

Sensory profile and likeability of Croatian traditional dry meat products from different regions

Ivica Kos¹, Jelka Pleadin^{2*}, Tina Lešić², Lidija Dergestin Bačun², Tomaž Polak³, Ivan Vnučec¹, Darija Bendelja Ljoljić¹, Nada Vahčić⁴

Abstract

The aim of this paper was to determine the sensory profiles and likeability of two types of traditional dry-cured meat products from four Croatian regions (Central and Northern, Eastern, Western and Southern Croatia). For this purpose, 24 samples of dry-cured ham and 26 samples of dry-cured bacon were evaluated by a trained panel of 9 judges using quantitative descriptive analysis. It was found that the sensory profiles of dry-cured ham and bacon differed significantly in 12 and 13 of the 22 sensory traits, respectively. Nearly all likeability traits of dry-cured ham differed significantly between regions, with the exception of the cross-section likeability which was the only trait that differed among dry-cured bacon samples between regions. The results of principal component analysis (PCA) showed that the attributes of odour and aroma were most important for characterizing and differentiating dry-cured meat products. PCA analysis revealed a strong separation of samples between the Western Croatia region, where aromatic and spicy herb aroma was most important, and the Southern Croatia region, where buttery aroma and smoky odour were most important. Samples from the Central and Northern Croatia region were well recognized within the Southern Croatia region, possibly due to the use of smoke, but with less buttery aroma. Samples from the Eastern Croatia region were poorly recognized, having much overlap with other regions. It can be concluded that the influence of regions on sensory traits is evident regardless of the product, but the contribution of the region should be well defined and robust.

Keywords: dry-cured ham, dry-cured bacon, Croatia, sensory, quantitative descriptive analysis, principal component analysis

Introduction

Traditional dry meat products (TDMPs) are becoming more widely consumed because they represent nutritionally rich products and are made

locally from ingredients familiar to consumers. These products are known and highly appreciated not only in Croatia, but also in many other Europe-

¹ Assoc Prof Ivica Kos, Ph D; Assoc Prof Ivan Vnučec, Ph D; Darija Bendelja Ljoljić, Ph D, postdoctoral assistant, Faculty of Agriculture, University of Zagreb, Svetošimunska cesta 25, 10000 Zagreb, Croatia

² Prof Ph D Jelka Pleadin, Scientific Advisor in Tenure; Tina Lešić, M Sc Biotechnology Engineer, Senior Expert Associate; Lidija Dergestin Bačun, B Sc, Senior Expert Associate, Croatian Veterinary Institute, Savska cesta 143, 10000 Zagreb, Croatia

³ Assoc Prof Ph D Tomaž Polak, Associate Professor, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva ulica 101, 1000 Ljubljana, Slovenia

⁴ Prof Nada Vahčić, Ph D, Full Professor, Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, 10000 Zagreb, Croatia

*Autor za korespondenciju: pleadin@veinst.hr

an countries for their distinctive and delicious odour, taste and texture (García-González et al., 2006). Within the TDMPs in Croatia, dry-cured ham (DCH) and dry-cured bacon (DCB) receive the most attention.

The transformation of meat into dry-cured meat products is mainly because of an increase in salt concentration and decrease of water activity due to curing and drying. The changes in physicochemical properties such as pH and water activity, together with proteolytic and lipolytic reactions, lead to changes in colour, odour, taste, and texture that produce the typical characteristics of the final products (Toldrá, 2004). The conditions during the production (temperature, relative humidity and air flow velocity) along with duration play an important role in the product formation, as they influence the activity of enzymes (Toldrá, 2006). The final sensory properties are additionally promoted when mould growth occurs (Lešić et al., 2021), when different spices are added or when smoke is applied (Kos et al., 2019).

During the production process, not only differences in the recipes of different households, but also major differences in hygienic and environmental production conditions are encountered, which are responsible for the growth of specific microflora, leading to differences in the quality and safety of TDMPs (Asefa et al., 2011). The sensory characteristics of TDMPs depend on the raw materials and ingredients used, the technological process (salting, smoking, drying, ripening) and the microbial ecology developed. Therefore, the use of sensory analysis is necessary as it provides solid and important information about the sensory profile of a product and/or information about consumer preference (Juárez et al., 2016). Among sensory methods, descriptive analysis is widely used because it is possible to obtain a sensory profile by defining and quantifying the attributes associated with the sample (Lawless and Heymann, 2010).

Most recognized dry-cured meat products carry quality labels that ensure production in a specific region, the use of traditional practices, and quality controls, making these products recognizable overall. Moreover, this production is often adapted to regional environmental conditions, which are exploited as much as possible and contribute to the final sensory profile. Therefore, a region was considered as a variable combining manufactu-

rer's skills and technical possibilities, adaptation to climate conditions, raw material selection along with traditional spices and procedures applied in manufacture. Within this, it was hypothesised that region of production will have impact on sensory traits and the aim of this study was to investigate the sensory profiles and likeability of two types of traditional dry-cured meat products from four Croatian regions.

Materials and Methods

Samples

Samples of Croatian TDMPs ($n = 50$) including dry-cured ham ($n = 24$) and dry-cured bacon ($n = 26$) were sampled in the amount of 1.5 to 2 kg from individual small manufacturers during the period 2020 - 2021. TDMPs were produced using traditional recipes and starter cultures-free technologies in different Croatian regions (CNC = Central and Northern Croatia, $n = 12$; EC = Eastern Croatia, $n = 6$; WC = Western Croatia, $n = 11$; SC = Southern Croatia, $n = 21$). Information on technological process, raw material or additives were not collected. Out of 24 dry-cured ham samples, 3 were from CNC region, 4 from EC region, 5 from WC region and 12 from SC region. Out of 26 dry-cured bacon samples, 9 were from CNC region, 2 from EC region, 6 from WC region and 9 from SC region.

