.7	1.8	Ns	1.6^B	1.9^A	1.5^B	*	0.7	1.8
Porousness (1-7)	1.4^{ab}	1.3^{ab}	1.7^a	1.3^b	1.2^b	*	1.6^A	1.3^B	1.1^B	**	0.5	1.4
Texture												
Fattiness (1-7)	2.2^{bc}	2.0^c	3.0^a	2.4^{abc}	2.9^{ab}	**	2.8^A	2.3^B	2.4^B	*	1.1	2.5
Hardness (1-7)	5.0^a	4.3^b	3.9^b	5.2^a	5.0^a	***	4.1^B	4.8^A	4.6^{AB}	***	0.9	4.6
Integrity of slice (1-7)	5.4^b	5.1^b	3.8^c	5.9^a	6.0^a	***	4.2^B	5.5^A	5.4^A	***	1.0	5.1
Toughness (1-7)	3.3^{ab}	2.8^b	2.8^b	3.8^a	3.9^a	***	2.7^B	3.5^A	3.1^{AB}	**	1.1	3.2
Smell												
Acid (1-7)	1.8^b	1.7^{bc}	1.4^c	1.6^{bc}	2.2^a	***	1.6	1.7	1.7	Ns	0.6	1.7
Smoke (1-7)	3.4^{ab}	2.6^{cd}	2.0^d	2.8^{bc}	3.5^a	***	2.8	2.8	2.3	Ns	1.2	2.7
Mould (1-7)	1.2^{ab}	1.0^b	1.3^{ab}	1.1^b	1.4^a	*	1.2	1.1	1.4	Ns	0.4	1.2
Rancid (1-7)	1.4^a	1.1^b	1.1^b	1.1^b	1.4^a	*	1.3	1.1	1.1	Ns	0.5	1.2
Frowst (1-7)	1.7	1.4	1.5	1.5	2.0	Ns	1.5	1.5	1.9	Ns	0.9	1.6
Harmony (1-7)	4.4^c	5.1^{ab}	5.0^{ab}	5.3^a	4.8^b	***	4.9	5.0	5.0	Ns	0.6	5.0
Aroma												
Saltiness (1-4-7)	4.1	4.1	4.0	4.1	4.0	Ns	3.9^B	4.1^{AB}	4.2^A	**	0.4	4.0
Acid (1-7)	2.0^a	2.1^a	1.5^b	1.7^{ab}	2.1^a	**	1.7	1.9	1.9	Ns	0.6	1.8
Rancid (1-7)	1.7^a	1.2^b	1.1^b	1.1^b	1.4^{ab}	*	1.4	1.2	1.1	Ns	0.7	1.3
Bitter (1-7)	2.0^b	1.7^b	1.8^b	1.6^b	2.7^a	**	1.9	1.8	1.9	Ns	0.8	1.9
Smoke (1-7)	3.2^{ab}	2.6^{bc}	2.0^c	2.6^{bc}	3.5^a	***	2.5	2.7	2.7	Ns	1.1	2.6
Mould (1-7)	1.1^b	1.2^b	1.4^{ab}	1.1^b	1.6^a	*	1.2^B	1.2^B	1.7^A	*	0.6	1.2
Odd (1-7)	1.7^b	1.5^b	1.8^b	1.3^b	2.3^a	**	1.8^{BA}	1.5^B	2.1^A	*	0.8	1.6
Harmony (1-7)	4.7^b	5.0^{ab}	5.1^a	5.4^a	4.7^b	**	4.9	5.1	5.0	Ns	0.7	5.0

