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THE EFFECT OF GREEN HAM QUALITY ON THE TECHNOLOGICAL, CHEMICAL AND SENSORIAL TRAITS OF DRY-CURED HAM KRAŠKI PRŠUT

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ABSTRACT

This work studies the relationship among raw material characteristics, such as green ham pH value, fat thickness, trimmed ham weight and the main technological, chemical and sensorial traits, in the production of dry-cured *Kraški pršut*. For the scope of the study a sample of 251 hams, supplied by two producers, was used. Trimmed ham weight, fat thickness and pH value of *semimembranosus* muscle (pH_{24}) were recorded on green hams. On dry cured hams the following parameters were assessed: colour (CIE L*,a*,b*), intramuscular fat (IMF), proteolysis index, salt percentage, sensorial analysis. Principal component analysis (PCA) was used to assess the relationships among variables. Among green ham traits, pH_{24} affected the largest number of parameters measured on the dry-cured ham. Higher pH_{24} of green ham was associated with darker muscles of dry cured ham, lower salting and seasoning losses. Extreme values of pH_{24} were associated with the highest values of proteolysis index. As regards sensorial traits, harder and dryer texture was associated with the increase of pH_{24}. Salt percentage was negatively associated with IMF. Fat thickness was negatively associated with salting and seasoning losses. No significant effect of green ham weight was found on any of the parameters considered in this study. As regards PCA analysis the first two components explained 34.5% of the variance. In the first one, trimmed weight, salting and seasoning losses, moisture of *biceps femoris* and *semimembranosus* muscles showed the highest loading values. In the second one saltiness, texture, IMF content, showed the highest loading absolute values.

Key words: green ham traits / dry-cured ham / Kraški pršut / technological quality / chemical composition / sensory traits

1 INTRODUCTION

One of the most appreciated dry-cured meat products in Slovenia is dry-cured ham *Kraški pršut*, which is waiting for the final approval of European Commission for protected geographical indication (PGI). To ensure consistent quality and typical nutritional and sensory properties the producers can play according to several aspects of dry curing process such as the environmental conditions (temperature, relative humidity) and seasoning time. Some of these are reported in the PGI specification for *Kraški pršut*, however no indications are given in terms of characteristics of pigs that provide raw material. The protection of PGI does not consider a control over the origin of raw material, which however is a key factor in the case of dry-cured hams (for review see Čandek-Potokar and Škrlep, 2012). Once the process of drying is standardised the only factor affecting the quality of dry-cured ham is its raw material quality. Dry-curing is a very complex process which involves many biochemical reactions and changes. Induced changes concern water loss and salt intake affecting mainly proteins and lipids. During seasoning proteins and lipids undergo an intense proteolysis and lipolysis, resulting in a great amount of small peptides, free amino acids, free fatty acids and a great number of volatile compounds characterising the product. *Kraški pršut* is now days produced with thighs belonging to conventional pig production characterised by

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relatively low slaughter weights and high leanness which are generally associated with higher seasoning loss and lower dry-cured ham sensory quality (Guerrero *et al.*, 1996). Studies on the effect of raw material on dry-cured ham quality have been carried out extensively on many Mediterranean types of product e.g. Iberian *Parma, San Daniele, Bayonne*. Such studies have been performed on *Kraški pršut* but in a limited extent (Čandek-Potokar *et al.*, 2002; Čandek-Potokar and Škrlep 2011; Škrlep *et al.*, 2011a; Škrlep *et al.*, 2011b). In view of the restricted information, the aim of this work was to study the relationship among green ham characteristics, such as pH_{24}, fat thickness, trimmed weight and the main technological, chemical and sensorial traits, in dry-cured ham *Kraški pršut*.

2 MATERIAL AND METHODS

For the present study 251 hams were used. Two producers of dry hams participated in the present study giving twelve batches of hams in total. All the green hams were weighed before and after the trimming phase. Subcutaneous fat was measured on each trimmed ham below *caput ossis femoris*. The measurements of ultimate pH value (pH_{24}) were taken in m. *semimembranosus* (SM) with the pH Meter MP120 (Mettler-Toledo, GmbH, 8603 Schwarzenbach, Switzerland) on two sites within muscle: Weight of the hams was recorded after trimming, second salting and ripening. Processing losses (%) were calculated as cumulative losses at the end of each phase. On SM and *biceps femoris* (BF) moisture content was performed according to the ISO 6496 (ISO 6496, 1999). At the end of the seasoning process, the following determinations were carried out on SM and BF: 1) Minolta L*a*b* Chroma and Hue values were measured (Minolta Chroma Meter CR-300, Minolta Co, Osaka, Japan), 2) intramuscular fat content determined according to ISO 1443 (ISO, 1443, 2001) using the Büchi Extraction System B-811 (Büchi Labortechnik AG, Flawil,Switzerland); 3) protein calculated from total nitrogen content and determined according to ISO 5983-2 (ISO 5983-2, 2005) using the Kjeltec 2300 nitrogen analyser (Foss Analytical, Hileroed, Denmark). Non-protein nitrogen content was determined as described in Monin *et al.* (2007) and expressed as a percentage of total nitrogen (proteolysis index); 4). Sodium chloride (salt) content was determined as described in Monin *et al.* (1997). On all seasoned hams sensory evaluation was carried out by six trained panellists who assessed sensorial traits on a 7-point scale, with intensity increasing from 1 to 7. The analysis was performed in 18 different sessions and the sample order was randomised. As regard statistical analysis, firstly the original data set of panel test was submitted to analysis of variance (GLM procedure SAS Inc., Cary, NC, USA) with fixed effect of sensory session and residual values were taken. Data set with all variables was then submitted to analysis of variance (GLM procedure SAS Inc., Cary, NC, USA) including producer, batch, producer×batch interaction as fixed and pH_{24}, fat thickness, trimmed weight as covariates. The corresponding regression equations were calculated. Principal component analysis (PCA) was applied to evaluate the relationships among variables and latent variables were constructed.

