Original scientific paper
DOI: /10.5513/JCEA01/20.4.2431
Journal of Central European Agriculture, 2019, 20(4), p.1089-1098

Sensory profiles of artisanal smoked dry-cured ham as affected by production season

Senzorni profili zanatskih dimljenih pršuta pod utjecajem proizvodne sezone

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ABSTRACT

The aim of this paper was to determine the effect of production season on sensory attributes of artisanal smoked dry-cured ham and to elaborate findings by non-parametric testing and principal component analysis. Artisanal dry-cured hams (73 samples) were collected on open market during five consecutive production seasons from the year 2011 to 2015, and quantitative descriptive analysis was performed. The results showed that 10 out of 18 sensory attributes were significantly different ($P<0.05$) between production seasons. Principal component analysis revealed that the first two principal components explained 45.53% of the total variance. It was found that the odor intensity and after-taste had the strongest positive correlations with the overall acceptability, whereas rancid flavor, mold aroma, bitterness and sourness had the strongest negative correlations. There was no clear separation of production seasons, and a lot of overlapping was observed because dry-cured hams within every production season originated from 12 to 18 individual producers on open market which raised product variability. However, it was possible to describe the seasonal pattern of every production season with specific sensory profile. It can be concluded that production season is a useful variable for describing changes of sensory traits in artisanal dry-cured ham manufacture.

Keywords: dry-cured ham, principal component analysis, production season, sensory traits, artisanal, environmental, manufacture

SAŽETAK

Cilj ovog rada bio je utvrditi utjecaj proizvodne sezone na senzorna svojstva zanatskih dimljenih pršuta i elaborirati rezultate neparametrijskim testovima i analizom glavnih komponenti. Zanatski proizvedeni pršuti (73 uzoraka) su skupljani na otvorenom tržištu tijekom pet uzastopnih proizvodnih sezona od 2011. do 2015. godine i obrađeni pomoću kvantitativne deskriptivne analize. Utvrđeno je da se 10 od 18 senzornih svojstava značajno razlikovalo ($P<0,05$) između proizvodnih sezona. Analiza glavnih komponenti pokazala je da su prve dvije glavne komponente objasnile 45,53% ukupne varijance. Utvrđeno je da su intenzitet mirisa i postojanost arome bili najjače pozitivno povezani s ukupnom dopadljivošću, dok su ranketljive arome, arome po plijesnima, gorkost i kiselost bili najjače negativno povezani. Kao što je bilo očekivano, nije bilo jasnog razdvajanja proizvodnih sezona i uočena su mnogo preklapanja zbog korištenja pršuta

individualnih proizvođača s otvorenog tržišta što je povećalo varijabilnost. Međutim, bilo je moguće opisati obilježja svake proizvodne sezone sa specifičnim senzornim profilom. Može se zaključiti da je proizvodna sezona korisna varijabla za opisivanje promjena senzorskih svojstava zanatski proizvedenih pršuta.

Ključne riječi: pršut, analiza glavnih komponenti, proizvodna sezona, senzorna svojstva, zanatski, okolišni, proizvodnja

INTRODUCTION

The quality of dry-cured ham is influenced by external and internal factors that can be divided into factors related to the raw material and processing conditions (Ruiz et al., 2002; Kos, 2011; Čandek-Potokar and Škrlep, 2012). Most of the distinguished dry-cured hams are designated with one of the quality labels as Protected Designation of Origin label (PDO) or Protected Geographical Indication (PGI) which assures quality procedures and controls and makes those products recognizable. In those specifications, several important criteria like pig genotype, breeding technology, slaughter procedure, fresh meat quality traits and technological processing are specified leading to product uniformity as it was found beneficial in many studies (Gonzalez and Ockerman, 2000; Schivazappa et al., 2002; Gilles, 2009; Božac et al., 2011; Čandek-Potokar and Škrlep, 2012). Many artisanal meat products rely on manufacturer's knowledge and technological capabilities where environmental conditions are much used in production. That production is characterized by low to medium level of technologically modern procedures and practices, and products are regionally distributed. Moreover, it is not unusual to find that raw material (fresh hams) used for artisanal production are not fully controlled in terms of pig genotype, feeding, age nor sex, all that could be an important source of product variability. Furthermore, artisanal production of dry-cured ham is often aligned with annual seasons during which the favorable environmental conditions are exploited as much as possible. In these circumstances the production season can be specified as the period from salting and smoking in the colder seasons (late autumn, winter) following drying in spring and ripening in summer and autumn, usually in cellars (Kos and Sinčić, 2013). Previous studies related to manufacture process have shown that intentionally induced different temperatures and relative humidity, application of smoke as well as duration of the individual phases in the production have a significant influence on the physical, chemical and sensory traits of the finished products (Toldrá and Flores, 1998; Arnau et al., 2003; Kos et al., 2009; Martuscelli et al., 2009; Pugliese et al., 2012; Pleadin et al.,2015; Górska et al., 2017).

