Sensory characteristics of dry cured ham Dalmatinski pršut: Influence of water content and packaging for long period chilled storage

S. Petričević, E. Listeš, T. Bogdanović, T. Dujić and I. Listeš*

Abstract

This study examines the longevity and sensory stability of Dalmatinski pršut, a Protected Geographical Indication dry-cured ham (Commission Implementing Regulation (EU) No 2016/189), under protracted refrigerated vacuum storage. The objective was to elucidate a more empirical basis for shelf-life determination, countering the prevalent practice of arbitrary expiration dating. Over a span of 210 days, at a controlled temperature of 4±2°C, we monitored the ham's physicochemical properties (water activity water and salt content) and conducted comprehensive sensory evaluation. Findings show the excellent preservation of the ham's sensory profile, with minimal deviations in flavour intensity and no significant alterations in textural parameters (hardness, solubility) or salinity levels. However, a key finding is the decade-long trend of reduced water content among producers, now ranging between 30–46%, which is below the specified range of 40–55%. Despite this discrepancy, the reduction in water content did not adversely affect the ham's sensory attributes, indicating a robust resilience to changes in water content within the observed range. Our results challenge the current specifications for dry cured ham Dalmatinski pršut, suggesting a need for revision to reflect the empirical evidence of water content's insignificant effect on sensory quality. This study highlights the importance of revisiting and potentially adjusting the regulatory standards for water content in dry cured ham Dalmatinski pršut, lowering the established lower limit to 30% and ensuring they are aligned with practical production realities and scientific findings, thereby enhancing the product's shelf-life determination and maintaining its high-quality standards.

Key words: *Dalmatinski pršut; dry-cured ham; Protected Geographical Indication; water content; sensory analysis; physicochemical properties; vacuum packaging*

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Introduction

This study examines Dalmatinski pršut, a type of smoked dry cured ham produced according to specific guidelines and holding the Protected Geographical Indication (PGI). This PGI status means that the dry cured ham is produced in a specific geographical region and follows certain traditional methods or characteristics that make it unique to that area and is known for its distinctive flavour and production method. A dry-cured ham is a cured meat product whose preparation involves dry salting, dehydration, and gradual chemical-enzymatic transformations of fresh pork during long-term ripening (over 12 months). This regimented process is designed to develop the ham's characteristic flavour and texture. However, it is subject to variability stemming from differences in raw materials, environmental conditions, and the adoption of specific technological practices (Petričević, 2018). The post-maturation phase, critical for ensuring the ham's market readiness, necessitates a heightened focus on minimising the risk of microbial contamination and managing the reduction in water content, which could inadvertently affect the product's sensory attributes and shelf stability. It is well known that the biochemical changes related to maturing result in the modification of ham sensory properties, which develop the flavour and soften the texture (Careri et al., 1993, Córdoba et al., 1994, Ruiz et al., 1998). With increasing frequency, delicatessen meat products are being sliced and vacuum or modified atmosphere packaged for direct retail sale. In recent years, slicing followed by vacuum or modified atmosphere packaging are the most used methods to avoid unpleasant sensory changes and safety problems (Adamsen et al., 2003; García-Esteban et al., 2004). Despite its classification as a shelf-stable product, it has been established that dry-cured ham continues to undergo maturational transformations even during storage, potentially leading to textural and flavour defects that compromise its acceptability among consumers (Cilla et al., 2006). Post-processed operations, including deboning, slicing and packaging, are critical steps since they can contribute to cross-contamination that affects the shelf life and safety of the product, as well reducing the amount of water.

The present study aimed to examine the effect of mid-term refrigerated storage of dry-cured ham Dalmatinski pršut vacuum packaged for retail sale on the quality and sensory characteristics of the product. By analysing various quality indicators, the study also aimed to offer more accurate guidelines for the industry and potentially enhance consumer confidence in the product. The results of such studies could be crucial for quality assurance of the final product in terms of PGI.

Materials and methods

Dry cured ham production and sampling

A total of 16 dry-cured hams were included in the study. These hams had an average weight range of 7.5 to 8.5 kilograms, manufactured according to the specifications of protected geographical indications (PGI) for dry cured ham Dalmatinski pršut (Kos and Madir, 2015). Hams were sourced from eight manufacturers. In short, the dry cured ham Dalmatinski pršut is produced with pelvic bones, skin and subcutaneous fatty tissue. Dry salting of processed thighs

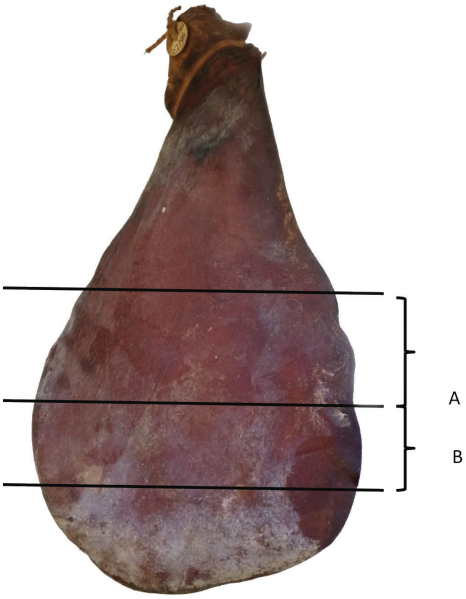

Figure 1. Photograph illustrating a schematic view for the sampling of a dry-cured ham: (A) sample used for physical and chemical analysis (length of the subsample 4.5 cm) and (B) sample used for sensory analysis (length of the subsample 2.5 cm)

