ORIGINAL SCIENTIFIC PAPER

Comparison of the physico-chemical parameters and sensory properties of selected pasteurized meat products on Slovenian market

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Abstract

Consumers often mix pasteurised meat products from the subgroup of smoked meat with a subgroup of meat products known as canned meat. The aim of this study was therefore to determine their physicochemical parameters and sensory properties of smoked meat and canned meat subgroups of pasteurised meat products on the Slovenian market. Chemical analyses of the content of ash, sodium chloride and phosphates, thiobarbituric acid number (TBA), instrumental measurements of the proximate composition (NIR), colour (CIE L*, a*, b*) and texture (Texture Profile Analysis) as well as the evaluation of sensory properties (Descriptive Analysis Method) were performed on 33 products. The products of smoked meat had a higher content of protein, ash, total phosphates and sodium chloride than the products of canned meat. All products were oxidatively stable (low TBA number). The products of smoked meat were darker (lower L* values) and redder in cross-section (higher a* values), they were tougher, gummier, more difficult to chew, more cohesive and less elastic in texture (Texture Profile Analysis) than the products of canned meat. The panel of experts evaluated the products of both subgroups with a similar average overall impression. Compared to the products of the canned meat, the products of the smoked meat showed worse slice colour uniformity, they contained a higher level of gelatinised connective tissue on the slice, had a worse slice connectivity, the texture of a slice was firmer with coarser fibres, they were saltier, with a less pronounced metallic and rancid aroma and a more pronounced bitter, acidic and odd aroma. Chewiness, gumminess, cohesiveness, hardness and elasticity (texture parameters) loaded strongly on the quality parameters of all products (Factor analysis). Furthermore, linear discriminant analysis confirmed that the products of the subgroups smoked meat and canned meat differ in their physico-chemical and sensory profile.

Key words: pasteurized meat products, pasteurized smoked meat products, pasteurized canned meat products, physico-chemical parameters, sensory properties

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Introduction

Slovenian consumers often mix pasteurized meat products called 'smoked meat' with products called 'canned meat'. Therefore, caution is needed when comparing these two subgroups of pasteurized meat products, i.e. smoked and pasteurised hams (Fig. 1.) with cooked hams (Prague ham in casing, canned ham, brick ham, etc.) or pizza/toast hams (Fig. 2 and 3). Everything is even more confusing if the above comparison also includes under-pasteurized (raw) smoked ham, which looks like a pasteurized smoked ham, but is only smoked with hot smoke and must be cooked/ regenerated before consumption (Fig. 4). In the Rules on the Quality of Meat Products and Meat Preparations (2017), all three types of products are precisely defined, but the dividing line between them is sometimes really thin.

According to the Rules on the Quality of Meat Products and Meat Preparations (2017), cooked prosciutto cotto is a product made from whole (integral) leg muscle, which is cured, tumbled and placed in the mold, while under the terms of cooked or baked ham, products made from diced/cut into larger pieces of pork leg muscle can be made, cured, tumbled and placed in the mold or filled into the fibrous or other permeable casings. Both products belong to a large group of pasteurized meat prod-

Figure 1 Pasteurized products of the smoked meat subgroup: smoked bacon, smoked pork neck, smoked ham and smoked turkey leg (from left to right)

Figure 2 Cooked prosciutto cotto (left), pressed bacon (middle) and pizza ham (right)

Figure 3 Comparison of the cross-section of cooked prosciutto cotto (left), showing individual muscles or larger pieces of pork, pressed meat bacon (middle) and pizza ham (right), showing that the product consists of smaller (undefined) pieces of meat

Figure 4 Under-pasteurized (raw) smoked ham, smoked with hot smoke which has to be cooked/regenerated before consumption

ucts, more precisely to the subgroup of canned meat. It is noticeable that the products in this subgroup are diverse. Some are actually made from whole (integral) muscles, while others can also be made from more disintegrated pork leg muscles; the latter are also known as reformulated meat products. If the product is made from reformulated and undefined leg muscles and shaped into a specific shape, consumers must be informed. Because of their price, these products are popular with consumers, the most well-known representative being toast/pizza ham. Consumers can distinguish cooked ham from toast/pizza ham by checking that the cross-section actually shows the integral muscles or larger pieces of the pork leg.

Pasteurized meat products from the subgroup of smoked meat include smoked ham, which is an integral muscle, or a piece of pork leg which is cured, smoked with hot smoke and pasteurized, must be separated from cooked ham or cooked prosciutto, which is massaged, shaped, pasteurized (optionally smoked) and wrapped. At first sight it appears that substitution between the three products is almost impossible, but this is not the case, especially when comparing products in the form of sales pieces, i.e. smaller pieces or sliced (Fig. 5). As mentioned above, there is another form of smoked ham on the market which, after being cured and hot-smoked, is sold under-pasteurized (raw). In this case, the packaging unit must indicate that this undercooked ham must undergo heat treatment (cooking) before consumption and that it belongs to the group of meat preparations (Rules on the Quality of Meat Products and Meat preparations, 2017).
Products from subgroups of smoked meat and canned meat can be produced without phosphate. In this case, the products usually have a loosely connected slice and can release meat juice, but belong to the group of meat products labelled as "without or less additives" and meet the requirements of the modern consumer. The final quality of the product therefore depends not only on the raw material used, but above all on the production technology, i.e. the use of additives for water binding, tumbling, smoking and heat treatment. Also, the level of injection of brine determines the quality of the meat, higher quality products have been made with a lower level of injection (Feiner, 2006; Casiraghi et al., 2007).

The aim of this study was therefore to determine the physico-chemical parameters and sensory properties of meat products from subgroups of smoked meat and canned meat and to identify meat products from both subgroups. Furthermore, we wanted to obtain our own data on the mentioned parameters and characteristics of these products on the Slovenian market and to evaluate their quality.

Material and methods

Sampling and preparation of samples for analysis

The 33 samples of canned meat (22) and smoked meat (11) were collected in Slovenian shops. A total of one to three pieces (depending on the mass of the packaging unit) were randomly selected for each sample, transported to the laboratory in refrigerated boxes at 4 °C and then used for analysis. After the sensory (descriptive) analysis, the samples were subjected to instrumental measurement of the proximate nutrient composition (water, protein, fat and NaCl), pH values, colour and texture parameters and determination of some chemical parameters (ash and phosphate content and the thiobarbituric acid number (TBA)).