Sensory traits of dry-cured ham are mostly affected by the degree of protein and lipid breakdown by proteolytic and lipolytic enzymes. These changes affect visual and textural traits, odor and taste causing specific consumer acceptability and likeability (Toldrá and Flores, 1998; Gandemer, 2009). Many studies suggest that enzyme activity is highly dependent on temperature and water activity implying the effect of environmental conditions and drying rate on sensory traits development. Recent study performed by Pena et al. (2013) demonstrated that even the genetic background of the pigs raised in identical nutrition and management conditions influenced appearance, taste, flavor, and texture attributes of dry-cured hams. Authors proposed that this is done probably through the regulation of both the animal body growth and composition and the biochemical reactions that underlie dry-cured ham processing. Furthermore, dry-cured ham is made from one shaped but intact piece of meat, and its final quality is known at the consumption. Hence, a better understanding of seasonal variations is an important topic, particularly essential for standardization of product quality. In the present study it was proposed that the production season is a highly complexed variable consisting of varying environmental and processing conditions as well as raw material quality, and which could affect the sensory profile of artisanal smoked dry-cured ham. Furthermore, it was assumed that it could serve as a tool for explaining small effects which were not identified in artisanal manufacture for the open market.

Therefore, the aim of this paper was to determine the effect of production season on sensory attributes and to elaborate findings by non-parametric testing and principal component analysis.

MATERIALS AND METHODS

The data used for the study were taken from the sensory analyzes of smoked dry-cured hams from local Croatian producers. Dry-cured hams were produced during five consecutive production seasons from the year 2011 to 2015. Sensory analyzes of dry-cured hams were carried out in October of each successive year, and the last analysis was performed in 2016. Dry-cured hams were between 12 and 18 months old at the time of sensory analysis. A total of 73 samples were analyzed, out of which 14 samples were from the production season 2011, 12 samples from the season 2012, 18 samples from the season 2013, 15 samples from the season 2014, and 14 samples from the season 2015.

Sensory profiles of dry-cured hams were obtained using quantitative descriptive analysis (Lawless and Heymann, 2010). Altogether, 14 educated assessors were included in the analysis. Assessors were certificated and trained under the ISO 8586-1 (1993) and ISO 8586-2 (1994) standards. A lexicon for describing the sensory profile was established with 18 sensory attributes and their description did not change during the following analysis. A 10-point structured scale from 0 (completely absent) to 9 (full intensity or presence of the trait) was used in the analysis. Sensory analyzes were conducted in a well-lit room temperature of about 23 °C and relative humidity of 50-70%. The samples were prepared in a uniform manner by cutting dry-cured hams 7 cm deep on caudal part. From that point, samples were prepared with a knife having a thickness of 2 mm, a length of 10 cm, and a width of the ham cross section and then individually labelled. Sample preparation was performed immediately before serving on a white porcelain plate. During sensory analyses, each sample was evaluated in duplicate (two sessions). In each session, assessors were offered with tap water and bread to rinse and neutralize the mouth.

The data were processed using the NPAR1 non-parametric test procedure of the SAS Studio University Edition 3.4 (SAS Institute, 2015). Production seasons were compared using the Kruskal-Wallis test and the DSCF (Dwas, Steel, Critchlow-Flinger) method. Differences were considered if $P<0.05$. The results of non-parametric analyzes are expressed as means and standard deviations. Principal component analysis (PCA) was applied on the correlation matrix with Varimax rotation using the XLStat statistical suite Version Pro 7.5. (XLSTAT, 2004).