Sensory analysis

Sensory evaluation of TDMP samples was conducted by a trained panel of 9 judges (5 males and 4 females) with an age range of 34 to 60 years (mean age = 42.3, SD = 5.9). The judges were selected and generically trained according to the ISO 8586:2012 (ISO, 2012). Additionally, 7 training sessions of 60 min each took place for attribute generation, quantification of the selected terms and calibration across assessors for improved consistency and reproducibility (Lešić et al., 2021). Sensory analysis was carried out in the sensory laboratory of the Faculty of Food Technology and Biotechnology University of Zagreb and in the sensory laboratory of the Faculty of Agriculture University of Zagreb according to the ISO 8589:2007 (ISO, 2007) (room-related technical requirements: relative humidity 50 %–55 %, temperature 20–22 °C) and illumination of 4000 K and 500 lux provided for the working table. Prior sensory evaluation, assessors gave informed

consent. Sensory evaluation made use of a quantitative descriptive analysis (QDA) based on the numerical and unipolar intensity scale developed in collaboration with the Centro Studi Assaggiatori (Brescia, Italy). The intensity of each sensory property was estimated using a numerical scale calibrated from left to right, with “0” indicating the absence of a given sensory trait and “9” indicating its strongest intensity. Sensory traits, definitions and range implemented for sensory evaluation are presented in detail in the study by Lešić et al. (2021).

Sensory evaluation

Individually coded samples were served at the room temperature (two 1.5 mm-thick slices) in sensory booths. Samples were presented in monadic way in a randomized order and 5 min break was considered between samples. In total, 10 sessions were held during 4 days, and within each session five samples and one replicated sample were assessed. Replicated sample was used for the calculation of assessor’s repeatability (the

calculation is based on the differences in absolute value between the scores assigned to the different descriptors of the sample and its replica) within Big Sensory Soft (Centro Studi Assaggiatori, Brescia, Italy). Water, yogurt, sour apple, and unsalted bread were provided to assessors between samples as palate cleansers. Sensory analysis embraced the assessment of 22 sensory profile traits regarding appearance (muscle tissue colour, colour uniformity, presence of adipose tissue-marbling, surface humidity), odour (favourable, unfavourable, smoky odour), texture (tenderness and juiciness), taste (saltiness, sweetness, sourness, bitterness) and aroma (buttery, aromatic herbs, spicy herbs, cured meat, oxidized, fresh meat, mouldy, after-taste and aroma richness). Additionally, likeability of the cross-section, odour, taste, texture, maturity and overall likability was determined.

Statistical analysis

Statistical analyses were performed using the SPSS Statistics Software 22.0 (IBM, NY, USA)

Table 1 Sensory profile of Croatian traditional dry-cured ham in different regions (*mean ± standard error*)

Sensory trait	Traditional dry-cured ham ¹			
	CNC (3)	EC (4)	WC (5)	SC (12)
Colour of the muscle tissue	7.39 ± 0.15	7.88 ± 0.26	7.32 ± 0.56	7.28 ± 0.20
Colour uniformity	6.33 ± 0.75 ^b	7.46 ± 0.21 ^{ab}	7.69 ± 0.50 ^a	7.49 ± 0.14 ^a
Presence of adipose tissue-marbling	3.56 ± 0.31 ^b	3.42 ± 0.57 ^b	3.40 ± 0.50 ^b	5.20 ± 0.50 ^a
Surface humidity	2.89 ± 0.43	3.38 ± 0.41	3.00 ± 0.39	3.72 ± 0.40
Favourable odour	6.22 ± 0.15 ^{ab}	5.46 ± 1.15 ^b	6.93 ± 0.15 ^{ab}	7.06 ± 0.23 ^a
Unfavourable odour	1.17 ± 0.29 ^{ab}	3.21 ± 1.40 ^a	1.34 ± 0.22 ^{ab}	1.00 ± 0.29 ^b
Smoky odour	4.33 ± 0.50 ^a	2.33 ± 0.12 ^b	0.16 ± 0.07 ^c	3.88 ± 0.18 ^a
Tenderness	7.28 ± 0.39	6.67 ± 1.04	6.35 ± 0.55	6.83 ± 0.28
Solubility	6.78 ± 0.20	7.21 ± 0.53	6.83 ± 0.30	7.35 ± 0.25
Saltiness	4.56 ± 0.24	4.58 ± 0.66	5.86 ± 0.42	5.88 ± 0.26
Sweetness	1.39 ± 0.20	1.79 ± 0.38	1.65 ± 0.17	2.25 ± 0.20
Sourness	0.89 ± 0.29	0.96 ± 0.13	1.17 ± 0.08	1.22 ± 0.12
Bitterness	1.06 ± 0.24 ^b	2.08 ± 0.32 ^a	0.98 ± 0.21 ^b	1.11 ± 0.18 ^b
Buttery aroma	3.83 ± 0.35 ^b	3.29 ± 0.62 ^{bc}	2.19 ± 0.13 ^c	5.37 ± 0.29 ^a
Aromatic herbs aroma	1.44 ± 0.29 ^b	1.46 ± 0.18 ^b	3.18 ± 0.22 ^a	1.08 ± 0.08 ^b
Spicy herbs aroma	2.33 ± 0.29 ^b	1.92 ± 0.39 ^b	3.36 ± 0.40 ^a	0.62 ± 0.05 ^c
Cured meat aroma	6.61 ± 0.06	5.92 ± 0.66	6.63 ± 0.27	6.71 ± 0.22
Oxidized aroma	1.11 ± 0.24 ^b	2.92 ± 0.74 ^a	0.79 ± 0.14 ^b	0.86 ± 0.21 ^b
Fresh meat aroma	1.22 ± 0.31 ^a	1.42 ± 0.39 ^a	1.31 ± 0.16 ^a	0.49 ± 0.05 ^b
Mouldy aroma	0.83 ± 0.19 ^b	2.42 ± 0.63 ^a	0.90 ± 0.19 ^b	0.75 ± 0.16 ^b
After-taste	7.50 ± 0.10	6.67 ± 0.70	7.02 ± 0.20	7.54 ± 0.18
Aroma richness	6.94 ± 0.20 ^{ab}	5.75 ± 0.87 ^b	6.72 ± 0.23 ^{ab}	7.23 ± 0.19 ^a