Methods

Instrumental methods: The moisture, protein and fat content in samples were determined with the Food ScanTM Analyser with self-calibration (FOSS, Denmark), which was developed especially for meat and meat products. The NaCl content was determined automatically with an ion-selective sodium electrode (DX223; Sodium Analyzer AP214, Mettler Toledo, USA) which determines Na^+ ions following standard addition technique. The measurements were performed in two parallels and the salt content was expressed in g/100 g product. The pH values were measured in two parallels in water

	Pasteurized meat products		
	Smoked meat	Canned meat	
Meat	**whole muscles** (pH 5,7–6,1; CFU 102–104/g T od 0 °C to 4 °C)	**whole muscles or parts of muscles** (pH 5,7–6,1; CFU 102–104/g T 0 °C to 4 °C)	**undefined pieces of meat re-formulated products** (pH 5,7–6,1; CFU 102–104/g T 0 °C to 4 °C)
Muscle/ cut	abdomen, neck, shoulders, leg (with/without fat, with/without bone)	belly, neck, shoulders, leg (boneless)	trimmings
			grinding
Brine(injection/%)	dry, wet, combined curing (up to 70%)	dry, wet, combined curing (40 to 70%)	brine is added to the minced meat (25% to 100%)
Additives	phosphates, salt, sugars, nitrite, colour and flavour enhancers, dyes, carrageenan and starch	phosphates, salt, sugars, nitrite, colour and flavour enhancers, dyes, carrageenan and starch	phosphates, salt, sugars, nitrite, colour and flavour enhancers, dyes, carrageenan, soy proteins, starch, hydrocolloids
Tenderizing	optional: with needles and blades		
Tumbling/mixing	optional: slow tumbling/mixing	tumbling/mixer-massaging (T between 0 °C and 4 °C, interval rest, under vacuum)	mixing: T from -1 °C to 2 °C
Filling		stuffing into impermeable or permeable (smoking/baking) casings and filling into molds	filling into cellulose or collagen casings and placed into moulds
Smoking	required: • *drying:* T 60-70 °C, RH 30-40%, t 30-120 min • *smoking*: 65-75 °C, RH 50-70%, to desired colour • *or liquid* smoke	optional: • *drying:* T 60-70 °C, RH 30-40%, t 30-120 min • *smoking:* 65-75 °C, RH 50-70%, to desired colour • *or liquid* smoke into the mass	optional: • *drying:* T 60-70 °C, RV 30-40% • *smoking:* 65-75 °C, RV 50-70%, to desired colour • *or liquid* smoke into the mass
Heat treatment	• *dry heat* treatment: T 76-80 °C, to Ti of product 69-72 °C	• *moist heat treatment in steam or water:* T constant, gradual or ΔT to Ti 69-72 °C • *dry heat treatment:* T 76-80 °C to Ti of product 69-72 °C • *sous vide:* medium T a53-81 °C, vacuum packed • *high pressure heat treatment:* Ti 25-30 °C, few min	• *wet heat treatment in steam* or water: T 74-80 °C to Ti 69-72 °C • *dry heat treatment:* T 74-80 °C,to Ti of product 69-72 °C
Cooling	rapid cooling, below 5 °C	rapid cooling, below 5 °C	rapid cooling, below 5 °C
Slicing	usually not	optional: thicker or thinner slices	slicing
Packing	vacuum	vacuum, modified atmosphere	vacuum, modified atmosphere
Storage (T)	-1 °C to 4 °C	-1 °C to 4 °C	-1 °C to 4 °C
Products	smoked ham, smoked belly, smoked belly bacon, smoked pork loin, smoked pork	cooked or roasted prosciutto cotto, cooked or roasted ham, cooked shoulder	pizza ham, toast ham, delicates ham, sandwich ham, chicken loaf

Figure 4 Technology schemes for the production of smoked meat and canned meat (adapted according Feiner, 2006).

extract with a combined glass-gel spear electrode (type 03, Testo Pty Ltd, Australia) with a thermometer (type T, TestoPty Ltd, Australia) connected to a pH meter (Testo 230, Testo Pty Ltd, Australia). Accuracy of reading was ±0.01 pH-unit. A CR-400 colorimeter (Konica Minolta Optics, Inc., Osaka, Japan; Illuminant C, 0° viewing angle) was used to determine the Commission Internationale de l'Eclairage (CIE; International Commission on Illumination) L* (lightness), a* (±, red to green) and b* (±, yellow to blue) values on the surface of a 1 cm slice. A white ceramic tile with the specifications of Y = 93.8, x = 0.3134, y = 0.3208 was used to standardise the colorimeter. The CIE L*, a*, b* colour values were measured at four different points on the surface of the sample. Instrumental texture analysis were performed using Texture Profile Analysis (TPA) using a TA.XT plus Texture Analyser (Stable Micro Systems Ltd., Godalming, Surrey, UK) with a 50 kg load cell and a 50 mm diameter compression plate (P100). The samples were conditioned at 4 ºC for 1 h. For the TPA, the samples (diameter 40 mm, height 40 mm) were compressed twice to 50% of their original height, at a crosshead speed of 5 mm/s and 5 s between the 1st and 2nd compression cycle. The force vs. time curves were recorded and the following parameters were calculated: hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness and resilience (Morales et al., 2007). The texture parameters were measured four times on one sample.

Chemical analyses: Approximately 100 g of a representative sample was homogenized for 20 s with a Grindomix homogeniser (GM 200; Retch, Germany) at 5000-6000 rpm (ISO 3100-1, 1991). All chemical parameters were performed in parallel. The thiobarbituric acid number (TBA) was determined using a modified extraction method described by Witte et al. (1970). The method was precisely described in the study of Penko et al. (2015). The TBAs were measured at 532 nm with a spectrophotometer (Shimadzu, UV-160 A) and calculated as mg malondialdehyde/kg product. The total phosphate content was determined spectrophotometrically after the sample was dried at a temperature of 650 °C and hydrolyzed with HNO3 (Jamnik and Bertoncelj, 2009). The total phosphate content was expressed as P2O5 in g/kg. The ash content was determined according to the official method described in AOAC Official Method 920.153 Ash of Meat (AOAC, 1997).