RESULTS AND DISCUSSION

Sensory attributes of smoked dry-cured hams produced during five consecutive production seasons are presented in Table 1. The results showed that 44.44% of the observed attributes (8 out of 18) were not significantly different ($P>0.05$) between the seasons. These attributes were redness, color uniformity, marbling, odor intensity, saltiness and sourness, rancid flavor and mold aroma. All other attributes (10 out of 18 attributes) significantly differed ($P<0.05$) between production seasons. These attributes were smoke intensity, surface wetness, tenderness, solubility, sweetness and bitterness, butter flavor, fresh meat aroma, after-taste and overall acceptability. Kos and Sinčić Pulić (2013) investigated differences among sensory attributes of 24 Dalmatian hams produced during the season 2010, 2011 and 2012. They reported significant differences ($P<0.05$) in tenderness, solubility, butter flavor and overall acceptability between production seasons, similarly to the present study. However, they also reported significant differences ($P<0.05$) in redness, color uniformity, marbling and odor intensity. Somewhat different conclusions were given by Andrés et al. (2004) who established that different temperature conditions in Iberian ham processing did not affect most of the analyzed sensory traits, except dryness, hardness and rancid flavor. The afore-mentioned effect of temperature combined with the effect of relative humidity on physicochemical and appearance traits as stated in the study by Arnau et al. (2003) could be the reason that production season had an influence on sensory attributes

in our study. Furthermore, results of the study reported by Pena et al. (2013) demonstrate that genetic factors of the pig also influence the perception of the sensory attributes generated during dry-cured ham processing and it should be considered as underlying influence.

The effect of production season on quality of dry-cured ham was previously reported by Pleadin et al. (2015). Those authors reported that the fatty acid composition was significantly different during three production seasons. It is known that numerous quality traits of dry-cured hams depend on lipid content and changes during processing (Gandemer, 2002). Throughout a complex set of chemical reactions, lipids are solvent of many aroma components and are precursors of many volatiles affecting aroma (Gandemer, 2009). These are highly correlated with other sensory traits related to appearance, texture and taste (Ventanas et al., 2007; Marušić et al., 2014). Therefore, it is possible that the changes in fatty acid composition could had also an impact on sensory profile of hams confirming the effect of season variations.

Differences between the individual production seasons are complex and therefore in the present study are not explained for each sensory trait, but several important attributes were evaluated. It could be pointed out that smoke intensity statistically differed between production seasons ($P<0.05$). Toldrá (2002) and Marušić Radovčić (2016) reported that smoking has several advantages, i.e. it gives a distinctive aroma and flavor, influences the texture and color of meat (reaction of smoke carbonyls with amino groups of proteins), improves the overall sensory acceptability of foods, and because of the presence of phenols smoke has bactericidal, bacteriostatic and antioxidant effect. The highest smoke intensity in the present study was assessed in the production year 2011 (6.04), whereas the lowest was in the production year 2012 (4.24). Such significant differences between production seasons could be because of modifications of smoking treatment in artisanal production. Namely, smoking is usually a subjective assessment of a producer given by the climatic conditions. In the case of more humid days, hams are smoked more (Kos, 2011), and therefore a higher smoke intensity in the product could be expected. According to the results of the smoke intensity, it could be concluded that the hams from the production season 2011 were subjected to a stronger smoking process than the ones from the other production seasons because of adaptation of production process to specific environmental conditions.

The results showed that the hams from the production season 2011 and 2014 had significantly higher ($P<0.05$) surface wetness when compared to the season 2013. According to Ruiz-Carrascal et al. (2000) high concentration of oleic acid in the intramuscular fat of dry-cured hams is linked to a high fluidity of the fat in the surface of the lean which influences on the wetness and finally appearance of the product. It is well-known that fatty acid composition of pig meat is highly depended on rearing system and feeding regime. When this is added to the insufficient control of fresh ham which could happen in artisanal production, higher product variability can occur. This is in accordance with the results of Pleadin et al. (2015) who reported that the production season could significantly influence fatty acid profile of dry-cured ham. Furthermore, it has been reported that in various Iberian dry-cured products high concentrations of oleic acid have been related to pleasant aroma like butter flavor (Ruiz et al., 2002; Ventanas et al., 2007). Similar was established in this study because butter flavor had significantly lower intensity in the production season 2013, as surface wetness had too.