was carried out with sea salt. Salting was performed in cooling chambers at a temperature (T) of 0–5°C and a relative humidity (RH) of 80–90%, lasting up to 1 month, depending on the weight of the raw leg. The salting phase was followed by the pressing phase lasting 7–10 days. The tested hams were then dried in drying chambers (T 12–16°C, RH 90–70%). During the drying phase, dry cured hams Dalmatinski pršut were cold smoked (T <22ºC) for 20 to 45 days. After smoking, dry cured hams were transferred to ripening chambers (12–15ºC and RH 65–75%). At the end of ripening (15 ± 3 months), samples of dry cured ham were taken. A total of 16 hams were randomly selected from the pool of hams of same lot of production, with two hams from each manufacturer. These selected hams were deboned, and a specific portion of the ham was extracted (Fig 1). The extracted portions of the hams, about 500 g boneless piece and 200 g sliced dry cured ham, were vacuum-packed and stored at 4±2ºC in darkness. The laminated film used for packaging consisted of a pouch made of PET/PE/EVOH/PE-MY23 with water vapor permeability <7.3 g/m^2/24 h at 38°C and oxygen permeability <3 mL/m^2/24 h at 23°C (AMB SPA, Udine, Italy). Pouches were vacuum sealed using a Multivac (Model #C500, Sepp Haggenmuller GmbH and Co. KG, Wolfertschwenden, Germany). The samples were opened for subsequent analysis after 1, 60, 120, 180 and 210 days of storage.

Methods

Salt content

The sodium chloride content was determined by the Volhard method (ISO 1841-1:1996). The sample was treated with silver nitrate ($AgNO_3$) then wet-ashed, and the excess $AgNO_3$ was back titrated with potassium thiocyanate (KSCN). Double determinations were made as follows: 10 g of extensively homogenised sample was diluted with 100 mL hot (50°C) 40% ethanol, mixed thoroughly and filtered through quantitative paper. Chloride determinations were carried out as endpoint titrations on volumes containing 10 mL filtrate, mixed with 1 mL 65% nitric acid (HNO_3), 50 mL distilled water, 1 mL 4% ammonium iron(II)sulphate $(NH_4)_2Fe(SO_4)_2$ $(H2O)_6$ and 10 mL $AgNO_3$. Excess $AgNO_3$ was determined with KSCN 0.1 M. Results were expressed as g salt (NaCl) per 100 g dry cured ham. This method is applicable to the determination of salt in processed meat products at a level ≥ 0.08%.

Water activity and moisture

Water activity (aw) measurement was carried out by ISO 18787:2017 Foodstuffs - Determination of water activity at 25°C with a LabMaster (Novasina AG, Lachen, Switzerland) instrument that allows temperature-controlled measurements of aw. After measuring aw, the moisture of the samples was immediately determined by drying at 103±2ºC until reaching a constant weight (ISO 1442:2023) as the loss in mass obtained under a direct drying method divided by the mass of the test portion.

Sensory analysis

Sensory analysis was carried out by a trained panel (eight judges), selected and trained following the procedures of the ISO standard (ISO 11132: 2021). Preliminary sessions use of the sensory card comprising 20 attributes, chosen among those most relevant to the ham type under investigation (Parolari et al., 1994; Virgili and Schivazappa, 2002; Andrés et al., 2004; Guárdia et al., 2010; Resano et al., 2010; Petričević et al., 2018). The following attributes were evaluated: colour intensity of muscle and fat tissue, colour uniformity, amount of intramuscular fat (marbling), surface moisture (sheen), tyrosine crystal coverage (white crystals), odour intensity, hardness, solubility, salinity, sweetness, acidity, bitterness, vegetable, smoky, spicy, rancidity, mould, by soil, animal, rotten egg. Descriptor selection was carried out on the basis of previous publications on Iberian ham (Cava et al., 2000; Andrés et al., 2004; Guerrero et al., 2005) and Dalmatinski pršut (Petričević, 2018; Petričević et. al., 2018). Each attribute was evaluated on a 10 cm non-structured linear scale (0 = completely absent, 10 = maximum perception) on a whole dry-cured slice including 1 cm subcutaneous adipose tissue, ranging from the lowest intensity of each trait (left side) to the highest (right side), following the sensory descriptive test previously developed by Ruiz et al. (1998). Definitions of sensory traits and extremes are explained elsewhere (Cava et al., 2000; Ruiz et al., 1998). The precision and trueness of each expert assessor were determined by the repeatability index, intermediate precision index, and homogeneity of the panel (González-Casado et al., 2019). About 50 mL water at room temperature and 20 g unsalted bread was provided between successive hams. All sessions were performed at 22°C in a sensory panel room equipped with white fluorescent lighting (Philips TLD 86, 5600 K, 800 lux). Four hams from different manufacturers were successively evaluated in each session. To test panel reproducibility, one additional ham was presented at each session. It was the replicate of the second sample of the set and was served as the last of the session. The panel sessions were held mid-morning, about 3 hours after breakfast. The sample order was randomised within sessions.