PR, *statistical probability of region effect.* PP, *statistical probability of manufacturing practice effect.* *** P ≤0.001 *statistically very highly significant;* ** P ≤0.01 *statistically highly significant;* * P ≤0.05 *statistically significant;* Ns – P >0.05 *statistically not significant.* SEM, *standard error of mean. Data with different superscript letters within a row differ significantly (least-squares means; P <0.05, a-d differences between regions; A-C differences between manufactures practices). Region I: Dolenjska, region II: Gorenjska, region III: Primorska, region IV: Štajerska, region V: Pomurje. Manufacturing practice: H: households, P: industrial plants, SW: small workshops.*

attributes, like acid, smoke, mould, rancid and harmony of smell, and the aroma attributes, such as acid, rancid, bitter, smoke, mould, odd aroma and harmony of aroma. Samples from Dolenjska stood out in the equality of sausage length parameter, the size of the sausage ends were very uneven (5.6), and samples from Štajerska were significantly darker in colour on the surface (4.9) than samples from other regions. As cross-section, the samples from Štajerska and Pomurje stood out again; as compared to the samples from the other regions they had a more distinct mosaic (5.3-5.5), consequently due to smaller number of pores on the slice (1.2-1.3), more reddish (vivid) colour of the meat particles (5.5-5.7). In attributes related to the texture, samples from Štajerska and Pomurje differed from others regions, their texture emphasizes noticeable grease (2.4-2.9), and hardness (5.0-5.2) as well as toughness (3.8-3.9) and consequently stronger integrity of slice (5.9-6.0). Samples from Pomurje stood out in the profile of smell, strongly noticeable acid, smoke, mould and rancid smell; the relatively frequent occurrence of these smells affected the low average rating of the smell harmony (4.8). The average aroma of samples from Pomurje and Dolenjska relatively often showed the aroma of acid, rancid, bitter, mould and odd, so the harmony of aroma was evaluated as relatively weak (4.7). On average, the saltiness of the *Suha klobasa* was appropriate. Based on the results, we can summarize that *Suha klobasa* from Primorska, Štajerska and Gorenjska were the most sensory acceptable and samples from Dolenjska and Pomurje were less acceptable.

Despite modest equipment and technology available, there were no differences in the smell and aroma profile of *Suha klobasa* originated from households compared to those from small workshops and industry plants. *Suha klobasa* from households was described as being similar to an average Slovenian *Suha klobasa*, with a distinctive less salty aroma and some odd aromas detected (e.g., paprika, stable manure, milk, among others). The optimal sausage size and an uneven equality of length and mould free surface were the main visual characteristics of the *Suha klobasa* from households, on the basis of which the samples differed from samples of workshops and plants. Those products had also unevenly distributed fat and meat (4.9), relatively poor colour of meat particles (5.2), noticeable porousness and glassiness of fat particles (1.6). *Suha klobasa* from households were

markedly greasy (2.8), with a soft texture (4.1), with rapid split while chewing a slice in the mouth (4.2) and a small amount of collagen detected during bite (2.7), compared to other production practices.

On the basis of survey it can be said that technological production procedures of small workshops and industrial plants are, as expected, more precisely monitored physicochemical parameters (temperature during all phases of production, pH value of raw material, ventilation and humidity) and use more additives (reducing sugars, sodium ascorbate and antioxidants) than individual manufacturers in households.

Multivariate analysis

The structure of product quality parameters was checked by factor analysis. Before performing the factor analysis, a Bartlett test (hi-square = 1635.258, DF = 378, P <0.001) was conducted and the Kaiser-Meyer-Olkin sampling coefficient was calculated (0.684) to show thatthe factor analysis was justified and sample suitable for further processing. The communalities of 28 sensory attributes, indicating the amount of variance that a given variable shares with the extracted factors, have been tested and should not be less than 0.50. Therefore, four attributes (equality of length, surface wrinkleless, saltiness and bitter aroma) were eliminated from further processing.

With factor analysis, among the rest of the product attributes were chosen those that carry the largest share of all information. The first seven factors explain 72 % of the total variability, factor 1 (124 determinations, 24 properties) explains 20 %, factor 2 16 %, factor 3 9%, factor 4 9 %, factor 5 7 %, factor 6 6 % and factor 7 account for 5 % of the total variability, while the other factors together account for 28 % of the total variability. In the table 3 factor weights are presented; the size of the weights indicates the importance of each attribute in the factor. The greater was the weight, the more important was the attribute for the factor.