Tenderness and solubility were also significantly different among production seasons ($P<0.05$). Dry-cured hams produced in the season 2012 had the lowest score for tenderness (6.81) and solubility (6.98), whereas the hams produced in the year 2015 had the highest score for tenderness (7.58) and solubility (7.77). Literature data shows that changes in the tenderness and solubility of dry-cured hams could be numerous. Namely, Buscailhon et al. (1994) reported that tenderness decreases with ageing of the hams. Monin et al. (1997) reported that changes in the tenderness of Bayonne ham during ageing have been attributed to water content and the state

of the protein. Arnau et al. (1998) and Guerrero et al. (1999) reported that hams with low pH values have lower tenderness, whereas Andronikov et al. (2013) indicated that tenderness could be related to the muscle location of the hams, irrespective of the fresh ham mass and the salt content of the dry ham. As stated by Topel et al. (2013), tenderness and solubility of the hams (among other sensory attributes such as flavor and juiciness) are also related to the intramuscular fat content. Marbling, which could be explained as visual perception of intramuscular fat content, was not significantly different between production seasons, therefore it is assumed that the fatty acid composition could have a more important role as shown by Pleadin et al. (2015).

Aroma and flavor are key attributes that have an impact on the overall acceptance of dry-cured products (Górska et al., 2017). Results in the present study revealed that butter flavor differed significantly ($P<0.05$) between production seasons. The most intensive butter flavor was in the production season 2012 (5.46), whereas the lowest was in the production season 2013 (3.72). Main biochemical reactions involved in aroma and flavor characterization are lipolysis and proteolysis that produce a wide range of volatiles and precursors (Toldrá and Flores, 1998; Toldrá, 2009; Górska et al., 2017). According to Gonzalez and Ockerman (2000) and Gandemer (2002) processing duration and temperature have a major impact on the course of lipolysis and proteolysis, the content of free amino and fatty acids, and the activity of lipolytic and proteolytic enzymes. If the processing conditions with higher temperatures are longer, the activity of lipolytic and proteolytic enzymes will be higher, the content of free fatty acids and amino acids will be higher and consequently the aroma would be more pronounced and richer as reported by Toldrá (2002). Temperatures during drying and ripening in artisanal production of smoked ham are often uncontrolled and influenced by the environmental conditions (Kos et al., 2009). Therefore, some differences in the aroma between production seasons could be due to these uncontrolled conditions.

The overall acceptability of hams was significantly different ($P<0.05$) between production seasons. The highest overall acceptability was in the production season 2015 (7.58) whereas the lowest was in the production season 2011 (6.94) when smoke intensity had the highest score (6.04). Pham et al. (2008) reported that smoked dry-cured ham products have higher consumer acceptability scores than non-smoked ones. Morrissey et al. (1998) concluded that lipid oxidation is a major factor that has a detrimental impact on the quality and acceptability of meat products. It is well-known that smoking has many positive effects, so it is expected that smoked meat products will be more stable and durable. Smoking is an essential operation for smoked products making those products sensorially distinctive to non-smoked products. Although smoke perception is needed for smoked meat products, it appears that its intensity is not linearly but downward parabolically related to product's acceptability. This could mean that smoke intensity is beneficial to some point from which forward could have negative effect.

The principal component analysis (PCA) was conducted with the aim of determining the most suitable attributes for elaboration and description of production seasons. The analysis included sensory evaluation scores of 73 smoked dry-cured hams. The first principal component (PC1) explained 25.95% of the variation in the data, the second principal component (PC2) explained 19.58% of the variation, whereas the third principal component (PC3) explained 19.11% of the variation. Cumulatively, the first two PCs explained 45.53% of the total variance. Contribution of the attributes to the first three principal components are shown in Table 2. The emphasis is made on attributes with a contribution of more than 1/18 (1/number of attributes). Attributes like butter flavor, surface wetness, sweetness, marbling, and saltiness had the highest contribution to PC1 characterization with a total participation in of 90.61%. Characterization of PC2 was mostly attributed to the overall acceptability, marbling, rancid flavor, after-taste, smoke intensity, color uniformity and solubility with a participation of 78.31%. PC3 was mostly characterized by the smoke intensity, redness and salty flavor with a total participation of 83.81%.