Data analysis

A multivariate analysis approach was applied to the quality parameters, such as water content, water activity and salt content, using XLSTAT (Addinsoft, New York, USA). In addition, one-way analysis of variance (ANOVA) was used to determine if there were significant differences between the quality parameters observed in the vacuum-packed boneless piece and sliced dry cured ham samples. Where treatment effects were significant, the means were compared with Fisher's Least Significant Difference (LSD), α=0.05. To determine the linear correlations of quality parameters and panel sensory perceptions of the meat samples,

Pearson's correlation coefficients were used. Figures were prepared using XLSTAT (Addinsoft, New York, USA).

Results and discussion

By examining the basic chemical composition (aw, salt content), it was determined that there were no statistically significant differences ($P>0.05$) for the tested dry cured ham in relation to storage time or type of packaging. During the production process, the water activity decreased, mostly depending on the amount of added salt. In this study, the aw value showed no statistically significant difference ($P>0.05$) and the results were in the range 0.776–0.874. The Spanish types of ham, Iberian and Serrano ham, have similar values of water activity (0.850) (García-Rey et. al, 2004; Carrapiso and García, 2008), while Italian types of dry cured hams have a slightly higher value (0.930) (Marušić et al., 2014). The results of determining salt content showed no statistically significant differences ($P>0.05$), with salt content in the examined samples ranging from 5.38–6.92%. The results of salt content in the examined dry cured ham depending on storage method are shown in Figure 2. Each type of dry-cured ham has a characteristic salt content which varies significantly among types. For Parma ham, the final salt content should be 4.2–6.2% (Commission Implementing Regulation (EU) No 1208/2013), as opposed to 6.5% for Iberian ham, (Toldra, 2002), and 7.7% for Bayonne ham (Monin et al., 1997). However, there are several types of dry cured ham with even higher salt contents, including Toscano (8.3%) and Juinhua hams (8–15%) (Commission Implementing Regulation (EU) No 1135/2013; Zhou and Zhao, 2007).

Dry cured hams produced with skin and subcutaneous fatty tissue contain a higher proportion of water, such as Spanish Iberian ham (49%) (Carrapiso and García, 2008) and Serrano (48.5%) (Toldrá et al., 2002) and Italian dry cured hams, Parma (54.11%), San Daniele (54.63 %), Toscano (55.28%) (Laureati et al., 2014),

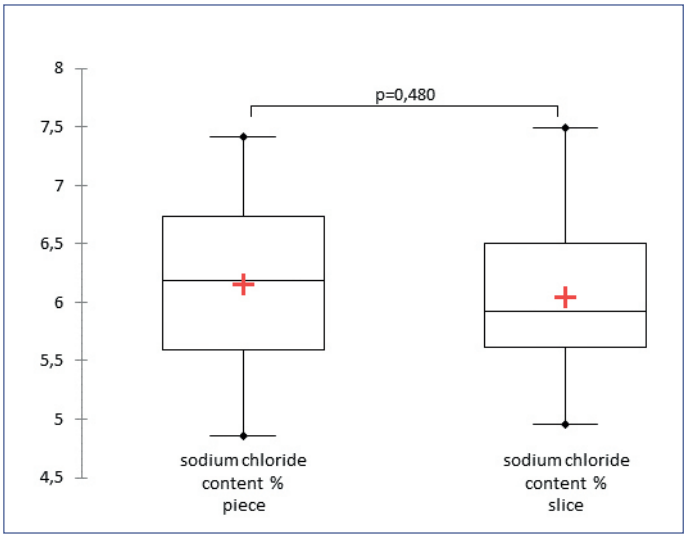

Figure 2. Means and confidence interval (sault content) for two type of vacuum packing

and Kraški pršut (58.2%) (Adronikov et al., 2013).

Dalmatinski pršut has a lower water content than other Mediterranean types of dry cured ham. The moisture content in the tested samples in this study ranged from 30.11–46.31% during a storage time of 210 days, both in a single piece and in the sliced vacuum-sealed package (Figure 3a). The dispersion of the results of determining the water content is shown in Figure 3b. The proportions of water in dry cured ham Dalmatinski pršut did not show a statistically significant difference ($P>0.05$) for a particular type of packaging (slice or piece) or storage time (Figure 4).