The first factor was called defects in aroma, as it mainly projects descriptors related to aroma such as smell stuffy, odd aroma, mould aroma and smell mould on the one and harmony of smell and aroma on the other side. Smell of frowst (r = 0.839) and odd aroma (r = 0.833) gave the greatest weight to this factor. The second factor was called smoke and acidity because it mainly projects smoke and acid descriptors. Similar weight were given to the

Table 3 Structure of the sensory attributes of *Suha klobasa* evaluated by factor analysis

Factor	Component (r, coefficient of correlation)						
	1	2	3	4	5	6	7
1. Factor *Defects in aroma*							
Smell of frowst	0.839						
Odd aroma	0.833						
Aroma of mould	0.600					0.306	
Smell of mould	0.573					0.384	
Harmony of aroma	-0.553	-0.334			0.384		
2. Factor *Smoke and acidity*							
Smell of acid		0.794					
Smell of smoke		0.745					
Aroma of smoke		0.732					
Aroma of acid		0.698					
3. Factor *Texture*							
Toughness			0.830				
Hardness			0.771				
Surface colour of sausage			0.658				
Integrity of slice		0.371	0.620				
4. Factor *Rancidity*							
Rancid aroma				0.950			
Rancid smell				0.922			
5. Factor *Cross-section of slice*							
Mosaic					0.829		
Porousness					-0.654		
Colour of meat particles				-0.589	0.625		
Harmony of smell	-0.499	-0.328			0.520		
6. Factor *Appearance of sausage*							
Surface mouldiness						0.782	
Sausage size						0.764	
7. Factor *Fat particles*							
Proportion of fat							0.791
Fatness							0.620
Glassines of fat particles	0.332		0.320		-0.393		0.523

smoke and acid smell/ aroma (r = 0.794-0.698). The third factor was texture, the fourth factor rancidity, cross-section of slice determined the fifth factor, attributes of appearance of sausage determined the sixth factor, and attributes of fat particles determined the seventh factor.

Linear discriminant analysis (LDA) was performed to classify regions of *Suha klobasa* production on the basis of the sensory profile of their *Suha klobasa*. Together 24 descriptors grouped in the six blocks were included in the analysis. Using LDA, the following parameters were selected as the most discriminating variables: visual attributes, such as colour of meat particles and glassiness of fat particles, attributes related to the texture, such as toughness, the olfactory and the aroma attributes, like smoke, mould, frowst and rancid, rest of attributes were less important. When the LDA was applied to the data (31 samples, 24 variables), four discriminant functions were obtained. Function 1 explains 49 %, function 2 explains 29 %, function 3 explains 15 %, and function 4 explains 7 % of the total variance. The scores of the samples and parameters for first two functions were plotted in Figure 2. As it can be seen, the *Suha klobasa* samples originated from different regions are well separated from each
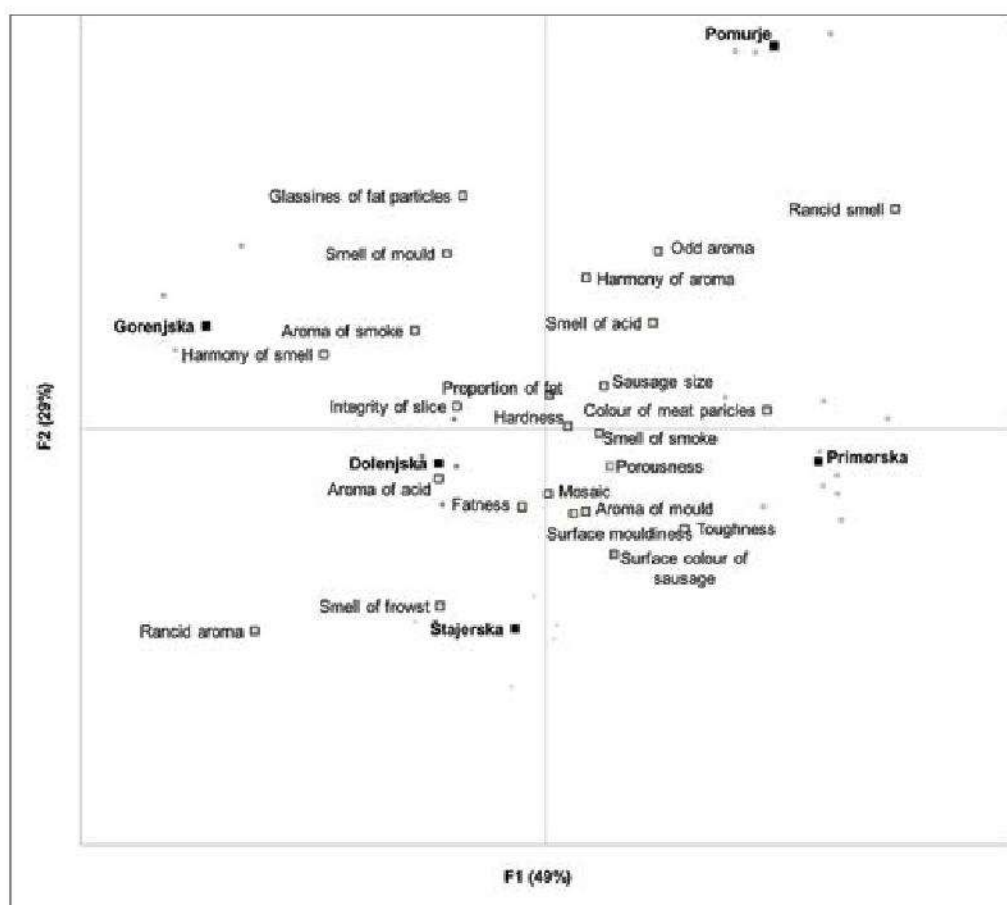
other. Overall, the accuracy of the placement of each sample into its corresponding region was 100 %.