Table 1. Sensory attributes (mean ± standard deviation) for smoked dry-cured hams produced during five production seasons

Attributes	Production season[d]				
	PS-2011	PS-2012	PS-2013	PS-2014	PS-2015
Redness	7.71 ± 0.25	7.52 ± 0.43	7.52 ± 1.12	7.69 ± 0.45	7.68 ± 0.42
Color uniformity	7.39 ± 0.32	7.41 ± 0.32	7.47 ± 0.50	7.35 ± 0.45	7.73 ± 0.59
Marbling	6.75 ± 0.55	6.64 ± 0.81	6.18 ± 0.77	6.45 ± 1.22	6.73 ± 0.80
Surface wetness	5.69 ± 0.53^{a}	5.25 ± 0.61^{a,b}	4.98 ± 0.54^{b}	5.89 ± 0.82^{a}	5.42 ± 0.63^{a,b}
Odor intensity	7.31 ± 0.37	7.49 ± 0.20	7.33 ± 0.39	7.42 ± 0.42	7.54 ± 0.57
Smoke intensity	6.04 ± 0.65^{a}	4.24 ± 0.67^{c}	4.66 ± 1.15^{b,c}	5.38 ± 0.44^{b}	5.45 ± 0.61^{a,b}
Tenderness	7.09 ± 0.41^{b}	6.81 ± 0.41^{b}	7.15 ± 0.42^{a,b}	6.94 ± 0.48^{b}	7.58 ± 0.37^{a}
Solubility	7.16 ± 0.30^{b,c}	6.98 ± 0.34^{c}	7.34 ± 0.35^{b}	7.07 ± 0.47^{b,c}	7.77 ± 0.32^{a}
Saltiness	6.05 ± 0.51	6.25 ± 0.49	6.38 ± 0.81	5.90 ± 0.56	6.33 ± 0.64
Sweetness	3.18 ± 0.43^{a,b}	3.52 ± 0.28^{a}	2.53 ± 0.40^{c}	3.30 ± 0.61^{a,b}	2.85 ± 0.58^{b,c}
Sourness	1.99 ± 0.38	2.20 ± 0.26	1.99 ± 0.51	1.85 ± 0.36	1.87 ± 0.56
Bitterness	1.29 ± 0.28^{c}	1.46 ± 0.20^{b,c}	1.81 ± 0.62^{a,b}	1.90 ± 0.40^{a}	1.97 ± 0.54^{a}
Butter flavor	5.42 ± 0.69^{a}	5.46 ± 0.45^{a}	3.72 ± 0.71^{b}	5.18 ± 0.70^{a}	5.00 ± 0.80^{a}
Rancid flavor	1.42 ± 0.54	1.13 ± 0.21	1.51 ± 0.69	1.45 ± 0.35	1.42 ± 0.75
Fresh meat aroma	1.22 ± 0.50^{a}	0.80 ± 0.24^{b}	1.15 ± 0.32^{a}	1.40 ± 0.45^{a}	0.84 ± 0.27^{b}
Mold aroma	0.18 ± 0.14	0.15 ± 0.07	0.50 ± 0.28	0.61 ± 0.16	0.37 ± 0.22
After-taste	6.92 ± 0.55^{b}	7.24 ± 0.27^{a,b}	7.24 ± 0.42^{a,b}	7.50 ± 0.47^{a}	7.65 ± 0.47^{a}
Overall acceptability	6.94 ± 0.48^{b}	7.33 ± 0.26^{a,b}	7.25 ± 0.50^{a,b}	7.37 ± 0.56^{a,b}	7.58 ± 0.66^{a}

^{a,b,c} Means with different letters in the same row significantly differ (P<0.05).
^{d} PS-2011: production season 2011; PS-2012: production season 2012; PS-2013¬: production season 2013; PS-2014: production season 2014; PS-2015: production season 2015.

The PCA loadings plot for the sensory attributes of the first two principal components is shown on Figure 1. The attributes are marked by different colors according to the type of sense they were perceived. There was a noticeable distribution of almost all sensory attributes throughout all quadrants, revealing that there was a good choice of attributes and a good characterization of hams. The relations between attributes and PCs were interpreted according to the correlations between them. Thus, attributes which were close to each other were considered positively correlated and those separated by 180° as negatively or by 90° as independently correlated. PC1 was positively correlated with the sweetness, butter flavor, surface wetness, and negatively with saltiness. PC2 was positively correlated with the overall acceptability, after-taste, odor intensity, color uniformity and solubility, and negatively with rancid flavor and fresh meat aroma. Since the overall acceptability is a subjective

Table 2. Contribution of the attributes to the first three principal components (%)