The specifications established for each PGI product define the raw materials and

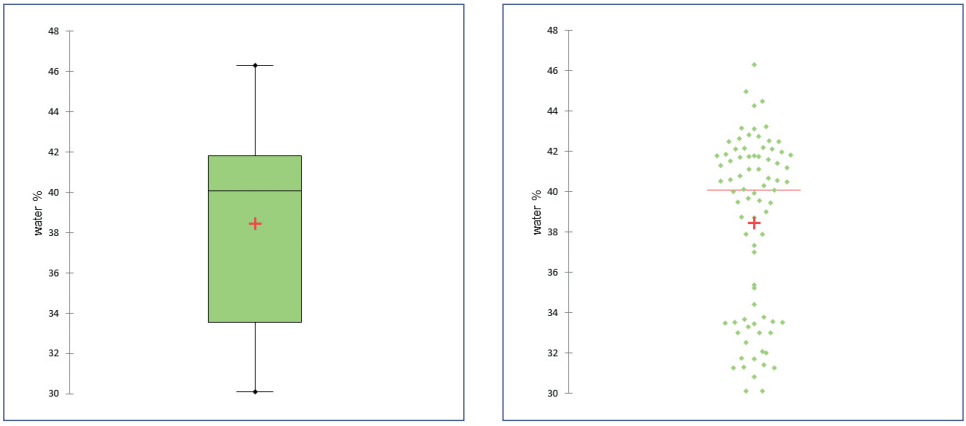

Figure 3. Means with confidence interval (a) and scattergram interval (b) for the water content in dry cured ham Dalmatinski pršut

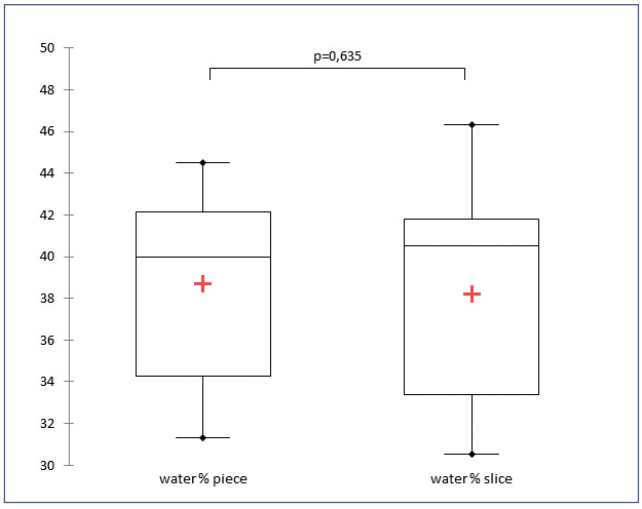

Figure 4. Means and confidence interval of water content for two types of vacuum packing, in a single piece or sliced

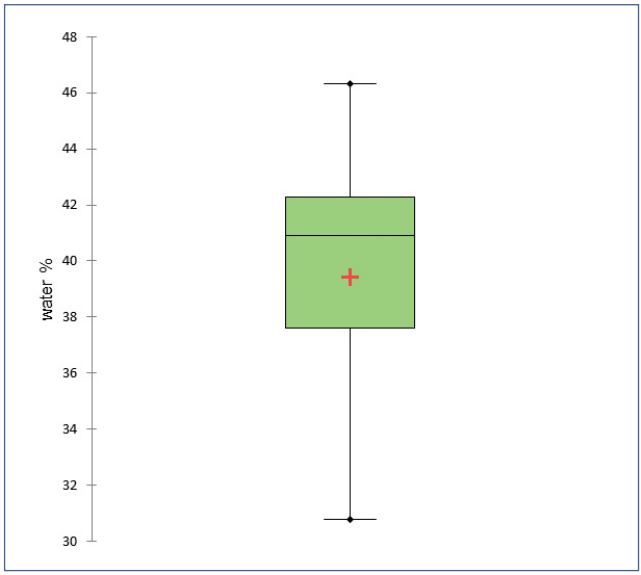

Figure 5. Means and confidence interval of water content on the zero day of sampling and vacuum packing

process characteristics, place of origin and certain physicochemical and sensory parameters of the final hams. The proportion of water in dry cured ham Dalmatinski pršut determined by the specification is in the range 40–55%. The research showed a lower water content in the investigated samples in dry cured ham Dalmatinski pršut. It is also necessary to emphasise that on the zero day of sampling, there was a statistically significant difference (P<0.05) in the water content among the tested dry cured hams Dalmatinski pršut (Figure 5). During the tested shelf life of dry ham, there was a statistically significant difference (P<0.05) between manufacturers and the shelf life of 0-210 days of storage at +4°C. The range of water content remained the same as on day zero and was statistically significant between producers. Mean value of water content was unchanged during 210 days of storage. The water content did not different between dry cured ham packed in a piece or sliced in the vacuum package (Figure 3).

Sensory analysis is a research discipline that should become one of the main driving forces to ensure the quality of protected geographical indications (PDO) and protected geographical indication (PGI) food products (Bertozzi and Panari, 1993; Perez et al., 1999). The results of the overall sensory perception are shown in Table 3. The results demonstrated that most sensory attributes did not vary significantly (P>0.05) throughout the storage period under vacuum packaging and refrigeration, with the exception of ham aroma (odour) of rancidity, which increased significantly (P<0.05) after 180 days. Sensory analysis results for dry cured ham Dalmatinski pršut packaged in a single piece are shown in Table 1, while Table 2 shows the results for sliced and vacuum-packed dry cured ham. These results show that the sensory profile of hams remained unchanged

Table 1. Results of sensory evaluation for piece in vacuum sealed dry cured ham Dalmatinski pršut (mean ± standard error)