¹ CNC = Central and Northern region; EC = Eastern region; WC = Western region; SC = Southern region; ^{abc} Means with different letters within a row differ significantly ($P < 0.05$)

and the Big Sensory Soft (Centro Studi Assaggiatori, Brescia, Italy). The results were tested for the normality of their distribution using the Shapiro-Wilks test. In order to determine the statistical significance of differences in sensory attributes between regions, the independent samples t-test and Mann-Whitney U test were used. Decisions on statistical significance were made at the level of $P < 0.05$ with assessor included as random error. The results were subjected to principal component analysis (PCA) on correlation matrix to interpret sensory profile traits using the Statistica 10.0 Software (StatSoft, CA, USA).

Results

Sensory profiles of Croatian traditional DCH from four different regions are shown in Table 1. It was found that 13 of the 22 sensory traits significantly differ between regions. These properties are colour uniformity, presence of adipose tissue/marbling, favourable and unfavourable odours, smoky odour, bitterness, buttery aroma, aromatic and spicy herbs aroma, oxidized aromas, fresh meat aroma, mouldy aroma, and aroma richness. It is worth noting that DCH from the CNC region stood out with less colour uniformity, and DCH from the SC region with more presence of adipose tissue/marbling and buttery aroma. DCH from the EC region stood out with a lower intensity of favourable odours and aroma richness, while the intensity of unfavourable odours, and bitterness were more pronounced.

Aromatic and spicy herbs aroma was significantly most pronounced in DCH from the WC region. In contrast, smoke intensity was least pronounced in DCH from the WC region which is consistent with the absence of smoke in that region, while DCH from the CNC and SC regions had the most pronounced smoke odour. DCH samples from the EC region stand out for their most pronounced oxidized aroma and mouldy aroma compared to DCH samples from other regions. Differences of texture and most of taste attributes between regions were not established. Based on the above, it can be concluded that it is possible to distinguish DCH samples from different regions because the methods of production, technological procedures and spices used are important in the characterization of mature products (Toldrá, 2004). Similar observations were shown in previous research on sensory traits

of Croatian DCH designated with PDO or PGI labels reported by Petričević et al. (2018). Authors found that fat color, colour homogeneity, salty and sweet taste and smoky and spicy aroma were significantly different between four types of DCH originating from the Western and Southern region of Croatia. As a contrast to our results, Petričević et al. (2018) reported significant difference in taste attributes, salty and sweet. Research on Chinese dry-cured hams from different regions showed that differences in volatile profile and in instrumental texture traits were significant between samples, and that it is possible to clearly discriminate the ham samples (Li et al., 2020). Accordingly, the sensory analysis of three protected Italian dry-cured hams with the PDO designation of origin (Parma, San Daniele and Toscano) differed from each other in 8 of the 14 sensory attributes as presented by Laureati et al. (2014). The same authors point out that the highest differences were found in the attributes of appearance, taste and texture, while differences in odours and aromas were not determined. This represents a difference in relation to the results obtained, because most of the differences between DCH from different Croatian regions were found in the properties of odour and aroma. The studies presented by Laureati et al. (2014) and Petričević et al. (2018) were conducted on PDO/PGI products, whose raw material characteristics and production processes are precisely defined in the production specifications. In addition, these products are externally controlled for production conformity, which could lead to a higher sensory uniformity of the individual DCH types. These production specifications are important to evaluate the differences between the DCH types. However, they were not taken into account in this study, as the aim was to sensory evaluate the products within the regions, regardless of the characteristics of the raw materials, the additives used and the production process, in order to better understand the impact of the region. Based on the results obtained, it was possible to conclude that the significant differences in DCH between the regions were due to the application of smoke and the use of different spices.

According to the obtained results, the sensory profiles of DCB differed significantly by regions in 13 of 22 traits (Table 2). DCB samples from the EC region stood out with the lowest colour uniformity, the most pronounced presence of adipose tissue/marbling, surface moisture and

saltiness. DCB samples from the CNC region are characterized by the most pronounced sourness and bitterness as well as fresh meat aroma. Smoky odour was least pronounced in DCB from the WC region, as was the case with DCH samples, while

sweetness, aromatic herbs aroma and cured meat aroma were most pronounced, and butter aroma were least pronounced in DCB samples from the EC and WC regions. DCB samples from the SC region stood out with the lowest expression of spicy and

Table 2 Sensory profile of Croatian traditional dry-cured bacon in different regions (*mean ± standard error*)