Sensory analysis: A panel of five qualified and experienced panellists in the field of meat products was set up to assess the sensory qualities. The sensory evaluation of canned meat and smoked meat samples was carried out in accordance with international standards (ISO 8589:2007, ISO 8586:2012). The analytical-descriptive 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. The exceptions here were typicality of surface colour 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 higher indicating greater expression of a property, and those of 3.5 or lower indicating insufficient expression of a property. These sensory profiles of the samples were assessed using 18 descriptors grouped into four blocks. The first block referred to the visual attributes of the product, such as surface colour uniformity an typicality and drip loss in casings, as well as attributes of cross-section, such as uniformity of colour, colour of meat and fat particles, proportion of fat, porousness, gelatinisation rate of connective tissue and connectivity of the slice. The second block related to texture, including rate of falling apart, toughness, juiciness and mouth-feel. The third block referred to olfactory attributes, such as rancid, odd and harmony in the smell. The last block referred to the evaluation of the flavour attributes, such as saltiness, acid, rancid, metal, bitter, sweet and odd aroma, and harmony of aroma. For the sensory evaluation, the samples were cut as 2-mm-thick slices, which were evaluated by the panellists. To neutralise the taste, the panel used the central dough of white bread.

Data analysis: The data were analysed for normal distributions using the UNIVARIATE procedure (SAS/STAT). Differences by subgroup and product type of the sample were analysed using a general linear model procedure and least squares mean tests (SAS/STAT), with a 0.05 level of significance. The multivariate analysis included factor analysis and linear discriminant analysis (LDA). The statistical analysis was performed using SPSS version 15.0 for Windows as evaluation version (SPSS Inc., Chicago, IL, USA).

Results and discussion

Proximate composition

The protein content (Table 1) in the smoked meat subgroup (SM) was higher (18.34 ± 2.63 g/100 g) compared to samples in the canned meat subgroup (CM; 15.21 ± 3.18 g/100 g). These data are not precisely in agreement with those of Golob et al. (2006; canned meat 17.3-21.7 g/100 g) but are in good agreement with this type of Serbian meat products (Kulier, 2019; smoked meat 18 g/100 g, canned meat 9.1-21 g/100 g). The differences between all product types in this study were not significant, but the lowest protein content (13.56 g/100 g) was seen in CM-Belly bacon (13.56 g/100 g) and is significantly higher than in CM-Belly bacon from Serbia (9.1 g/100 g; Kulier, 2019). In contrast, the highest protein content was determined in the SM-Ham (19.36 g/100 g). Differences in fat and water contents between SM in CM subgroups were statistically not significant. The water content of the products in this study is comparable to that of Golob et al. (2006; 68.2-75.3 g/100 g) and higher compared to such Serbian products (20-50.2 g/100 g). On the contrary, according to the literature the fat content is between 3.9 and 65 g/100 g, and in our experiment the highest fat content in the CM-Belly bacon (29.50 g/100 g) and the lowest in the CM-Ham is 3.75 g/100 g.

The ash content in SM products (ham, shoulder, neck, tongue and ribs) was significantly higher than in CM ones. The same was observed for the salt content, but the values varied considerably between products, from 3.45 g/100 g (SM-Ham) to 2.09 g/100 g (SM-Belly bacon). Salt is an indispensable ingredient in the meat industry, but some meat products have a rather high, even too high level (over 3 g/100 g).

Products from both subgroups can be produced without the addition of phosphates (Casiraghi et al., 2007), but this can lead to the release of meat juice and poorer slice connectivity. In this study, the total phosphate content in both subgroups was on average below the legal limit (5 g/kg of finished product, Regulation (EC) No 1333/2008), with SM standing out among the product groups. Higher phosphate levels may affect sensory properties, change nutritional value and increase water binding (Demšar and Polak, 2010).

No differences in pH values and TBA number were observed between the two product groups. The products analysed did not show any oxidative defect, which reflects an overall low TBA number. For raw and heat-treated steaks from Iberian pigs (roasted, fried, grilled or microwaved) TBA numbers were determined between 0.26 (raw) and 1.35 mg MDA/kg (Broncano et al., 2009), while in this study the highest numbers were between 0.02 and 0.07.

Instrumentally measured colour and texture

Instrumental measurement of colour showed that the SM products were generally darker (lower L* values), redder (higher a* values) and likewise yellow (b* values) compared to CM products (Table 2). The colour parameters of nine observed types of products varied widely and were probably related to a part of the pig carcass used in production and the associated mioglobin content. The stable colour of cured meat is mainly given by nitrites (Feiner, 2006; Demšar and Polak, 2010), the colour is also positively influenced by ascorbic acid (Feiner, 2006), the addition of blood plasma (Heinz and Hautzinger, 2007) and colouring agents such as carmine (Ho-Soo et al., 2014) and beetroot extract (Feiner, 2006).

The results of the texture measurements are presented in Table 2 and show that the subgroup has significantly influenced hardness, flexibility, cohesiveness and gumminess. On the contrary, the

Table 1 Proximate composition, pH value and TBA of the pasteurized meat products according to the subgroup and product type