A group of variables included in function 1 was clearly distinguished, far from the origin. This group included surface, smell of rancid and acid, odd aromas, colour of meat particles and toughness. These variables are correlated and negatively correlated with rancid, smoke, acid and harmony of aroma, smell of mould and smell of frowst as well as integrity of slice, which lie near function 1 on the opposite side. Function 2 essentially grouped the variables, with glassiness of fat particles, rancid, mould and acid smell, odd aroma and harmony of aroma placed farthest from the origin; on the opposite side of function 2 there were rancid and mould aroma, smell of frowst, colour of surface, mould cover and fatness.

Samples from Gorenjska lay on the left upper side of the graph (Figure 2), where the variables glassines of fat particles, smell of mould, aroma of smoke, as well as harmony of smell lay. Samples from Dolenjska and Štajerska were on the left lower side of the graph, where the variables

rancid aroma, smell of frowst, aroma of acid and fatness lay. Samples from Primorska lay on the right lower side of the graph, where surface colour and mouldiness of sausage, toughness, aroma of mould and porousness were grouped. In contrast, all of the samples from Pomurje lay on the upper right side of the graph, where the rancid and acid smell, odd/harmony of aroma as well as sausage size and colour of meat particles were grouped.

LDA was also performed to classify manufacturing production practices of *Suha klobasa* on the basis of the sensory profile. The following parameters were selected as the most discriminating variables from this manner: visual attributes, such as surface mouldiness and colour of meat particles, attributes related to the texture, such as hardness, toughness and integrity of slice, the olfactory attributes, like rancid, acid, mould and frowsty, and the aroma attributes, such as rancid, smoke, mould and harmony, rest of attributes were less important. When the LDA was applied to the data, two discriminant functions were obtained. Function 1 explains 94% and function 2 explains
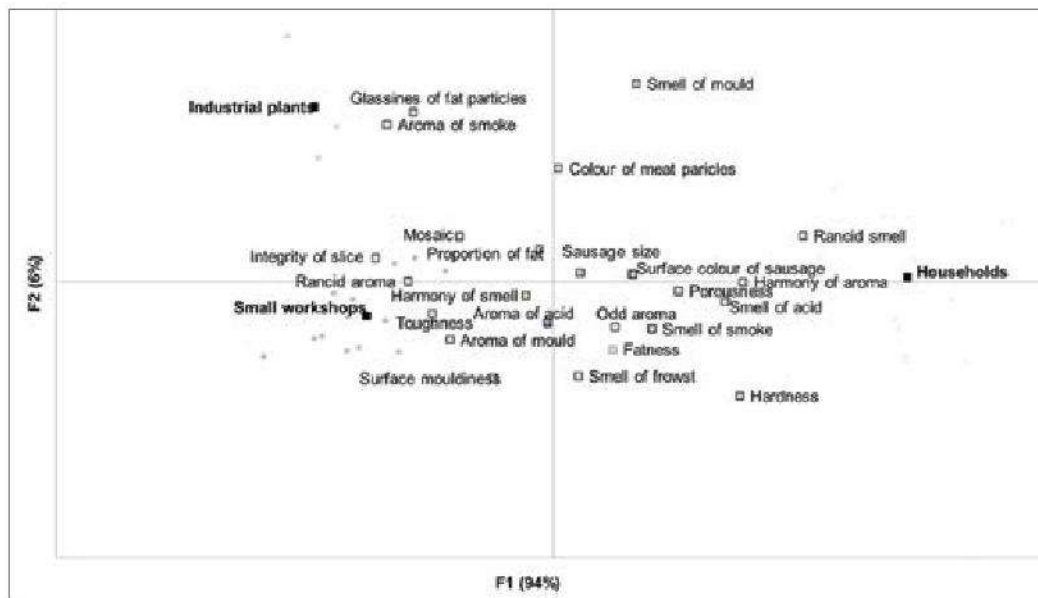