Sensory trait	Traditional dry-cured ham ¹			
	CNC (3)	EC (4)	WC (5)	SC (12)
Colour of the muscle tissue	6.84 ± 0.31	6.70 ± 1.10	7.93 ± 0.30	7.22 ± 0.25
Colour uniformity	6.84 ± 0.17 ^a	5.60 ± 1.20 ^b	6.93 ± 0.30 ^a	7.36 ± 0.17 ^a
Presence of adipose tissue-marbling	5.80 ± 0.43 ^{ab}	7.30 ± 0.50 ^a	4.93 ± 0.51 ^b	6.22 ± 0.33 ^{ab}
Surface humidity	2.31 ± 0.31 ^c	5.90 ± 0.50 ^a	4.20 ± 0.44 ^b	4.98 ± 0.15 ^{ab}
Favourable odour	6.38 ± 0.24	7.00 ± 0.60	6.50 ± 0.57	5.89 ± 0.22
Unfavourable odour	0.80 ± 0.13	0.30 ± 0.10	1.70 ± 0.79	0.93 ± 0.21
Smoky odour	5.00 ± 0.47 ^a	4.30 ± 0.70 ^a	1.00 ± 0.72 ^b	3.89 ± 0.33 ^a
Tenderness	6.07 ± 0.34	7.20 ± 0.40	6.00 ± 0.42	6.62 ± 0.21
Solubility	7.22 ± 0.11	7.40 ± 0.60	6.87 ± 0.36	7.27 ± 0.11
Saltiness	5.13 ± 0.25 ^b	6.50 ± 0.10 ^a	4.83 ± 0.16 ^b	4.80 ± 0.16 ^b
Sweetness	1.20 ± 0.17 ^c	2.20 ± 0.20 ^{ab}	2.50 ± 0.20 ^a	1.67 ± 0.16 ^b
Sourness	1.27 ± 0.16 ^a	0.40 ± 0.00 ^b	0.50 ± 0.11 ^b	0.76 ± 0.06 ^b
Bitterness	1.00 ± 0.16 ^a	0.60 ± 0.20 ^{ab}	0.33 ± 0.11 ^b	0.60 ± 0.08 ^b
Buttery aroma	4.13 ± 0.21 ^b	2.90 ± 0.50 ^c	2.23 ± 0.23 ^c	4.82 ± 0.16 ^a
Aromatic herbs aroma	0.98 ± 0.11 ^b	2.80 ± 0.20 ^a	2.87 ± 0.21 ^a	1.04 ± 0.09 ^b
Spicy herbs aroma	2.87 ± 0.15 ^a	3.20 ± 0.20 ^a	3.20 ± 0.27 ^a	1.04 ± 0.06 ^b
Cured meat aroma	6.16 ± 0.28 ^b	7.70 ± 0.10 ^a	7.23 ± 0.43 ^a	5.82 ± 0.18 ^b
Oxidized aroma	0.69 ± 0.13	0.50 ± 0.10	1.87 ± 0.75	0.96 ± 0.20
Fresh meat aroma	1.07 ± 0.13 ^a	0.00 ± 0.00 ^b	0.47 ± 0.17 ^b	0.60 ± 0.07 ^b
Mouldy aroma	0.40 ± 0.12	0.10 ± 0.10	0.47 ± 0.15	0.44 ± 0.06
After-taste	7.82 ± 0.17	8.00 ± 0.20	7.70 ± 0.33	7.62 ± 0.12
Aroma richness	7.33 ± 0.14	7.70 ± 0.30	7.10 ± 0.61	7.40 ± 0.22

¹ CNC = Central and Northern region; EC = Eastern region; WC = Western region; SC = Southern region; ^{abc} Means with different letters within a row differ significantly ($P < 0.05$)

aromatic herbs aroma, and a similar finding was found in the DCB from the CNC region. Differences of texture and most odour and aroma attributes were not found between samples from different regions.

Almost all likeability traits of DCH differed significantly between regions, except for cross-section likeability. The higher likeability of odour, taste, texture and maturity of DCH samples from the SC and WC region was found, while the lower expression of these traits was present in the EC region, and the intermediate value in the CNC region. These differences were manifested in the

overall likeability, which was significantly more pronounced in DCH in the CNC, WC and SC region, and lower in the EC region. Unlike DCH products, DCB products were almost indistinguishable in likeability traits, except in cross-section likeability. The expression of that trait was the highest in the WC region, and the lowest in the EC region. Interestingly, although differences in all taste and some odour and aroma attributes of DCB samples were found (Table 2), there were no differences in likeability of odour, taste, nor overall likeability. Previous research on dry cured ham show that juiciness as texture attribute, bitterness as taste attribute and aroma attributes were closely associated with ham

acceptability (Ruiz et al., 2002). Somewhat different results were established in current research, where texture and most of taste attributes were not significantly different between DCH samples, but significant differences were found in likeability of those traits. It appears that odour and aroma attributes have a major role in determining the likeability of Croatian DCH. In support of this is a

previous study on the sensory properties, which found that overall acceptability of Croatian smoked dry-cured ham is closely related to odour intensity and after-taste (Kos et al., 2019). While investigating sensory traits of dry-cured bacon, Saldaña et al. (2019) found that the main drivers of liking were the attributes related to texture, as well as juiciness and the smoky aroma. In the present research