	Value of property according to subgroup			Value of property according to product type									
	SM	CM		SM						CM			
Parameter	(22)	(11)	*Ps*	S (3)	R (1)	B (2)	H (10)	N (5)	T (1)	S (1)	B (2)	H (8)	*PT*
Protein (g/100 g)	18.34^{A}	15.21^{B}	*	16.40	17.20	17.92	19.36	17.62	19.41	15.69	13.56	15.57	Ns
Fat (g/100 g)	10.06	8.45	Ns	6.94^{c}	14.16^{abc}	18.31^{abc}	6.05^{c}	12.76^{bc}	25.43^{ab}	4.00^{c}	29.50^{a}	3.75^{c}	***
Water (g/100 g)	67.09	71.21	Ns	70.74^{a}	64.18^{ab}	61.29^{ab}	69.42^{a}	65.90^{ab}	53.34^{b}	74.64^{a}	54.09^{b}	75.07^{a}	**
Ash (g/100 g)	4.20^{A}	3.25^{B}	***	4.29^{ab}	3.29^{ab}	2.71^{b}	4.65^{a}	4.13^{ab}	3.70^{ab}	3.12^{ab}	4.05^{ab}	3.07^{ab}	***
Phosphate (g/kg)	4.57^{A}	3.82^{B}	**	4.88^{a}	4.75^{ba}	3.82^{bac}	4.90^{a}	4.24^{bac}	3.23^{c}	4.02b^{ac}	3.40^{bc}	3.89^{bac}	**
NaCl (g/100 g)	3.05^{A}	2.38^{B}	*	3.07	2.79	2.09	3.45	2.77	2.66	2.31	3.01	2.24	Ns
pH value	5.95	6.06	Ns	6.11	5.97	6.01	5.89	6.03	5.61	6.01	6.12	6.06	Ns
TBA (mg MDA/kg)	0.11	0.1	Ns	0.11	0.07	0.07	0.12	0.09	0.09	0.09	0.07	0.11	Ns

*SM, smoked meat; CM, canned meat; S, shoulder; R, ribs; B, belly bacon; H, ham; N, neck; T, tongue; numbers in bracket mean number of samples. Ps, statistical probability of subgroup effect; PT, statistical probability of product type 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. Data with different superscript letters within a row differ significantly (least-squares means; P <0.05, A-B differences between subgroups; a-c differences between product types).*

subgroup had no influence on texture parameters, such as adhesiveness and resilience. The SM products were harder (tongue, ham, ribs), more flexible (ham, neck), more cohesive (tongue, ribs, ham, neck), more gummy (ham, tongue) and harder to chew (tongue, thigh) compared to the CM products. In the literature, Piton et al. (2019) find that a soft and juicy texture can be achieved by adding the right amount of phosphates. A positive effect on texture can also be achieved by adding carrageenan, which improves the connectivity of the slices and gives the product juiciness (McHug, 2003; Feiner, 2006; Chun et al., 2014). Increasingly, we are seeing some other additives that have a positive effect on texture, e.g. dietary fibers (Gibis et al., 2015; Mehta et al., 2015; Henning et al., 2016; Han and Bertram, 2017) and starch (Xiong et al., 2012).

Sensory properties

Statistical analysis of sensory profile data was performed to classify pasteurised meat samples into two subgroups. Visual attributes were selected as the most discriminating variables, such as uniformity of colour cross-section, gelatinized connective tissue and connectivity of slice, attributes related to texture, such as toughness and mouth-feel, and aroma attributes, such saltiness, metal, bitterness, acidity, rancid and odd aroma. The panellists noted that the products in the CM subgroup had better uniformity in slice colour (more pink), less jelly-like connective tissue, better slice connectivity but softer (descriptor toughness), smoother (mouth-feel) slice texture, less salty but with a more pronounced metallic and rancid aroma and less pronounced bitter, acidic and odd aromas compared to the SM products.

In both product subgroups, the panellists observed drip loss and a slightly uneven but distinct colour of muscle and fat in cross section (naturally in products with bacon). In both SM and CM products, porosity was observed on the cross section, the general texture was assessed as gentle, the smell as harmonium on average, with a slightly detectable odd smell, but without the rancid notes. The panellists also noted that the average aroma of all products was too salty; average in harmony, due to the slightly noticeable bitter, sweet, acid and odd notes.

Multivariate analysis

With multivariate data analysis we wanted to visualize data matrices; the structure of the quali-

Table 2 Colour and texture parameters of the pasteurized meat products according to the subgroup and the product type

	Value of property according to subgroup			Value of property according to product type									
	SM	CM		SM						CM			
Parameter	(22)	(11)	*P*s	S (3)	R (1)	B (2)	H (10)	N (5)	T (1)	S (1)	B (2)	H (8)	*P*T
Instrumentally measured colour													
L^* value	61.0^{B}	66.7^{A}	***	61.72^{c}	63.70^{bc}	59.53^{c}	61.97^{c}	58.77^{c}	59.86^{c}	71.34^{a}	59.14^{c}	67.94^{ba}	***
a^* value	12.3^{A}	9.9^{B}	***	12.43^{bac}	13.40^{ba}	14.61^{a}	11.49^{bc}	12.51^{bac}	12.55^{bac}	5.71^{d}	12.51^{bac}	9.76^{c}	***
b^* value	8.2	8.6	Ns	7.38^{d}	7.59^{dc}	7.40^{d}	8.34^{dc}	8.12^{dc}	11.53^{a}	9.80^{b}	7.75d^{c}	8.64^{c}	***
Instrumentally measured texture													
Hardness (N)	80.46^{A}	61.64^{B}	***	69.71^{bc}	75.59^{bac}	69.77^{bc}	92.98^{ba}	63.49^{c}	98.61^{a}	65.85^{c}	55.73^{c}	62.60^{c}	***
Adhesiveness (N.s)	-0.19	-0.14	Ns	-0.20	-0.20	-0.20	-0.15	-0.25	-0.27	-0.01	-0.07	-0.18	Ns
Springiness	0.81^{B}	0.89^{A}	***	0.86^{ba}	0.81^{ba}	0.90^{ba}	0.79^{b}	0.79^{b}	0.83^{ba}	0.92^{a}	0.87^{ba}	0.90^{ba}	***
Cohesiveness	0.53^{A}	0.46^{B}	***	0.49^{bc}	0.57^{ba}	0.51^{bc}	0.53^{bac}	0.53^{bac}	0.62^{a}	0.47^{bc}	0.48^{bc}	0.45^{c}	**
Gumminess (N)	43.53^{A}	29.57^{B}	***	35.01^{bc}	43.47^{bc}	36.44^{bc}	50.26^{ba}	34.49^{bc}	61.18^{a}	31.03^{c}	27.11^{c}	30.01^{c}	***
Chewiness (N)	35.13^{A}	26.47^{B}	***	30.42^{b}	35.16^{b}	32.92^{b}	38.82^{ba}	28.36^{b}	50.68^{a}	28.53^{b}	23.50^{b}	26.95^{b}	***
Resilience	0.23	0.21	Ns	0.23b	0.25^{ba}	0.23^{b}	0.23^{b}	0.23^{b}	0.31^{a}	0.20b	0.23^{b}	0.21^{b}	Ns