Figure 2 LDA using scores for attributes for the 31 Slovenian *Suha klobasa* samples originating from geographical region type (▪ Dolenjska, ▪ Gorenjska, ▪ Primorska, ▪ Štajerska, ▪ Pomurje, ▪ type centroid)

6% of the total variance. The scores of the samples and parameters for first two functions are plotted in Figure 3. As it can be seen, the *Suha klobasa* samples made according different manufacturing practices are well separated from each other. Overall, the accuracy of the placement of each sample into its corresponding practise was 100 %.

A group of variables included in function 1 was clearly distinguished, far from the origin. This group included smell of rancid and acid, harmony of aroma, hardness and porousness. These variables are correlated and negatively correlated with integrity of slice, smoke, rancid and mould aroma, as well as toughness, which lie near function 1 on the opposite side. Function 2 essentially grouped the variable smell of mould, glassines of fat particles, aroma of smoke and colour of meat particles placed farthest from the origin; on the opposite side of function 2 there were mould cover and smell of frowsy.

Figure 3 shows three separate groups of points. All of the household samples were on the right side of the graph, where lay the smell of rancid,

Figure 3 LDA using scores for attributes for the 31 Slovenian *Suha klobasa* samples originating from manufacturing practice type(• small workshop, • industrial plant, • household, ▪ type centroid)

acid and harmony, hardness and porousness. In contrast, most of the samples from small workshops lay on the left side of the graph, where lay the integrity of slice, rancid aroma, toughness, mosaic, aroma of mould and acid as well as surface mouldiness. The third group were samples from industrial plants, which lay on the upper left side of graph where the aroma of smoke and glassines of fat particles were grouped.

Conclusions

Dry-cured or dry fermented sausages are the traditional and one of the most popular European meat products. However, Slovenian *Suha klobasa*, one of the products from wide group of dry-cured sausages comprise from different raw material in wide range of proportions, additives, spices and manufacturing practices which differentiate it from other meat products. This is reason why individual product is heavily designated by consumers. For the sensory attributes, the marked smell/aroma smoke/mould is what characterise Slovenian *Suha klobasa*. We can conclude that although sausages from different regions differ in the estimated sensory profiles, differences between the regions are less pronounced than expected. Most of the sensorial parameters have relatively high variability, which makes it difficult to provide a designation of a unique product. One advantage in designation of this product on market is their appearance, typical thin two parts (two ends) looped around a wooden stick. Other characteristics are hidden from the eyes. *Suha klobasa* is usually made of pork or a mixture of pork and beef, around one month slow ripened at low temperature (12 to 16 °C), usually smoked or in case, when it is not smoked, casing is overgrown with mould.