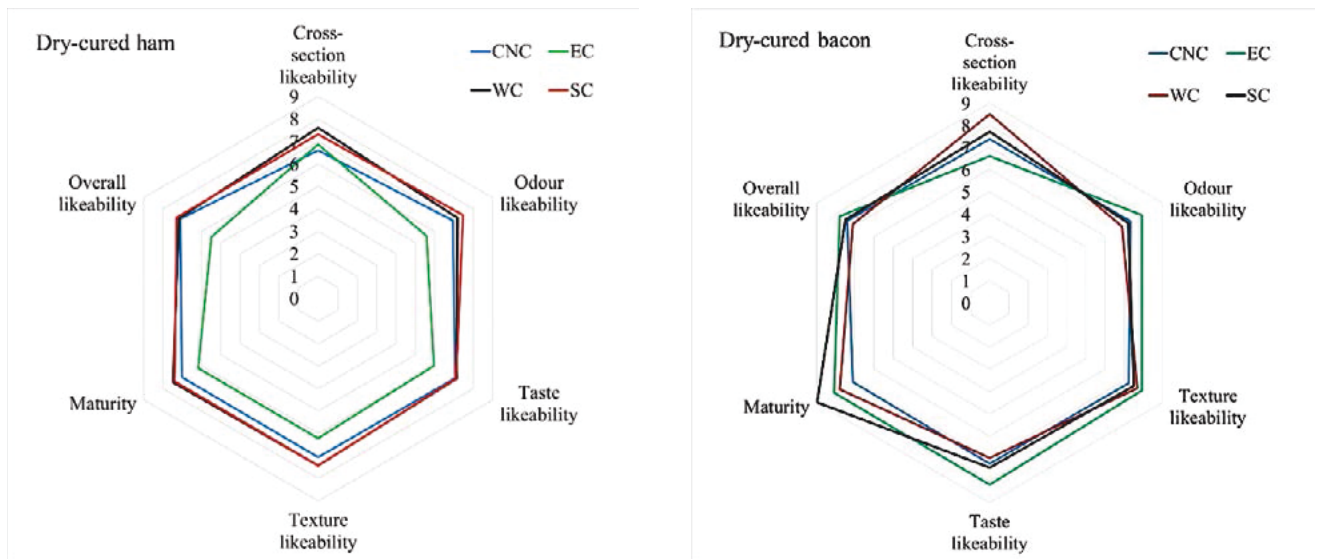


Figure 1 Likeability traits of dry-cured ham and dry-cured bacon from different regions
CNC = Central and Northern region; WC = Western region; EC = Eastern region; SC = Southern region

smoky odour was determined to be significantly different between regions along with other traits, but it seems that determined differences in attributes of sensory profile of DCB between regions are recognized only as differences and had no impact on likeability. Likeability traits of dry-cured ham and dry-cured bacon from different Croatian regions are shown in Figure 1.

The principal component analysis (PCA) was conducted with the aim of determining the underlying variables for elaboration and description of dry meat products. Therefore, PCA was performed only on sensory profile data while likeability traits were excluded from analysis. The first two principal components (PCs) accounted for 51.24 % of variance (PC1 = 30.95 %, PC2 = 15.29 %; Figure 2). The relations between variables and principal components were interpreted according to the correlations between them. Thus, variables that were close to each other were considered positively correlated and those separated by 180° as nega-

tively or by 90° as independently correlated. PC1 was positively correlated with odours and aromas related to products adulteration (unfavourable odour, fresh meat, mouldy and oxidized aroma), and negatively with favourable odours, aroma richness and after-taste. As stated, mouldy aroma was loaded closely to unfavourable odours as it was previously reported by Lešić et al. (2021) on Istrian and Dalmatian ham, while Kos et al. (2019) showed that mouldy aroma was related to rancid, bitterness and sourness when evaluating smoked Croatian DCH. PC2 was correlated with smoky odours on the positive side, and with aromatic and spicy herb aromas on the negative side. It was found that odour and aroma attributes were main sensory traits important for PC characterization as it is discussed above. On the other hand, sensory traits such as colour uniformity, saltiness, surface humidity, sweetness, tenderness and solubility had low importance for dry cured products characterisation between regions. Contrary to that finding,

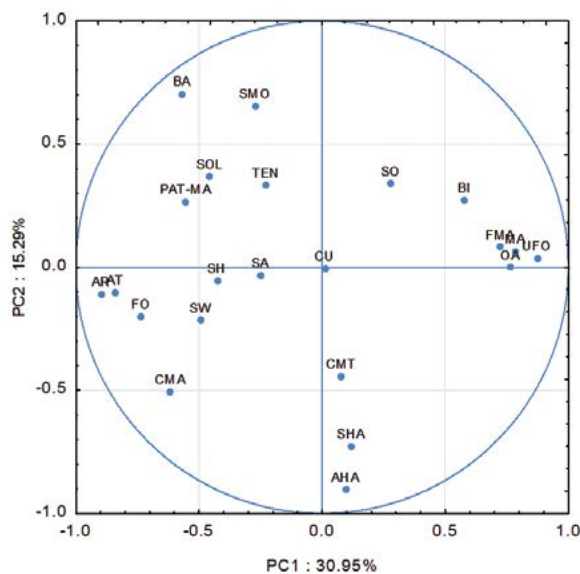


Figure 2 PCA loading plot of sensory profile data on the first two principal components (PC1 and PC2)

CMT = muscle tissue colour; CU = colour uniformity; PAT-MA = presence of adipose tissue-marbling; SH = surface humidity; FO = favourable odour; UFO = unfavourable odour; SMO = smoky odour; TEN = tenderness; SOL = solubility; SA = saltiness; SW = sweetness; SO = sourness; BI = bitterness; BA = buttery aroma; AHA = aromatic herbs aroma; SHA = spicy herbs aroma; CMA = cured meat aroma; OA = oxidized aroma; FMA = fresh meat aroma; MA = mouldy aroma; AR = aroma richness; AT = after-taste

sweetness and saltiness was assigned as highly important contributor to PC characterization in previous research on Croatian DCH (Kos et al., 2019; Lešić et al., 2021; Petričević et al., 2018). In literature there are scarce research on sensory traits of DCB, especially those related to Croatian products and QDA analysis, so it appears that PCA analysis on joined sensory data of DCH and DCB revealed new traits important for characterization of traditional dry cured meat products.