*SM, smoked meat; CM, canned meat; S, shoulder; R, ribs; B, belly bacon; H, ham; N, neck; T, tongue; numbers in bracket mean number of samples. Ps, statistical probability of subgroup effect; PT, statistical probability of product type effect. *** $P \leq 0.001$ statistically very highly significant; ** $P \leq 0.01$ statistically highly significant; * $P \leq 0.05$ statistically significant; Ns – $P > 0.05$ statistically not significant. Data with different superscript letters within a row differ significantly (least-squares means; $P < 0.05$, A-B differences between subgroups; a-d differences between product types).*

Table 3 A total of 24 sensory attributes of the pasteurized meat products according to the subgroup and the product type

Attribute	Value of property according to subgroup			Value of property according to product type									
	SM	CM		SM						CM			
Attribute	(22)	(11)	Ps	S (3)	R (1)	B (2)	H (10)	N (5)	T (1)	S (1)	B (2)	H (8)	PT
Appearance of surface													
Uniformity of colour (1-7)	6.7	7.0	Ns	6.7^{ba}	7.0^{a}	7.0^{a}	6.7^{ba}	6.7^{ba}	6.5^{b}	-	7.0^{a}	-	*
Typicality of colour (1-4-7)	4.4	4.0	Ns	4.4^{b}	4.0^{b}	4.0^{b}	4.2^{b}	4.6^{b}	5.3^{a}	-	4.0^{b}	-	**
Drip loss (1-7)	2.6	2.7	Ns	2.5^{b}	3.5^{a}	1.5^{c}	2.6^{b}	2.7^{b}	3.5^{a}	-	2.7^{b}	-	***
Cross-section													
Uniformity of colour (1-7)	5.2^{B}	5.9^{A}	***	4.8^{e}	4.7^{e}	5.1^{ed}	5.3^{bcd}	5.3^{cd}	5.6^{bc}	6.1^{a}	6.2^{a}	5.8^{ba}	***
Colour of meat particles (1-7)	5.9	5.8	Ns	6.0^{ba}	6.2^{ba}	6.0^{ba}	5.9^{ba}	6.0^{ba}	5.8^{ba}	6.4^{a}	6.5^{a}	5.5^{b}	*
Colour of fat particles (1-7)	5.9	5.7	Ns	6.3^{ba}	7.0^{a}	6.2^{bc}	5.5^{bc}	5.3^{c}	-	-	5.7^{bc}	-	**
Porousness (1-7)	1.7	1.7	Ns	1.2^{bc}	1.8^{ba}	1.9^{a}	$1.^{9a}$	1.6^{ba}	1.0^{c}	2.1^{a}	1.5^{bac}	1.7^{ba}	**
Gelatinized connective tissue (1-7)	2.1^{A}	1.3^{B}	***	2.4c	4.6^{a}	3.4^{b}	1.5^{fe}	2.3^{dc}	1.0^{f}	1.2^{f}	1.8^{de}	1.2^{f}	***
Connectivity of slice (1-7)	5.4^{A}	6.5^{B}	***	6.1^{bc}	3.3^{g}	4.3^{f}	5.8^{dc}	4.6^{fe}	6.8^{ba}	7.0^{a}	5.2^{de}	6.8^{ba}	***
Texture													
Rate of falling apart (1-7)	2.1	2.1	Ns	2.2^{bac}	1.6^{edc}	2.6^{a}	2.3^{ba}	1.9^{bdc}	1.0^{e}	2.2^{bac}	1.4^{ed}	2.2^{bac}	***
Toughness (1-7)	2.0^{A}	1.6^{B}	*	1.8^{dc}	2.8^{b}	1.2^{d}	2.0^{c}	1.7^{dc}	3.6^{a}	1.2^{dc}	2.0^{c}	1.6^{dc}	***
Juiciness (1-7)	5.7	5.8	Ns	5.8^{b}	6.3^{a}	5.6^{cb}	5.5^{cb}	5.8^{b}	5.2^{c}	5.3^{c}	5.9^{b}	5.8^{b}	***
Mouth feeling (1-7)	5.7B	5.9^{A}	***	5.9^{ba}	5.3^{dc}	5.8^{b}	5.6^{bc}	5.7^{b}	5.2^{d}	5.3^{dc}	6.2^{a}	5.9^{ba}	***
Smell													
Harmony in smell (1-7)	5.5	5.6	Ns	6.0^{a}	6.0^{a}	5.2^{c}	5.6^{ba}	5.4^{bc}	4.1^{d}	5.8^{ba}	5.2^{c}	5.6^{ba}	***
Rancid smell (1-7)	1.0	1.0	Ns	1.0^{b}	1.1^{a}	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	***
Odd smell (1-7)	1.9	1.7	Ns	1.3^{cd}	1.4^{cd}	2.0^{b}	1.8^{cb}	2.0^{b}	3.7^{a}	1.1^{d}	1.6^{cbd}	1.8^{cb}	***
Aroma													
Saltiness (1-4-7)	5.0^{A}	4.6^{B}	***	5.0^{bac}	4.6^{bdc}	4.3^{d}	5.3^{a}	4.7^{bdc}	4.3^{d}	4.4^{d}	5.1^{ba}	4.5^{dc}	***
Harmony (1-7)	5.4	5.3	Ns	5.9^{a}	5.4^{ba}	5.0^{b}	5.5^{a}	5.5^{a}	4.3^{c}	5.7^{a}	4.2^{c}	5.5^{a}	***
Metal (1-7)	1.2^{B}	1.6^{A}	***	1.5^{ba}	1.3^{bac}	1.1^{c}	1.2^{bc}	1.1^{bc}	1.0^{c}	1.1^{bc}	1.5^{ba}	1.6^{a}	***
Bitter (1-7)	1.5^{A}	1.3^{B}	*	1.8^{a}	1.2^{c}	1.1^{c}	1.7^{ba}	1.3^{bc}	1.3^{bc}	1.2^{c}	1.0^{c}	1.4b^{ac}	***
Acid (1-7)	1.5^{A}	1.2^{B}	***	1.4^{cb}	1.0^{c}	1.1^{c}	1.7^{b}	1.2^{c}	2.8^{a}	1.0^{c}	1.1^{c}	1.2^{c}	***
Sweet (1-7)	1.4	1.4	Ns	1.4	1	1.5	1.4	1.5	1	1	1.2	1.5	Ns
Rancid (1-7)	1.0^{B}	1.4^{A}	**	1.0b	1.1^{b}	1.1^{b}	1.0^{b}	1.0b	1.0^{b}	1.0^{b}	3.3^{a}	1.0^{b}	***
Odd (1-7)	1.8^{A}	1.6^{B}	*	1.4^{cd}	1.8^{cb}	2.0^{b}	1.9^{b}	1.8^{cb}	2.8^{a}	1.1^{d}	1.9^{b}	1.6^{cb}	***