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Senzorska različitost tradicionalnih slovenskih trajnih kobasica (suha klobasa)

Sažetak

Suha klobasa je popularna trajna kobasica koja se proizvodi gotovo svuda u Sloveniji. Cilj ovog rada bio je istražiti glavne značajke suhe klobase različitih proizvođača iz pet neslužbenih regija Slovenije. Proizvodi 31 proizvođača, odnosno domaćinstva (11), manjih gospodarstva (15) i industrijskih postrojenja (3), analizirani su na pH, vlagu, bjelančevine, masti i pepeo te senzorska svojstva, prema procjenama četiri značajke: izgled, tekstura, miris i aroma. Tehnološki proizvodni postupci ocjenjivani su na temelju ankete. Za suhu klobasu najčešće se upotrebljava svinjetina, a obilježavaju je sporo zrenje i dimljenje ili uporaba plemenitih plijesni bez dimljenja. Uvijek se puni u ovitke od svinjskog tankog crijeva ili propusne ovitke malog promjera (32-34 mm), a oblikuje se u dvije polovice jednake duljine koje su na jednoj strani (otvorena strana) presavijene, najčešće uporabom drvenog štapa. Ovisno o regiji Slovenije, možemo razlikovati nekoliko vrsta suhe klobase koje su, s jedne strane, određene duljinom kobasice i bojom površine, mozaikom i poroznošću te, s druge strane, kiselošću, dimom, plijesni i neugodnim mirisom/aromom. Iako se suhe klobase koje potječu iz različitih proizvodnih praksi razlikuju po vizualnim

značajkama proizvoda (veličina, ujednačenost oblika i prisustvo plijesni), presjeku (mozaik, poroznost i sjaj) i teksturi (tvrdoća, žilavost i cjelovitost), njihovi se olfaktorni i aromatični profili ne razlikuju.

Ključne riječi: mesni proizvodi, trajne kobasice, Slovenija, proizvodne prakse, senzorska svojstva

Sensorische Unterschiede zwischen traditionellen slowenischen Dauerwürsten (Trockenwurst - suha klobasa)

Zusammenfassung

Die Trockenwurst ist eine bekannte Dauerwurst, die fast überall in Slowenien hergestellt wird. In dieser Arbeit wurden die wichtigsten Eigenschaften der Trockenwurst von diversen Herstellern aus fünf nicht offiziellen Regionen Sloweniens untersucht. Die Produkte von 31 Herstellern, bzw. landwirtschaftlichen Haushalten (11), kleineren Bauernhöfen (15) und Industrieanlagen (3) wurden in Bezug auf den pH-Wert, die Feuchtigkeit, den Eiweiß-, Fett- und Ascheanteil sowie sensoriche Eigenschaften anhand einer Bewertung von 4 Merkmalen untersucht: Aussehen, Textur, Geruch und Aroma. Die technologischen Herstellungsverfahren wurden anhand einer Umfrage bewertet. Für die Herstellung der Trockenwurst wird am häufigsten Schweinefleisch verwendet. Das Herstellungsverfahren kennzeichnen eine langsame Reifung und Trocknung sowie der Einsatz von Edelschimmel ohne Räucherung. Sie wird immer in ein dünnes Schweinedarm oder durchlässige Därme mit einem geringen Durchmesser (32-34 mm) abgefüllt. Sie wird in zwei gleich lange Hälften geformt, die an einer Seite (der offenen Seite) gefaltet werden, meistens durch Einsatz eines Holzstocks. Abhängig von der Region Sloweniens können wir mehrere Sorten der Trockenwurst unterscheiden, die auf der einen Seite durch die Länge der Wurst und die Farbe der Oberfläche, das Mosaik und die Porosität bestimmt werden und auf der anderen Seite durch den Säuregrad, Rauch, Schimmel und unangenehmen Geruch/Aroma. Obwohl die Trockenwürste, die aus unterschiedlichen Herstellungspraxen stammen, nach ihren visuellen Eigenschaften (Größe, ausgewogene Form und Anwesenheit von Schimmel), dem Durchmesser (Mosaik, Porosität und Glanz) und der Textur (Härte, Zähigkeit und Kompaktheit) unterschieden werden, gibt es zwischen ihren olfaktorischen und aromatischen Profilen keine Unterschiede.