Attributes	PC1[a]	PC2[b]	PC3[c]
Redness	1.372	0.075	**16.165**
Color uniformity	0.036	**6.406**	0.187
Marbling	**9.561**	**16.588**	1.095
Surface wetness	**17.586**	0.355	1.754
Odor intensity	0.492	**8.265**	0.178
Smoke intensity	2.204	0.709	**56.309**
Tenderness	0.005	3.519	0.342
Solubility	0.021	**5.716**	0.000
Saltiness	**7.414**	0.170	**11.333**
Sweetness	**15.746**	0.490	0.420
Sourness	1.006	3.222	2.529
Bitterness	1.820	3.725	4.412
Butter flavor	**40.301**	3.561	1.422
Rancid flavor	1.030	**12.823**	2.529
Fresh meat aroma	0.165	4.759	0.032
Mold aroma	0.120	1.104	0.350
After-taste	0.532	**10.322**	0.829
Overall acceptability	0.589	**18.190**	0.112

[a] PC1: principal component 1; [b] PC2: principal component 2; [c] PC3: principal component 3

trait, it is important to observe with which attributes it was correlated to. The odor intensity and after-taste had the greatest positive correlations with the overall acceptability, whereas rancid flavor and mold aroma, and bitterness and sourness had the strongest negative correlations. According to Ruiz et al. (2002) juiciness and intensity of several flavor traits seemed to be the most important features in determining dry-cured Iberian ham acceptability, while rancid flavor tended to have a negative relationship which is similar to our results. However, on the loading plot Ruiz et al. (2002) showed that bitterness was located near to, and texture traits away from acceptability as a contrast to our results.

According to the PCA, there was no clear separation of production seasons, and a lot of overlapping was observed. This was expected because dry-cured hams within every production season originated from 12 to 18 individual producers on open market which raised product variability. This is seen on the plot of the sample scores as ellipse observations on the first two components (PC1 vs. PC2) on Figure 2. There is a noticeable difference in the distribution of production seasons per quadrants, which implies different sensory traits of dry-cured hams, but there are several observations. Hams from the production season 2014 are indicated with the biggest ellipse colored black that is extending largely in the lower left and right quadrants which were characterized by negative sensory attributes of aroma and taste (bitterness and sourness, rancid flavor, mold and fresh meat aroma). The hams from the production season 2013 (blue ellipse) were largely in the left upper and lower quadrants and had dominantly negative attributes (like the hams from the production season 2014) but with a higher saltiness. According to that, it can be concluded that hams from the production seasons 2013 and 2014 were characterized by higher intensity of negative flavor and aroma attributes. Hams from the production season 2011 (green ellipse) were dominantly in the right upper and lower quadrants in which the attributes of surface wetness, redness, tenderness and smoke intensity, as well as a negative aroma of fresh meat had a great importance. Therefore, the hams from that production season could be characterized as young, insufficiently mature, but at the same time with pronounced color. The hams from the production season 2012 (purple ellipse) were mostly placed around the starting point and in the upper right quadrant where the attributes of redness, smoke intensity and marbling were found. As they were largely placed in the same quadrant as the overall acceptability of hams, they could be characterized as desirable with no pronounced negative attributes. The hams from the production season 2015 (red ellipse) were placed very widely, from the left lower and upper quadrants to the