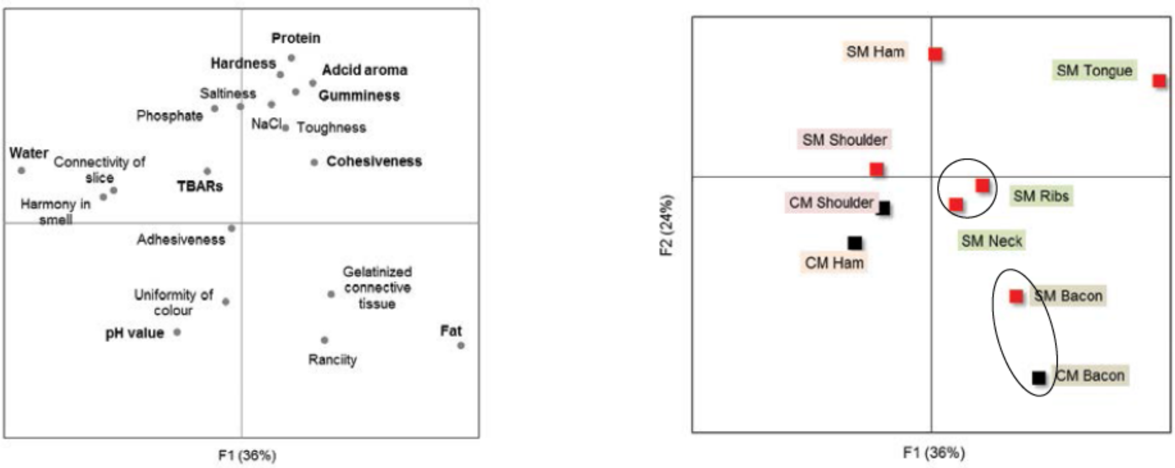
*SM, smoked meat; CM, canned meat; S, shoulder; R, ribs; B, belly bacon; H, ham; N, neck; T, tongue; numbers in bracket mean number of samples. Ps, statistical probability of subgroup effect; PT, statistical probability of product type effect. *** P ≤0.001 statistically very highly significant; ** P ≤0.01 statistically highly significant; * P ≤0.05 statistically significant; Ns – P >0.05 statistically not significant. Data with different superscript letters within a row differ significantly (least-squares means; P <0.05, A-B differences between subgroups; a-g differences between product types).*

ty parameters of all products was checked by factor analysis and the LDA separated the experimental groups as far as possible. Factor analysis was used to select from the product attributes those that carried the largest share of all information. The first eleven factors explain 80 % of the total variability, factor 1 (165 determinations, 37 parameters) explains 19 %, factor 2 12 %, factor 3 10, factor 4 8 %, factor 5 7 %, factor 6 and 5 % of the total variability, while the other factors together account for 20 % of the total variability. The size of the weights (r) indicates the importance of each parameter in the factor; the larger the weight, the more important the parameter is to the factor. The first factor (not presented in Table) was called texture, as it mainly projects parameters related to instrumental texture parameters, such as chewiness, gumminess, cohesiveness, hardness and resilience. Chewiness (r = 0.972) gave the greatest weight to this factor. The second factor was called saltiness because it mainly projects ash and NaCl content and sensory evaluated saltiness. Ash (r = 0.889) and NaCl (r = 0.855) contents gave the highest weight to this factor. The third factor was called the binding of water and fat, the highest weight was given water content (r = 0.877). The fourth factor was named the sliceability, contributing most to the evaluation of the gelatinous connective tissue and the slice connectivity (r = -0.896, r = 0.845). Odd aromas and smells (r=0.871, r=0.833) gave the highest weight to the fifth factor, and protein content (r = -0.755) to the sixth factor.

Linear discriminant analysis (LDA) was performed to classify the products from the subgroups of SM and CM on the basis of physico-chemical, instrumental and sensory profile. The LDA analysis identified nineteen of the most discriminatory variables among seventy-three variables: water, fat, protein, phosphate, NaCl, TBA and pH, instrumentally measured hardness, cohesiveness, adhesiveness, gumminess and chewiness, sensory assessed saltiness, gelatinized connective tissue, slice connectivity, rancidity, uniformity of colour, harmony of odour and acidity. The first four characteristics (165 determinations, 37 parameters) explained 84.8 % of the total variability (36.3 %, 24.4 %, 13.7% and 10.3 %).

In Fig. 6a, we see the variables defined by function 1, which are far from the baseline, namely water and fat content. Function 2 was defined by a group of variables such as protein content, hardness, saltiness, phosphate and NaCl content, gumminess, bitterness and chewiness. Properties that lie close to each other were in high positive correlation.

Overall, the accuracy of the placement of each sample into its corresponding type of product was 98.8%, one sample of CM (ham) is incorrectly allocated between SM (neck), and a sample of SM (neck) is incorrectly allocated between SM (shoulder) (not shown). Seven product groups are shown clearly in Fig. 6b. The first group (SM ribs and SM neck) differs from the other groups in that it is a smaller group with a very specificity (high fat content, high connective tissue content). It can also be seen that the belly bacon products (from both subgroups) are



a) b)

Figure 6. LDA using scores for attributes for the 33 pasteurized meat products (the most discriminating variables of the first two functions are boldly indicated – Fig. a) originated from two different subgroups, smoked meat and canned meat, and nine product types on Fig. b) (•, group centroids).

positioned relatively close together in the right lower quadrant, which implies certain similarities in the physico-chemical and sensory profile. The other five products cannot be grouped together.