The spatial position of individual samples in the PCA coordinate system based on first two PCs is shown in the score plot (Figure 3), where ellipses containing samples from the same region marked with the same colour are presented. Weak sample discrimination was observed when moving along PC1 (from left to right) on which favourable and unfavourable odours and aromas had the highest impact. Much better discrimination of samples according to the region of production was observed when moving along PC2 axis (from top to bottom). It was found that DCB and DCH samples from the SC region (marked green) were grouped in the upper quadrants where buttery aroma, smoky odour, solubility, tenderness, presence of adipose tissue or marbling and sourness had greatest importance. On the other hand, samples from the WC region (marked blue) were grouped only in the lower quad-

rants where aromatic and spicy herb aroma, colour of muscle tissue and cured meat aroma had the largest contribution. There was no overlapping of TDCP samples between those two regions meaning that sensory profile can be clearly separated between Southern (SC) and Western (WC) region of Croatia. As contrast, the samples from other two regions (CNC marked purple and EC marked yellow) overlapped with the SC and WC regions. It was found that the samples from the CNC region were placed closer to the SC region probably due to inclusion of smoking in product manufacture, but sensory traits like surface humidity, saltiness and colour uniformity had more impact for region definition. Even more, samples from EC region were positioned on much wider space in PCA score plot meaning much higher variability of products within that region. Furthermore, samples from EC region showed highest degree of overlapping with other regions which entails that discrimination from other samples would be very difficult. Previous research on Croatian designated dry-cured hams presented by Petričević et al. (2018) showed similar pattern. Those authors reported clear separation of Istrian and Krk ham (which are produced in WC region) from Dalmatian and Drniš ham (which are produced in SC region). Furthermore, similar main drivers for such orientation were determined,

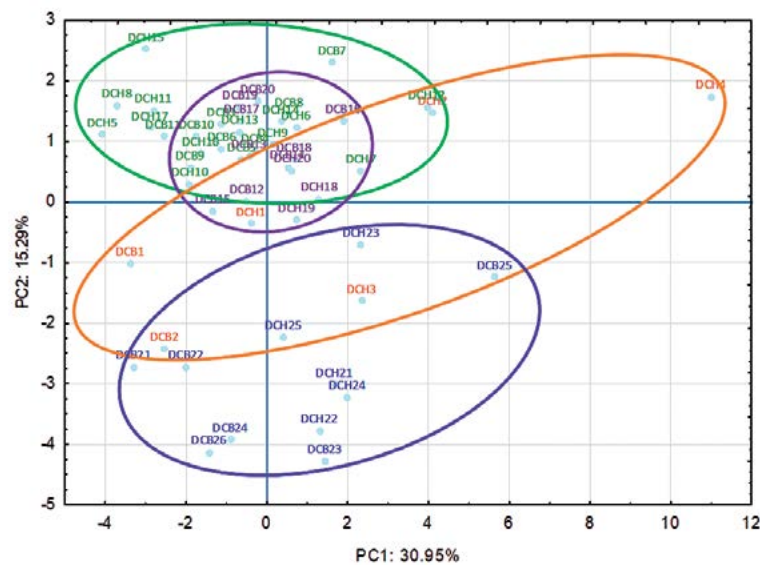


Figure 3 PCA score plot of the first two principal components (PC1 and PC2) of dry-cured ham (DCH) and dry-cured bacon (DCB) samples

Green = SC-Southern region; purple = CNC-Central and Northern region; orange = EC-Eastern region; blue = WC-Western region fresh meat aroma; MA = mouldy aroma; AR = aroma richness; AT = after-taste

namely smoky odour on one side and spicy aroma on the another. Based on that, it can be concluded that contribution of region to TDMP characterization is high regardless which product is produced, but properties of region should be well defined and robust, like in WC and SC region.

Conclusions

Based on the results of sensory analysis of Croatian dry-cured ham (DCH) and dry-cured bacon (DCB), it can be concluded that region plays an important role in defining sensory profile of traditional dry-cured meat products. Although discriminating sensory traits between those two product types were not the same, more than 50% of sensory profile attributes were significantly different. When analysing 6 likeability traits, the impact of region was also established, with five traits differing in DCH resulting in high discrimination among regions. Contrary to this, only one likeability trait in DCB was significantly different between regions, so it can be concluded that differences in sensory profile had no impact on likeability. After analysing sensory profile traits with principal component analysis, attributes related to odour and aroma were recognized as most important. The PCA score plot revealed strong separa-

tion of DCH and DCB samples between WC region where aromatic and spicy herbs aroma were most important and SC region where buttery aroma and smoky odour were most important. Samples from CNC region were well recognized within SC region possibly because of application of smoke but with less buttery aroma. Samples from EC region were poorly recognized on largest area, and with much overlap with other regions. Based on that, it can be concluded that effect of region in TDMP characterization is evident regardless the product, but contribution of region should be well defined and robust, like in WC and SC region.

Acknowledgement

The authors would like to thank the sensory analysts that supported the data obtained for the study. This research was funded by the Croatian Science Foundation under the project "Mycotoxins in traditional Croatian meat products: molecular identification of mycotoxin-producing moulds and consumer exposure assessment" (No. IP-2018-01-9017) and by the "Food Safety and Quality Center" (KK.01.1.1.02.0004) project funded by the European Regional Development Fund.