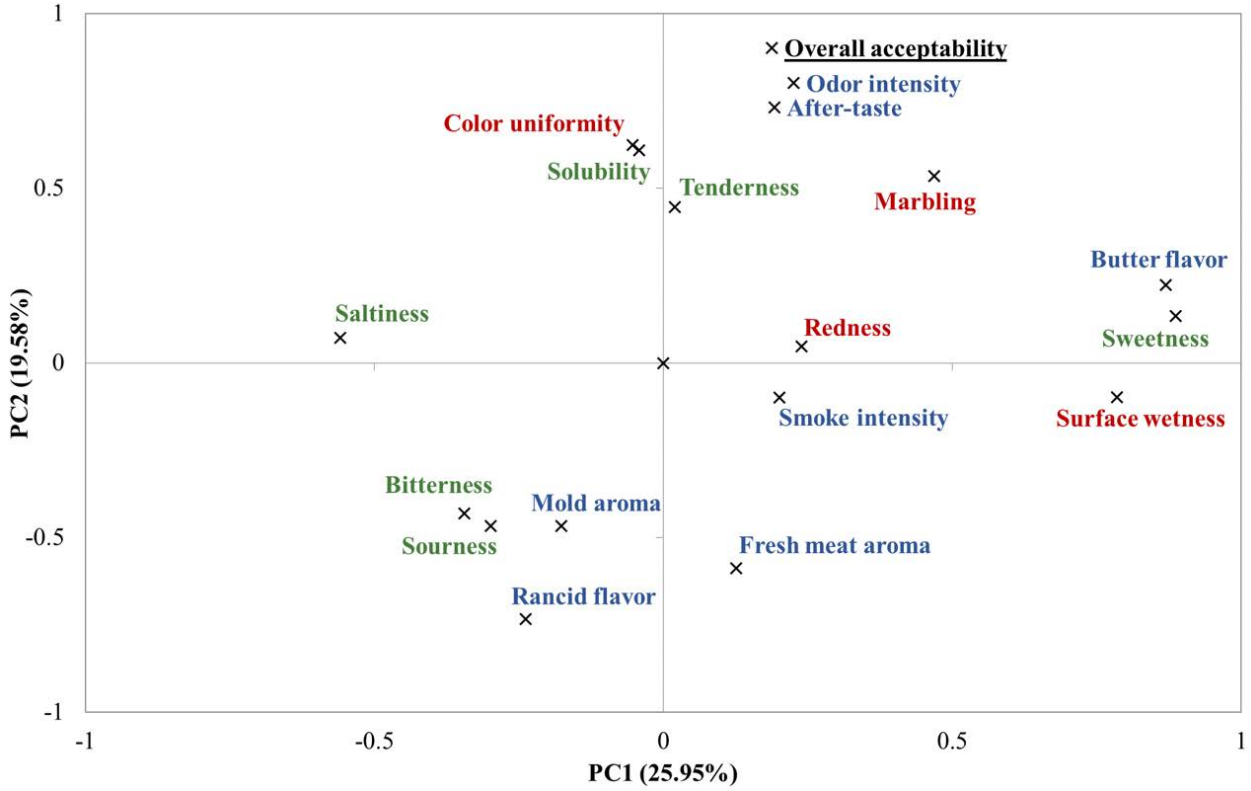

Figure 1. PCA loadings plot (PC1 vs. PC2) of the sensory attributes

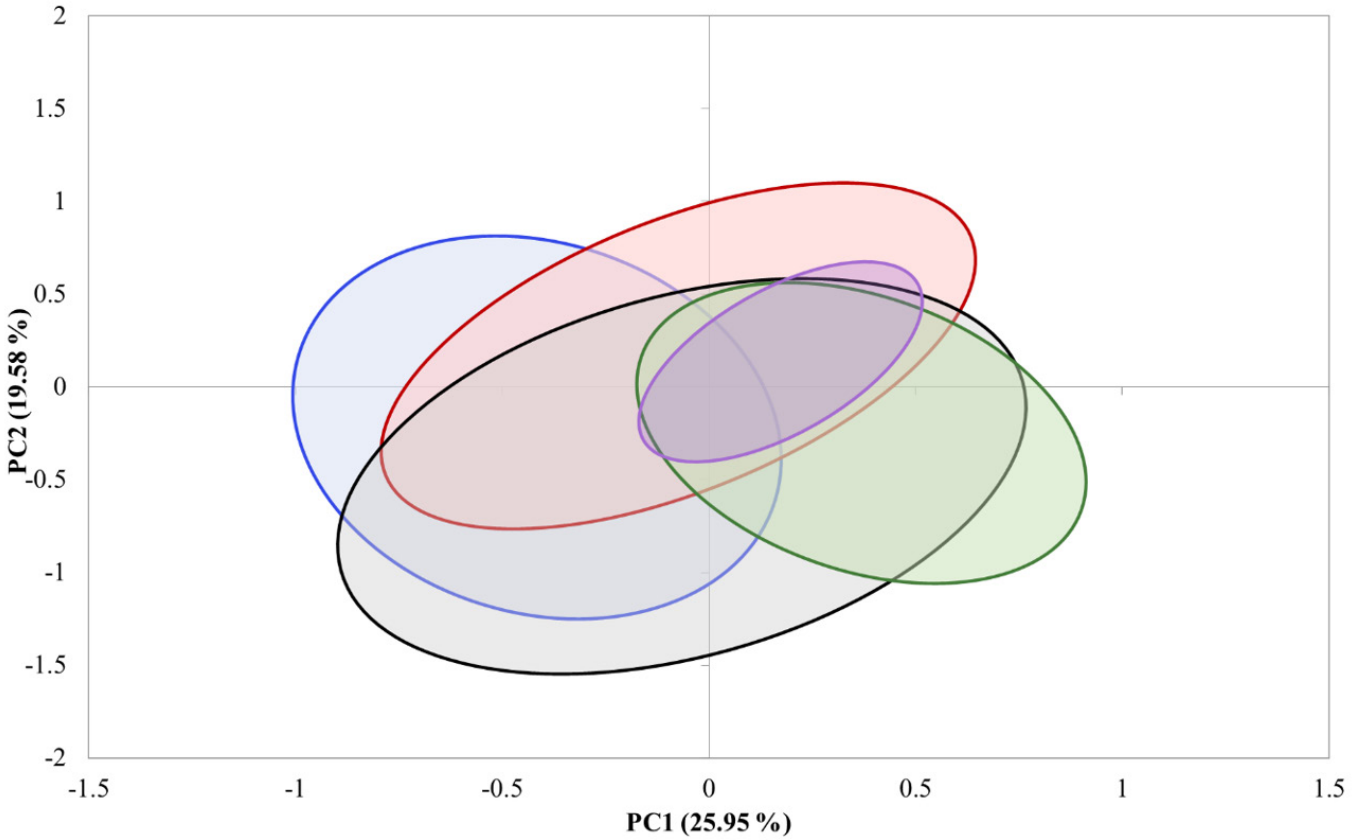

Figure 2. Plot of sample scores on the first two principal components (PC1 vs. PC2) (Ellipses indicate dry-cured hams; green from the production season 2011, violet from the 2012 season, blue from the season 2013, black from the season 2014, and red from the season 2015)

upper right quadrant. The hams from that season were closest to the overall acceptability, odor intensity, after-taste, color uniformity, tenderness and solubility found in upper quadrants. However, the red ellipse extends over the negative attributes of taste and aroma (except of the fresh meat aroma). Therefore, the hams from that production season could be characterized as mature, but mutually different, with distinctive positive and negative attributes. This could be caused by the very pronounced maturity where the best characteristics of hams are present, and in the same time with the excessive expression of proteolytic and lipolytic processes that may result in the development of negative attributes (Cilla et al., 2005).

CONCLUSION

The production season in this study was proposed to be a highly complexed variable consisting of varying environmental and processing conditions as well as raw material quality which cannot be unambiguously described. It was assumed that it could serve as a tool for explaining small effects which were not identified in artisanal manufacture for the open market. According to the obtained results, it could be concluded that production season have a noticeable effect on the sensory attributes of artisanal smoked dry-cured hams. Most of the sensory attributes (10 out of 18) were significantly different between production seasons with possible explanation. It is most likely that most of the differences in sensory attributes arises from variations in