Conclusion

On the Slovenian market, the range of meat products is very diverse, but the decision which product to choose depends primarily on our consumers. Producers strive to produce quality products, to offer as many different products on the market as possible, but they must also be affordable.

In this study, the industrial processes of production of smoked meat and canned meat products were recorded, and our own data on physico-chemical parameters and sensory properties of these products on the Slovenian market were obtained and their quality assessed. Using multivariate data analysis, we visualized data matrices; product quality parameters were selected that carry the largest share of all information, i.e. chewiness, gumminess, cohesiveness, hardness and elasticity. The hypothesis was also confirmed that nine pasteurized meat products from smoked meat and canned meat (98.8% of the samples were correctly classified) are separated in the physico-chemical and sensory profile. Despite the fact that product groups are precisely defined (Rules on the quality of meat products and meat preparations, 2017), the dividing line between them sometimes remains really thin.

Aknowlegment: This article is part of a MSc. thesis named Comparison of physico-chemical parameters and sensory properties of selected pasterized meat products, issued by Katja Babič

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Delivered: 13. 05. 2020. **Accepted: 25.05. 2020.**

Usporedba fizikalno-kemijskih značajki i senzorskih svojstava odabranih toplinski obrađenih mesnih proizvoda na slovenskom tržištu

Sažetak

Potrošači toplinski obrađene mesne proizvode (pasterizacija) iz podskupine dimljenih proizvoda (polutrajni suhomesnati proizvodi od jednog komada mesa), često miješaju s podskupinom polutrajnih proizvoda od komada mesa ("konzerve"). Cilj je ovog rada, stoga, bio utvrditi fizikalno-kemijske značajke i senzorska svojstva proizvoda iz ovih podskupina na slovenskom tržištu. Kemijskim analizama provedenima na 33 proizvoda utvrđeni su udio pepela, soli i fosfata te TBA vrijednost (test tiobarbiturne kiseline) i izvršena instrumentalna mjerenja kemijskog sastava (NIR), boje (CIE L*, a*, b*) i teksture (analiza profila teksture), kao i procjena senzorskih svojstava (metoda opisne analize). Dimljeni mesni proizvodi imali su veći udio bjelančevina, pepela, ukupnih fosfata i soli od konzerviranih mesnih proizvoda. Svi proizvodi bili su oksidativno stabilni (niska TBA vrijednost). Dimljeni mesni proizvodi bili su tamniji (niže vrijednosti L*) i crveniji u presjeku (više vrijednosti a*), žilaviji, ljepljiviji i teži za žvakanje te kohezivnije i manje elastične teksture (analiza teksturnog profila) od polutrajnih proizvoda od komada mesa. Stručna skupina proizvode iz obje podskupine ocijenila je sličnim prosječnim ukupnim dojmom. U usporedbi s polutrajnim mesnim proizvodima, dimljeni mesni proizvodi pokazali su lošiju ujednačenost boje kriški, sadržavali višu razinu želatiniziranog vezivnog tkiva u kriški, imali lošiju povezanost kriške, tekstura kriške bila je čvršća i sadržavala grublja vlakna, bili su slaniji, s manje izraženom aromom metala i užeglosti te izraženijom gorkom, kiselom i neobičnom aromom. Lakoća žvakanja, ljepljivost, kohezivnost, tvrdoća i elastičnost (značajke teksture) kod svih su proizvoda značajno utjecale na značajke kvalitete (faktorska analiza). Osim toga, linearnom analizom različitih potvrđeno je da se proizvodi iz navedemih podskupina razlikuju po svom fizikalno-kemijskim i senzorskom profilu.

Ključne riječi: toplinski obrađeni mesni proizvodi, dimljeni mesni proizvodi, polutrajni proizvodi od komada mesa, fizikalno-kemijske značajke, senzorska svojstva

Vergleich der physikalisch-chemischen Merkmale und sensorischen Eigenschaften ausgewählter pasteurisierter Fleischprodukte auf dem slowenischen Markt

Zusammenfassung

Verbraucher verwechseln häufig pasteurisierte Fleischprodukte aus der Untergruppe der geräucherten Produkte (halbhaltbare Produkte aus einem Stück Fleisch) mit der Untergruppe von halbhaltbaren Produkten, die aus einem Stück Fleisch hergestellt wurden („Konserven"). Ziel dieser Studie war es daher, die physikalisch-chemischen Merkmale und sensorischen Eigenschaften von Produkten aus diesen zwei Untergruppen auf dem slowenischen Markt zu bestimmen. In den an 33 Produkten durchgeführten chemischen Analysen wurden der Gehalt an Asche, Salz und Phosphat sowie der TBA-Wert (Thiobarbitursäuretest) ermittelt und es wurden instrumentelle Messungen der chemischen Zusammensetzung (NIR), der Farbe (CIE L *, a *, b *) und der Textur (Texturprofilanalyse) sowie die Bewertung sensorischer Eigenschaften (Methode der deskriptiven Analyse) durchgeführt. Die geräucherten Fleischprodukte hatten einen höheren Anteil an Eiweiß, Asche, Gesamtphosphaten und Salz als die konservierten Fleischprodukte. Alle Produkte waren oxidativ stabil (niedriger TBA-Wert). Die geräucherten Fleischprodukte waren dunkler (niedrigere L * -Werte) und röter im Querschnitt (höhere a * -Werte), zäher, klebriger und schwerer zu kauen sowie kohäsiver und weniger elastisch (Texturprofilanalyse) als halbhaltbare Produkte aus einem Stück Fleisch. Die Expertengruppe bewertete die Produkte beider Untergruppen mit einem ähnlichen durchschnittlichen Gesamteindruck. Im Vergleich zu den halbhaltbaren Fleischprodukten zeigten geräucherte Fleischprodukte eine ungleichmäßigere Farbe der Scheiben, sie enthielten höhere Mengen an gelatiniertem Bindegewebe in der Scheibe, hatten eine schlechtere Scheibenkohäsion, die Textur der Scheibe war fester und die Scheiben enthielten gröbere Fasern, waren salziger und hatten einen weniger ausgeprägten metallischen und ranzigen Geschmack sowie ein ausgeprägteres bitteres, saures und ungewöhnliches Aroma. Die Leichtigkeit des Kauens, die Klebrigkeit, Kohäsivität, Härte und Elastizität (Texturmerkmale) haben bei allen Produkten die Qualitätsmerkmale signifikant beeinflusst (Faktoranalyse). Darüber hinaus bestätigte die lineare Analyse der verschiedenen Produkte, dass sich die Produkte aus diesen zwei Untergruppen in ihrem physikalisch-chemischen und sensorischen Profil unterscheiden.