Sensory attribute	Days of storage					Mean value	Effect of product (*P*-value)
	0	60	120	180	210		
Odour intensity	5.5 ± 0.7	5.2 ± 0.7	5.1 ± 0.6	4.8 ± 0.5	5.1 ± 0.8	5.1 ± 0.7	0.39
Intensity colour of muscle tissue	5.6 ± 0.6	5.7 ± 0.7	5.7 ± 0.9	5.6 ± 1.0	5.6 ± 0.7	5.7 ± 0.7	0.99
Intensity of the colour of adipose tissue	5.1 ± 1.2	4.8 ± 1.2	4.5 ± 1.1	4.8 ± 1.1	5.3 ± 0.9	4.9 ± 1,1	0.66
Colour homogeneity	4.9 ± 1.0	4.1 ± 0.8	5.0 ± 0.9	4.2 ± 0.9	4.3 ± 0.8	4.5 ± 0.9	0.97
Biochemical (Rancid)	ND[a]	ND[a]	ND[a]	ND[a]	0.9b ± 0.1	0.9 ± 0.1	0.01
Marbling	3.7 [a]± 1.2	3.7[a] ± 0.6	3.8[a] ± 0.7	2.9[b] ± 0.5	3.0[b] ± 0.9	3.4 ± 0.9	0.05
Sheen	4.0 ± 0.9	3.7 ± 0.6	3.5 ± 0.5	3.3 ± 0.8	3.2 ± 1.0	3.6 ± 0.8	0.20
Salty taste	4.3 ± 0.5	3.9 ± 0.7	4.1 ± 0.5	4.0 ± 0.3	4.5 ± 0.6	4.2 ± 0.6	0.17
Sweet taste	2.3 ± 0.7	2.5 ± 0.6	2.4 ± 0.6	2.1 ± 0.5	2.4 ± 0.8	2.4 ± 0.6	0.80
Smoky aroma	3.2 ± 0.8	3.6 ± 1.0	3.0 ± 0.5	3.3 ± 0.5	3.2 ± 0.6	3.2 ± 0.7	0.63
Bitter taste	1.4 ± 0.8	1.9 ±1.3	2.2 ± 0.8	2.1 ± 0.5	2.3 ± 0.6	2.0 ± 0.8	0.23
Hardness	4.8 ± 0.6	4.7 ± 0.5	4.7 ± 1.4	4.9 ± 0.8	5.1 ± 0.8	4.8 ± 0.8	0.86
Solubility	4.3 ± 0.5	5.8. ± 0.9	4.7 ± 1.5	4.7 ± 1.3	4.1 ± 1.0	4.7 ± 1.3	0.10

[a,b,c] Means with different letters in the same row significantly differ ($P<0.05$), ND not detected

after 210 days for all visual and textural attributes and for some of the odour/taste attributes (saltiness, rancidity and off-flavours). The evolution of flavour and saltiness were very similar to that of aroma, showing no significant variations ($P>0.05$) after 210 days of storage. Rancidity was mild and hardly noticeable throughout storage. According to Ventanas et al. (2007), marbling has a positive effect on the aroma and sensory properties of prosciutto (juiciness, softness, meltability). Statistically significant difference ($P<0.05$), were found between dry-cured hams in terms of marbling which depends on the source of raw material for the production of dry cured ham.

Tyrosine crystals were found in 10% samples. They appear in the form of white precipitates of varying shapes, sizes and locations. Long-term drying and ripening processes favour the appearance of tyrosine crystals. A sweet taste was found in all dry cured ham samples in mild intensity (2.2 ± 0.7) (Table 3.) In the research of Hernández-Ramos et al. (2020), Spanish types of dry cured ham contain a 1.83 ranked sweet taste. The interaction between the product and the assessor was evaluated at each session and there were no statistically significant differences ($P<0.05$).

Iberian dry cured ham contains a bitter taste (1.07), while this taste is sim-

Table 2. Results of sensory evaluation for sliced and vacuum sealed dry cured ham Dalmatinski pršut (mean ± standard error)

Sensory attribute	Days of storage					Mean value	Effect of product (*P*-value)
	0	60	120	180	210		
Odour intensity	5.2 ± 0.7	5.0 ± 0.7	5.1 ± 0.6	5.0 ± 0.5	5.0 ± 1.2	5.2 ± 0.7	0.62
Intensity colour of muscle tissue	5.6 ± 0.7	5.6 ± 0.6	5.7 ± 0.5	5.7 ± 0.7	5.4 ± 0.8	5.5 ± 1.1	0.29
Intensity of the colour of adipose tissue	5.0 ± 1.4	4.8 ± 0.7	4.6 ± 0.6	4.2 ± 1.0	3.6 ± 1.0	4.5 ± 1.0	0.09
Colour homogeneity	4.7 ± 1.0	4.4 ± 0.7	4.1 ± 0.7	4.4 ± 0.7	4.0 ± 0.7	4.3 ± 0.3	0.39
Biochemical (Rancid)	ND	ND	ND	0.8 ± 0.2	1.7 ± 0.7	1.3 ± 0.6	0.02
Marbling	4.3^{a} ± 1.2	3.7^{a} ± 0.6	3.8^{a} ± 0.7	2.9^{b} ± 0.5	3.0^{b} ± 0.9	3.4 ± 0.9	0.01
Sheen	4.0 ± 0.9	3.7 ± 0.6	3.5 ± 0.5	3.3 ± 0.8	3.2 ±1.0	3.6 ± 0.8	0.37
Salty taste	4.4 ± 0.6	4.2 ± 0.4	4.3 ± 0.4	3.9 ± 0.5	4.2 ± 0.6	4.2 ± 0.3	0.42
Sweet taste	2.3 ± 0.7	2.5 ± 0.6	2.4 ± 0.6	2.1 ± 0.5	2.4 ± 0.8	2.4 ± 0.6	0.61
Smoky aroma	3.6 ± 0.9	3.6 ± 0.7	2.9 ± 0.6	2.5 ± 0.4	3.1 ± 0.7	3.2 ± 0.7	0.37
Bitter taste	2.0 ± 0.8	2.2 ± 0.6	1.8 ± 1.2	2.2 ± 0.6	2.2 ± 0.7	2.1 ± 0.7	0.09
Hardness	4.3 ± 0.6	4.0 ± 0.8	4.7 ± 0.8	4.4 ± 1.1	4.8 ± 1.1	4.5 ± 0.8	0.38
Solubility	5.6 ± 1.0	5.5 ± 1.3	4.5 ± 1.0	5.5 ± 1.3	4.5 ± 0.7	5.1 ± 0.5	0.15