fresh ham quality and environmental conditions in artisanal dry-cured ham production as it was proposed or established in previous studies. Principal component analysis (PCA) explained 45.53% of the total variance by the first two principal components and it proved to be a beneficial tool for understanding underlying pattern which was not observed by non-parametric testing. It was found that the odor intensity and after-taste had the strongest positive correlations with the overall acceptability, whereas rancid flavor, mold aroma, bitterness and sourness had the strongest negative correlations. As it was expected, there was no clear separation of production seasons, and a lot of overlapping was observed because dry-cured hams within every production season originated from 12 to 18 individual producers on open market which raised product variability. However, it was possible to describe the seasonal pattern in which hams from production season 2011 were characterized as young, insufficiently mature, but at the same time with pronounced color. Hams for production season 2012 were described as desirable with no pronounced negative attributes. Hams from production seasons 2013 and 2014 were characterized by higher intensity of negative flavor and aroma attributes, while those for season 2015 were marked as mature, but mutually different, with distinctive positive and negative attributes. It can be concluded that production season is a useful variable for describing changes of sensory traits in artisanal dry-cured ham manufacture.

ACKNOWLEDGEMENT

The authors would like to thank the Sensory analyst association Gustus that supported the data obtained for the study. This study is a part of diploma thesis of Domagoj Gorup, MsC under the title “Influence of production season on sensory profile of smoked dry cured ham”, mentored by Assoc. Prof. I. Kos.

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