Schlüsselwörter: pasteurisierte Fleischprodukte, geräucherte Fleischprodukte, halbhaltbare Produkte aus einem Stück Fleisch, physikalisch-chemische Eigenschaften, sensorische Eigenschaften

Comparación de las características físico-químicas y de las propiedades sensoriales de productos cárnicos tratados térmicamente seleccionados del mercado esloveno

Resumen

Los consumidores frecuentemente confunden los productos cárnicos procesados (pasteurización) del subgrupo de los productos ahumados (los productos crudo curados semi secos de una pieza de carne) con el subgrupo de los productos semi secos de piezas de carne ("latas"). Por lo tanto, el fin de este trabajo fue determinar las características físico-químicas y las propiedades sensoriales de los productos de estos subgrupos en el mercado esloveno. Los contenidos de cenizas, de sal, de fosfatos y los valores de TBA (la prueba del ácido tiobarbitúrico), tanto como las medidas instrumentales de las composiciones químicas (NIR), del color (CIE L*, a*, b*) y de la textura (el análisis del perfil de textura), junto con la evaluación de las propiedades sensoriales (el método de análisis descriptivo) fueron determinados por los análisis químicos en 33 productos. Los productos cárnicos ahumados tenían un mayor porcentaje de proteínas, cenizas, fosfatos en total y de sal que los productos cárnicos enlatados. Todos los productos fueron oxidativamente estables (bajo valor de TBA). Los productos cárnicos ahumados eran más oscuros (valores L * más bajos) y más rojos en la sección transversal (valores a * más altos), más duros, más pegajosos y más difíciles de masticar, con texturas más cohesivas y menos elásticas (el análisis de perfil de textura) que los productos cárnicos enlatados. El grupo de expertos calificó los productos de ambos subgrupos con una impresión general promedio similar. En comparación con los productos cárnicos semi secos enlatados, los productos cárnicos ahumados mostraron una menor uniformidad del color del corte, contenían niveles más altos de tejido conjuntivo gelatinizado en el corte, tenían una cohesión de corte más pobre, la textura del corte era más firme y contenía fibras más gruesas, eran más salados, con un aroma metálico y la rancidez menos pronunciados y con un un aroma amargo, agrio e inusual más pronunciado. La facilidad de masticación, la pegajosidad, la cohesión, la dureza y la elasticidad (las características de la textura) en todos los productos afectaron significativamente las características de calidad (análisis factorial). Además, el análisis lineal de los diversos confirmó que los productos de los subgrupos dichos difieren en su perfil físico-químico y sensorial.

Palabras claves: productos cárnicos térmicamente tratados, productos cárnicos ahumados, productos cárnicos semi secos de piezas de carne, características físico-químicas, propiedades sensoriales

Raffronto tra le caratteristiche fisico-chimiche e le proprietà sensoriali di alcuni prodotti a base di carne trattati termicamente e selezionati sul mercato sloveno

Riassunto

I consumatori spesso confondono i prodotti a base di carne trattati termicamente (pastorizzati), appartenenti al sottogruppo dei prodotti affumicati (salumi semi stagionati a pezzo intero), con un altro sottogruppo di prodotti semi stagionati di pezzi di carne ("carne in scatola"). L'obiettivo di questa ricerca è, dunque, quello di accertare le caratteristiche fisico-chimiche e le proprietà sensoriali dei prodotti appartenenti a questi sottogruppi in vendita sul mercato sloveno. Grazie alle analisi chimiche svolte su 33 prodotti differenti, è stato possibile accertare la quantità di cenere, sale e fosfati ed il valore TBA (test dell'acido tiobarbiturico), è stata eseguita la misurazione strumentale della composizione chimica (NIR), del colore (CIE L*, a*, b*) e della texture (analisi del profilo di texture) e sono state valutate le proprietà sensoriali (analisi descrittiva) dei prodotti testati. I prodotti a base di carne affumicati esaminati hanno evidenziato una maggiore percentuale di proteine, cenere, fosfati totali e sale rispetto ai prodotti a base di carne conservati. Riguardo alla stabilità ossidativa, tutti i prodotti esaminati sono risultati stabili (valore TBA basso). I prodotti a base di carne affumicati sono risultati più scuri (minor valore L*) e più rossi in sezione (maggior valore a*), oltre che più tigliosi, pastosi e meno masticabili, di texture più coesa e meno elastica (analisi del profilo di texture) dei prodotti semi stagionati a pezzo intero. Il gruppo di esperti ha avuto, nei confronti dei prodotti di entrambi i sottogruppi, una simile impressione globale media. Rispetto ai prodotti semi stagionati a base di carne, le fette dei prodotti insaccati affumicati hanno mostrato una minor uniformità di colore, una maggiore quantità di tessuto connettivo gelatinoso, una peggiore connessione, una texture più compatta con tessuti più grossolani, una maggior salinità, con aroma di metallo e di rancido meno accentuati e un più accentuato aroma amaro, acido e insolito. La maggiore masticabilità, la pastosità, la coesione, la durezza e l'elasticità (caratteristiche della texture) in tutti i prodotti esaminati incidono non poco sulle caratteristiche qualitative (analisi fattoriale). Inoltre, l'analisi discriminante lineare ha confermato che i prodotti a base di carne dei suddetti sottogruppi si differenziano sia sotto il profilo fisico-chimico, sia sotto il profilo sensoriale.

Parole chiave: prodotti a base di carne trattati termicamente, prodotti a base di carne affumicati, salumi semi stagionati a pezzo intero, caratteristiche fisico-chimiche, proprietà sensoriali