References

- [1] Asefa, D.T., C.F. Kure, R.O. Gjerde, S. Langsrud, M.K. Omer, T. Nesbakken, I. Skaar (2011): A HACCP plan for mycotoxigenic hazards associated with dry-cured meat production processes. *Food Control* 22, 831-837.
- [2] García-González, D.L., P. Roncales, I. Cilla, S. del Río, J.P. Poma, R. Aparicio (2006): Interlaboratory evaluation of dry-cured hams (from France and Spain) by assessors from two different nationalities. *Meat Sci* 73, 521-528.
- [3] ISO, International Organization for Standardization (2007): Sensory Analysis - General Guidance for the Design of Test Rooms. ISO Standard 8589:2007. ISO, Geneva, 2007.
- [4] ISO, International Organization for Standardization (2012): Sensory analysis — General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors. ISO Standard 8586:2012. ISO, Geneva, 2012.
- [5] Juárez, M.E., S.C. Carlin, F. Rebollo, A. Verdugo-Rodríguez, D. Martínez-Gómez (2016): Sensory evaluation of cooked pork meat (M. Bicepsfemoris) fed with and without ractopamine hydrochloride associated to age but not gender of the non-trained panelist. *J Anim Plant Sci* 26, 40–45.
- [6] Kos, I., B. Sinčić Pulić, D. Gorup, A. Kaić (2019): Sensory profiles of artisanal smoked dry-cured ham as affected by production season. *J Cent Eur Agric* 20, 1089-1098.
- [7] Laureati, M., S. Buratti, G. Giovanelli, M. Corazzin, D.P. Lo Fiego, E. Pagliarini (2014): Characterization and differentiation of Italian Parma, San Daniele and Toscano dry-cured hams: a multi-disciplinary approach. *Meat Sci* 96 (1), 288-294.
- [8] Lawless, H.T., H. Heymann (2010): Descriptive analysis. U: *Sensory Evaluation of Food*. Springer. New York, 2010., str. 227–257.
- [9] Lešić, T., N. Vahčić, I. Kos, M. Zadravec, D. Miličević, I. Perković, E. Listeš, J. Pleadin (2021): The Influence of Surface Mycobiota on Sensory Properties of "Istarski pršut" and "Dalmatinski pršut". *Processes* 9 (12), 2287.
- [10] Li, F., X. Feng, D. Zhang, C. Li, X. Xu, G. Zhou, Y. Liu (2020): Physical properties, compositions and volatile profiles of Chinese dry-cured hams from different regions. *Food Measure* 14, 492–504.
- [11] Petričević, S., N. Marušić Radovčić, K. Lukić, E. Listeš, E., H. Medić (2018): Differentiation of dry-cured hams from different processing methods by means of volatile compounds, physico-chemical and sensory analysis. *Meat Sci* 137, 217-227.
- [12] Ruiz, J., C. García, E. Muriel, A.I. Andrés, J. Ventanas (2002): Influence of sensory characteristics on the acceptability of dry-cured ham. *Meat Sci* 61 (4), 347-354.
- [13] Saldaña, E., L. Saldarriaga, J. Cabrera, J.H. Behrens, M.M. Selani, J. Rios-Mera, C.J. Contreras-Castillo (2019): Descriptive and hedonic sensory perception of Brazilian consumers for smoked bacon. *Meat Sci* 147, 60-69.
- [14] Toldrá, F. (2004): Dry-cured ham. U: *Handbook of food and beverage fermentation technology*. Marcel-Dekker Inc. New York, 2004., str. 369–384.
- [15] Toldrá, F. (2006): The role of muscle enzymes in dry-cured meat products with different drying conditions. *Trends in Food Science & Technology* 17(4), 164-168.

Delivered: 12.04.2022.

Accepted 26.05.2022.

Senzorski profili i dopadljivost hrvatskih tradicionalnih suhomesnatih proizvoda iz različitih regija

Sažetak

Cilj ovog rada bio je utvrditi senzorski profil i dopadljivost dviju vrsta tradicionalnih suhomesnatih proizvoda iz četiri hrvatske regije (srednja i sjeverna, istočna, zapadna i južna Hrvatska). U tu svrhu, 24 uzorka sušene šunke i 26 uzoraka sušene slanine ocijenjeno je od strane 9 sudaca senzorskog panela korištenjem kvantitativne deskriptivne analize. Utvrđeno je da se senzorski profili sušene šunke i slanine značajno razlikuju u 12 odnosno 13 od 22 senzorska svojstva. Gotovo sva svojstva dopadljivosti sušene šunke značajno su se razlikovala među regijama, s izuzetkom dopadljivosti presjeka koje je bilo jedino svojstvo koje se razlikovalo među uzorcima suhe slanine. Rezultati analize glavnih komponenti (PCA) pokazali su da su svojstva mirisa i arome najvažniji za karakterizaciju i razlikovanje suhomesnatih proizvoda. PCA analizom utvrđeno je jasno odvajanje uzoraka regije zapadne Hrvatske, gdje su arome aromatičnog i začinskog bilja bile najvažnije, od uzoraka iz regije južne Hrvatske, gdje su aroma maslaca i miris dima bili najznačajniji. Uzorci iz regije središnje i sjeverne Hrvatske bili su smješteni unutar regije južne Hrvatske, vjerojatno

zbog primjene dima, ali s manje arome maslaca. Uzorci iz regije istočne Hrvatske bili su najslabije okarakterizirani i u velikoj mjeri su se preklapali s drugim regijama. Može se zaključiti da je utjecaj regije na senzorska svojstva značajan neovisno o vrsti proizvoda, ali doprinos regije treba biti dobro definiran s opsežnim učinkom.