[a,b,c] Means with different letters in the same row significantly differ ($P<0.05$), ND not detected

ilar in samples of dry cured ham Dalmatinski pršut. It is formed during the ripening process of dry cured ham as a consequence of the exaggerated proteolysis of meat proteins, resulting in an increase in the concentration of nitrogenous compounds of low molecular mass (Toldra, 1998). In the research of Fuentes et al. (2013), Iberian dry cured ham received a 3.55 rating for hardness. Therefore, we can conclude that the hardness varies depending on the type of dry cured ham.

Hardness in all samples of dry cured ham Dalmatinski pršut was in the range 4.6±0.9. Hardness was moderately medium intense with no significant influence of packaging method or shelf life. Colour is an important characteristic of meat and meat products (Risvik, 1994; Resurreccion, 2003) and particularly in dry-cured ham, colour is one of the most important properties related to appearance (Gandemer, 2002). Moreover, the influence of colour perception of sliced and vacuum packaged dry-cured ham in consumer's choice is well established (Gandemer, 2002). In the examined samples of dry ham, the colour of the muscle tissue was moderately intense and uniform, while the colour of fat decreases, correlating with the increase in rancidity intensity. The scatterplot of results for sensory properties is shown in Figure 6.

Table 3. Summary of results of sensory evaluation of dry cured ham Dalmatinski pršut (mean ± standard error)

Sensory attribute	Days of storage					Mean value	Effect of product (*P*-value)	Judge effect (*P*-value)
	0	60	120	180	210			
Odour intensity	5.3 ± 0.7	5.1 ± 0.7	5.1 ± 0.6	5.0 ± 0.5	5,0 ± 1	5.1 ± 0.7	0.73	0.11
Intensity colour of muscle tissue	5.6 ± 0.6	5.6 ± 0.6	5.7 ± 0.8	5.5 ± 0.9	5.5 ± 0.9	5.6 ± 0.8	0.92	0.24
Intensity of the colour of adipose tissue	5.5 ± 1.3	4.8 ± 0.9	4.6 ± 0.8	4.5 ± 1	4.4 ± 1.3	4.7 ± 1.1	0.57	0.12
Colour homogeneity	4.8 ± 0,9	4.2 ± 0.8	4.6 ± 0.9	4.1 ± 0.8	4.4 ± 0.9	4.4 ± 0.9	0.18	0.14
Biochemical	0.0 ± 0,0	0.0± 0.0	0.2 ± 0.5	0.5 ± 1.1	1.3 ± 1.6	0.4 ± 1.0	0.02	0.13
Marbling	4.1 ± 1.1[a]	3.8 ± 0.6[a]	3.9 ± 0.8[a]	3.3 ± 0.7[b]	3.4 ± 1[b]	3.7 ± 0.9	0.02	0.85
Sheen	4.3 ± 0.8	4.0 ± 0.9	3.5 ± 0.7	3.4 ± 0.6	3.9 ± 1.5	3.8 ± 1.0	0.05	0.06
White crystal	0.4 ± 1.1	0.4 ± 1	0.4 ± 1.2	0.4 ± 1.1	0.2 ± 0.6	0.3 ± 1.0	0.09	0.50
Salty taste	4.3 ± 0.6	4.1 ± 0.6	4.3 ± 0.4	3.9 ± 0.4	4.4 ± 0.6	4.2 ± 0.5	0.15	0.10
Sweet taste	2.2 ± 0.9	2.2 ± 0.7	2.2 ± 0.7	2.2 ± 0.4	2.3 ± 1.0	2.2 ± 0.7	0.94	0.31
Smoky aroma	3.4 ± 0.9	3.6 ± 0.9	2.9 ± 0.5	2.9 ± 0.6	3.1 ± 0.7	3.2 ± 0.8	0.08	0.40
Bitter taste	1.7 ± 0.8	2.1 ± 1.0	2.0 ± 1.0	2.2 ± 0.6	2.4 ± 0.7	2.1 ± 0.8	0.42	0.15
Hardness	4.5 ± 0.7	4.4 ± 0.7	4.7 ± 1.1	4.6 ± 0.9	5.0 ± 0,9	4.6 ± 0.9	0.56	0.72
Solubility	5.0 ± 1.0[a]	5.6 ± 1.1[a]	4.6 ± 1.2[b]	4.6 ± 1.1[b]	4.2 ± 1,2[b]	4.8 ± 1.2	0.02	0.81