Schlüsselwörter: Fleischprodukte, Dauerwürste, Slowenien, Herstellungspraktiken, sensorische Eigenschaften

Diferencias en las características sensoriales de los salchichones tradicionales eslovenos (suha klobasa)

Resumen

El salchichón es el embutido curado popular producido casi en todas partes de Eslovenia. El fin de este trabajo fue investigar las características principales del salchichón suha klobasa de diferentes productores de cinco regiones no oficiales de Eslovenia. En los productos de 31 productores, es decir de hogares (11), granjas pequeñas (15) y plantas industriales (3), fueron analizados los pH, la humedad, las proteínas, la grasa, las cenizas y las características sensoriales, según las evaluaciones de cuatro características: la apariencia, la textura, el olor y el aroma. Los procesos tecnológicos de producción fueron evaluados a base de la encuesta. Para el salchichón suha klobasa se usa más a menudo la carne de cerdo, caracterizado por la maduración y el ahumado lentos o por el uso de las moldes nobles sin el ahumado. Siempre tiene el recubrimiento de la tripa del intestino delgado porcino o los recubrimientos permeables del diámetro pequeño (32-34 mm), es formada de dos partes de longitudes similares, doblada por un lado (la parte abierta) normalmente usando un palo de madera. Dependiendo de la región de

Eslovenia, es posible distinguir varios tipos de la salchicha suha klobasa, que están determinados por la longitud y el color de la superficie, el mosaico y la porosidad por un lado y por la acidez, el humo, las moldes y el olor/aroma desagradable por otro lado. Aunque las salchichas de diferentes prácticas de producción se diferencian por las características visuales del producto (el tamaño, la uniformidad de la forma y la presencia de moldes), el corte transversal (mosaico, porosidad y el brillo), y la textura (la dureza, a resistencia y la integridad), sus perfiles olfativos y aromáticos no se distinguen.

Palabras claves: productos cárnicos, salchichas crudo-curadas, Eslovenia, prácticas de producción, características sensoriales

Diversità sensoriale delle tradizionali salsicce secche originarie della Slovenia (suha klobasa)

Riassunto

La suha klobasa è una salsiccia secca molto popolare la cui produzione è largamente diffusa in Slovenia. La finalità di questa ricerca consiste nell'indagare le principali caratteristiche delle suhe klobase di diversi produttori provenienti da cinque regioni "ufficiose" della Slovenia. I prodotti di 31 produttori, 11 provenienti da aziende a conduzione familiare, 15 da piccoli stabilimenti e 3 da grandi impianti industriali sono stati analizzati riguardo al pH, all'umidità, alle proteine, ai grassi e alle ceneri e riguardo alle proprietà sensoriali secondo la valutazione di quattro caratteristiche: aspetto, consistenza, odore e aroma. I processi tecnologici di produzione sono stati valutati sulla base di un questionario. Per la produzione della suha klobasa prevale l'uso della carne suina. Il suo processo produttivo è caratterizzato da una lenta stagionatura e dall'affumicatura oppure dall'uso di muffe nobili senza affumicatura. Per fare la salsiccia si usa sempre il budello naturale suino (intestino tenue) o un budello sintetico permeabile di piccolo diametro (32-34 mm) che si modella in due metà d'identica lunghezza, incurvate nella parte aperta di solito con l'uso di una bastone di legno. A seconda della regione slovena di provenienza, possiamo distinguere differenti tipologie di suha klobasa, alcune caratterizzate dalla lunghezza della salsiccia e dal colore della sua superficie, dal tipico mosaico e dalla porosità, altre caratterizzate dall'acidità, dall'affumicatura, dalla muffa e dal profumo/aroma sgradevole. Sebbene le suhe klobase derivanti da differenti prassi produttive si differenzino per le peculiarità visive del prodotto (grandezza, uniformità della forma e presenza di muffe), per la sezione al taglio (mosaico, porosità e lucentezza) e per la consistenza (durezza, tigliosità e integrità), i loro profili olfattivi e aromatici non si differenziano.

Parole chiave: prodotti a base di carne, salsicce secche, Slovenia, prassi produttiva, proprietà sensoriali

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19. – 22. svibnja 2021.
Valamar Diamant Hotel, Poreč