Ključne riječi: sušena šunka, slanina, Hrvatska, senzorno, kvantitativna deskriptivna analiza, analiza glavnih komponenti

Sensorisches Profil und Markensympathie von traditionellen kroatischen Trockenfleischprodukten aus verschiedenen Regionen

Zusammenfassung

Ziel dieser Arbeit war es, das sensorische Profil und die Markensympathie von zwei Arten traditioneller Trockenfleischprodukte aus vier kroatischen Regionen (Zentral- und Nordkroatien, Ost-, West- und Südkroatien) zu bestimmen. Zu diesem Zweck wurden 24 Proben trocken gepökelten Schinkens und 26 Proben trocken gepökelten Specks von einem Gremium aus 9 Richtern des sensorischen Panels anhand einer quantitativen deskriptiven Analyse bewertet. Es wurde festgestellt, dass sich die sensorischen Profile von trocken gepökeltem Schinken und Speck in 12 bzw. 13 der 22 sensorischen Merkmale signifikant unterscheiden. Fast alle Sympathiemerkmale des trocken gepökelten Schinkens unterscheiden sich signifikant zwischen den Regionen, mit Ausnahme der Sympathie von Querschnitten, die das einzige Merkmal war, das sich bei den Proben des trocken gepökelten Schinkens zwischen den Regionen unterscheidet. Die Ergebnisse der Hauptkomponentenanalyse (PCA) zeigten, dass die Attribute Geruch und Aroma für die Charakterisierung und Unterscheidung von gepökelten Fleischprodukten am wichtigsten waren. Die PCA-Analyse ergab eine starke Trennung der Proben zwischen der Region Westkroatien, in der aromatisches und würziges Kräuteraroma die größte Rolle spielten, und der Region Südkroatien, in der buttriges Aroma und rauchiger Geruch am wichtigsten waren. Proben aus der Region Mittel- und Nordkroatien wurden der Region Südkroatien zugewiesen, was möglicherweise auf die Verwendung von Rauch zurückzuführen ist, allerdings mit weniger Butteraroma. Proben aus der Region Ostkroatien wurden nur schlecht erkannt, da sie sich stark mit anderen Regionen überschneiden. Daraus lässt sich schließen, dass der Einfluss der Regionen auf die sensorischen Merkmale, unabhängig vom Produkt, offensichtlich ist, dass aber der Beitrag der Region genau definiert und umfassend sein sollte.

Schlüsselwörter: Trockenschinken, Trockenspeck, Kroatien, sensorisch, quantitative deskriptive Analyse, Hauptkomponentenanalyse

Perfiles sensoriales y agradabilidad de los productos cárnicos curados tradicionales croatas de diferentes regiones

Resumen

El objetivo de este estudio fue determinar el perfil sensorial y la agradabilidad de dos tipos de productos cárnicos curados tradicionales de cuatro regiones croatas (las regiones central y la del norte, la del este, la del oeste y el sur de Croacia). Para este propósito, 24 muestras de jamón seco y 26 muestras de tocino seco fueron evaluadas por 9 jueces del panel de sensores utilizando un análisis descriptivo cuantitativo. Se determinó que los perfiles sensoriales del jamón seco y del tocino difieren significativamente en 12 y 13 de 22 propiedades sensoriales, respectivamente. Casi todos los rasgos

de la agradabilidad del jamón seco difirieron significativamente entre regiones, con la excepción de la agradabilidad de la sección transversal, que fue el único rasgo que difirió entre las muestras de tocino seco. Los resultados del análisis de los componentes principales (ACP) mostraron que las propiedades de olor y aroma son las más importantes para la caracterización y diferenciación de los productos cárnicos curados. El análisis ACP reveló una clara separación de las muestras de la región del oeste de Croacia, donde los aromas de hierbas aromáticas y especiadas eran más importantes, de las muestras de la región del sur de Croacia, donde el aroma de la mantequilla y el olor a humo eran más importantes. Las muestras de la región del centro y del norte de Croacia fueron reconocidas en la región del sur de Croacia, probablemente debido al uso de humo, pero con menos aroma a mantequilla. Las muestras de la región del este de Croacia fueron las menos caracterizadas y fueron superpuestas en gran medida con otras regiones. Se puede concluir que la influencia de la región en las propiedades sensoriales es significativa independientemente del tipo de producto, pero la contribución de la región debe estar bien definida con un impacto extensivo.

Palabras claves: jamón curado, tocino, Croacia, sensorial, análisis descriptivo cuantitativo, análisis de componentes principales

Profilo sensoriale e gradimento dei tradizionali prodotti insaccati croati provenienti da diverse regioni

Riassunto

Lo scopo di questo documento consisteva nel determinare i profili sensoriali e il gradimento di due tipi di prodotti tradizionali insaccati provenienti da quattro regioni croate (Croazia centrale e settentrionale, orientale, occidentale e meridionale). A tale scopo, 24 campioni di prosciutto crudo essiccato e 26 campioni di pancetta essiccata sono stati valutati da un "panel" di 9 giudici mediante analisi quantitativo-descrittive. È stato riscontrato che i profili sensoriali del prosciutto crudo e della pancetta essiccata differivano in modo significativo rispettivamente in 12 e 13 dei 22 tratti sensoriali. Quasi tutti i tratti di gradimento del prosciutto crudo essiccato differivano significativamente tra le regioni, ad eccezione del gradimento della sezione trasversale, che era l'unico tratto che differiva tra i campioni di pancetta essiccata tra le regioni. I risultati dell'analisi dei componenti principali (PCA) hanno mostrato l'importanza degli attributi di odore e aroma per caratterizzare e differenziare i prodotti a base di carne essiccata. L'analisi PCA ha rivelato una netta separazione dei campioni tra la regione della Croazia occidentale, dove l'aroma di erbe aromatiche e speziate era più importante, e la regione della Croazia meridionale, dove erano più importanti l'aroma burroso e l'odore affumicato. I campioni della Croazia centrale e settentrionale sono stati ricondotti alla regione della Croazia meridionale, forse a causa dell'uso del fumo, ma con un aroma meno burroso. I campioni della Croazia orientale sono stati individuati con maggior difficoltà, avendo molti punti di sovrapposizione con altre regioni. Si può concludere che l'influenza delle regioni sui tratti sensoriali è evidente indipendentemente dal prodotto, ma il contributo della regione dovrebbe essere meglio e più efficacemente definito.

Parole chiave: prosciutto crudo essiccato, pancetta essiccata, Croazia, analisi sensoriale, analisi quantitativo-descrittiva, analisi delle componenti principali