[a,b,c] Means with different letters in thze same row significantly differ ($P<0.05$)

Odour intensity remained unchanged after 120 days of storage, whereas in other studies it was observed that odour and flavour intensity were reduced in time (Cilla et al., 2006). On the other hand, rancid odour and flavour intensity increased slightly during storage in the present study over 210 days. None of the attributes associated with texture showed significant changes throughout storage time (Table 3), which agrees with the results by Cilla et al. (2006).

No statistically significant differences were found in relation to the literature on dry cured ham Dalmatinski pršut (Petričević, 2018) in terms of odour, colour of muscle and adipose tissue, sheen, sweet taste, hardness and smoky aroma (Figure 7). Uniformity of colour (4.4), marbling (3.7) and salty taste (4.2) were statistically significant-

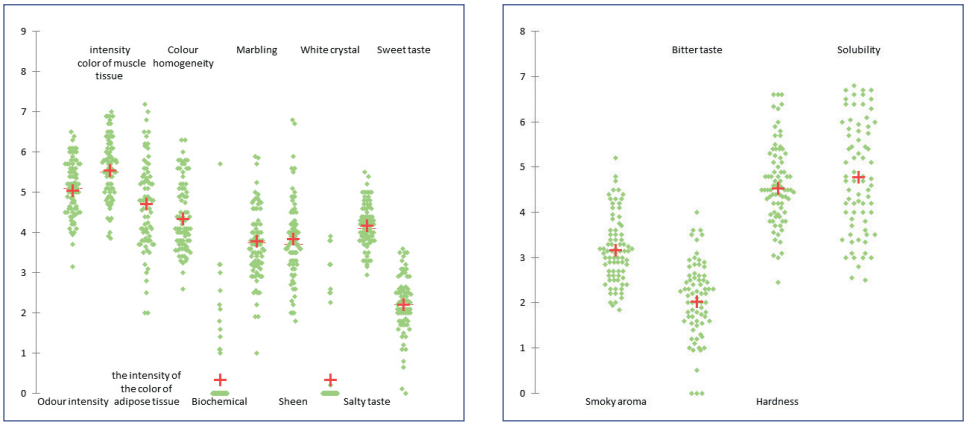

Figure 6. Scattergram interval (sensory attributes: odour intensity, colour intensity of muscle tissue, colour intensity of adipose tissue, colour homogeneity, rancidity, marbling, sheen, white crystals, salty taste, sweet taste, smoky aroma, bitter taste, hardness and solubility) for dry cured ham Dalmatinski pršut

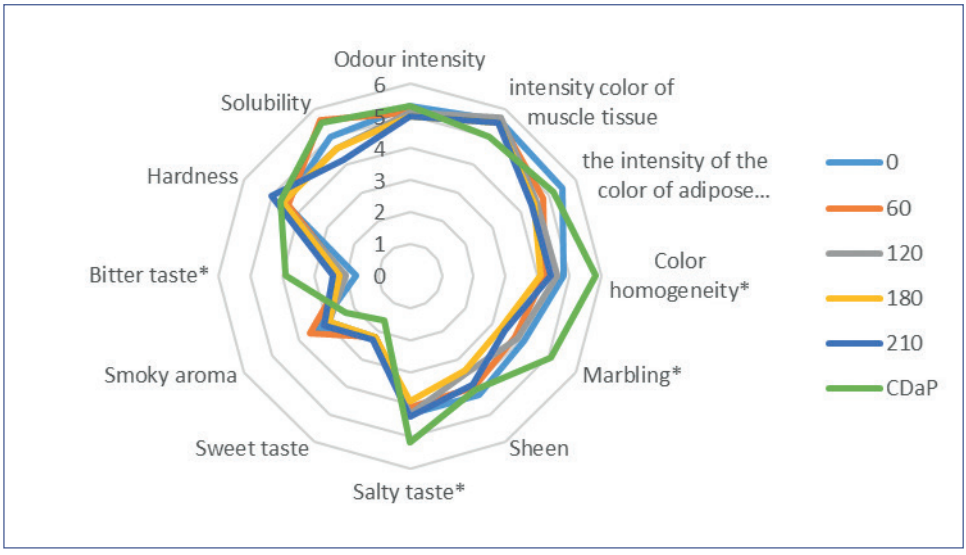

Figure 7. Sensory profile of dry cured ham Dalmatinski pršut during 210 days of storage and sensory profile dry cured ham "Dalmatinski pršut" (labeled as CDaP) in relation to the Petričević (2018)

ly lower (P<0,05) than literature reports on dry cured ham Dalmatinski pršut (Petričević, 2018). However, salt solubility is not the only factor determining salty taste. This attribute can also be influenced by other kind of compounds such as amino acids or nucleotides having a salty taste (Careri et al., 1993) or a low proportion of intramuscular fat (Buscailhon et al., 1994).

Conclusion

This study on the sensory characteristics and quality parameters of Dalmatinski pršut, smoked dry cured ham during mid-term refrigerated storage under vacuum packaging revealed critical insights into the resilience and stability of this PGI product. Despite the challenges associated with determining the shelf-life of such traditionally crafted food products, our findings suggest that dry cured ham Dalmatinski pršut maintained its sensory integrity and quality over a 210-day storage period at 4±2°C. Notably, the study highlights the minimal impact of reduced water content on the sensory profile of the ham, including attributes such as hardness, solubility, and salinity.

Furthermore, the results highlight the insignificant variation in the basic chemical composition, including water activity and salt content, regardless of storage duration or packaging method. This stability is paramount for ensuring the product's safety and consumer acceptability, addressing concerns over arbitrary shelf-life assignments, and offering a more evidence-based approach to quality assurance in the delicatessen meat industry. The sensory analysis, supported by rigorous methodological standards, corroborates the minimal changes in sensory attributes over the storage period, with the exception of a slight increase in rancidity after 180 days, which did not significantly detract from the overall sensory profile of the ham.

Recent analyses have identified a significant trend towards diminished water content in Dalmatinski pršut production, with current levels observed between 30–46%, diverging from the specifications set within the 40–55% range. This study evaluated the impact of this variance on the sensory characteristics of Dalmatinski pršut under vacuum packaging in either a single piece or sliced, and kept at 4±2°C over a 210-day period. Through quantitative sensory analysis and physicochemical assessments, including water activity and salt content, we carefully examined the effect of lowered water content on the product's sensory profile, specifically analysing attributes such as hardness, solubility, colour and salinity.

Contrary to prevailing standards, our findings revealed that the decrease in water content within the observed range did not negatively influence the sensory properties of Dalmatinski pršut. Given the empirical evidence demonstrating the negligible impact of reduced water content on the ham's sensory quality, this study indicates the need for a reassessment of the Dalmatinski pršut specifications. Specifically, we propose adjusting the lower limit of acceptable water content to 30%, a modification aimed at aligning regulatory criteria more closely with the actual production conditions and the scientific understanding of moisture's role in sensory attributes. Such a recalibration of standards is essential for enhancing the accuracy of shelf-life estimations and preserving the high-quality standards of Dalmatinski pršut, thereby supporting its continued recognition and value as a PGI product.

This study contributes to the scientific discourse on food preservation and quality control, and also provides a compelling case for the adaptation of food standards to reflect contemporary research findings and production realities, ensuring the sustainability of traditional food products in modern markets.

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Senzorske karakteristike "Dalmatinskog pršuta" – utjecaj sadržaja vode i pakiranja na dugi period hladnog skladištenja

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U ovom smo radu istražili produljeno skladištenje i senzorsku stabilnost "Dalmatinskog pršuta", pršuta s oznakom zaštićenog zemljopisnog podrijetla (ZZP) (Uredba Komisije (EU) br. 2016/189), tijekom produljenog razdoblja skladištenja na temperaturama hladnog lanca i pakiranja u vakum ambalaži. Cilj nam je bio razjasniti više empirijske osnove za određivanje roka trajanja, suprotstavljajući se prisutnoj praksi arbitrarnog određivanja isteka roka. Tijekom razdoblja od 210 dana, na kontroliranoj temperaturi od 4 ± 2 °C, pratili smo fizikalno-kemijska svojstva pršuta (aktivnost vode i udio soli) i proveli sveobuhvatnu senzorsku ocjenu. Rezultati istraživanja ističu iznimno očuvanje senzorskog profila pršuta, s minimalnim odstupanjima u intenzitetu okusa i bez značajnih promjena u parametrima teksture (tvrdoća, topljivost) ili u razinama soli. Međutim, ključno otkriće je desetljetni trend smanjenja udjela vode među proizvođačima, koji sada varira između 30-46 %, što je ispod raspona od 40-55 % određenog Specifkacijom za "Dalmatinski pršut". Unatoč tom odstupanju, smanjivanje udjela vode nije nepovoljno utjecalo na senzorske karakteristike "Dalatinskog pršuta", ukazujući na stabilnost senzorskog profila na promjene u udjelu vode unutar promatranog razdoblja. Naši rezultati dovode u pitanje definirani sadržaj vode naveden u Specifikaciji "Dalmatinski pršut", sugerirajući potrebu za dopunom kako bi se podržali znastveni dokazi o neznačajnom utjecaju udjela vode na senzorsku kvalitetu. Ovim istraživanjem naglašena je važnost ponovnog razmatranja i potencijalne prilagodbe regulatornih standarda za udio vode u "Dalmatinskom pršutu", snižavajući utvrđenu donju granicu na 30 % i osiguravajući usklađenost s praktičnim proizvodnim stanjem i znanstvenim spoznajama, čime se poboljšava određivanje roka trajanja proizvoda i održava visoki standard kvalitete.

Ključne riječi: *Dalmatinski pršut, pršut, zaštićeno zemljopisno podrijetlo, sadržaj vode, senzorska analiza, fizikalno-kemijska svojstva, vakuum pakiranje*