3 RESULTS AND DISCUSSION

In the figures 1–5 the relationship among pH24 and the main quality traits of dry-cured ham are reported, in Table 1 the corresponding equations of regression are shown. As regard colour parameters, a decrease of L* value is shown according to the increase of pH24 (Fig. 1), even if this trend was significant for SM muscle only. With the increase of pH24 a significant decrease of Chroma and Hue values was also evident (Figures 2, 3), in particular for SM muscle. The SM muscle showed the highest correlation with pH24 because it was the muscle where the ultimate pH was recorded. The decrease of Hue value, mainly due to a significant decrease of b* (data not shown), indicate the prevalence of a* parameters and, consequently, of the red colour.

As regards technological yields, apart from the strictly statistical significance, a decrease of process-

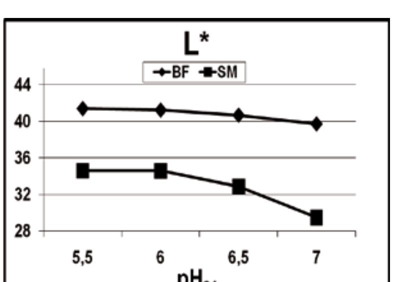

Figure 1: *Evolution of L**

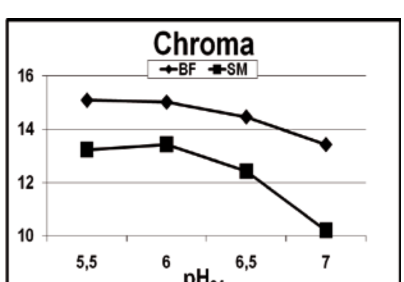

Figure 2: *Evolutiuon of chroma*

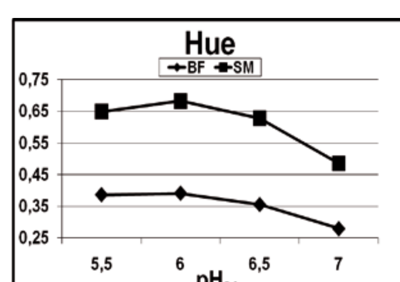

Figure 3: *Evolution of hue*

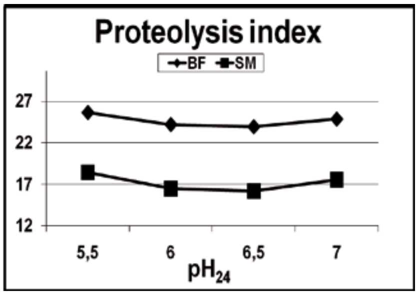

Figure 4: Evolution of proteolysis index

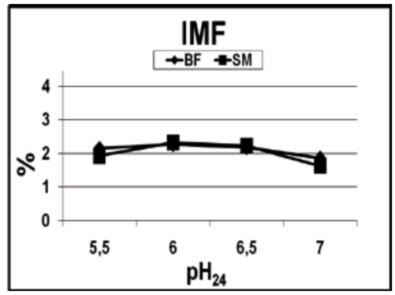

Figure 5: Evolution of IMF

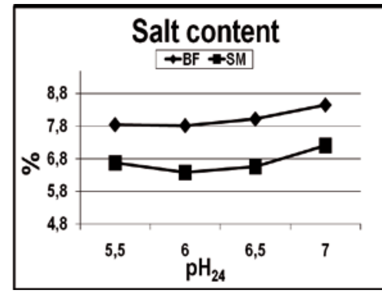

Figure 6: Evolution of salt content

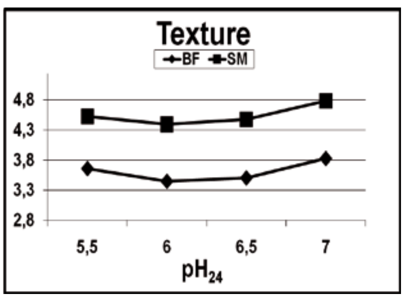

Figure 7: Evolution of texture

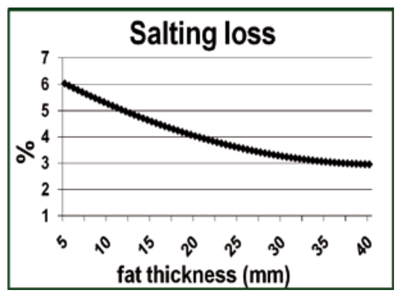

Figure 8: Evolution of salting loss

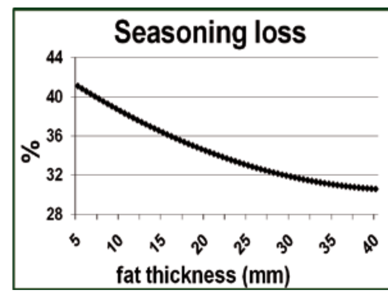

Figure 9: Evolution of seasoning loss

ing losses according to the increase of pH_{24} was found, particularly during salting phase (data not shown). This confirms previous results on *Kraški pršut*, where lower losses at higher pH_{24} were recorded, in particular in the first salting phase, (Čandek-Potokar and Škrlep, 2011), as well as on other type of dry cured ham (Schivazappa *et al.*, 2002).

In Figure 4 the proteolysis index trend is reported. At the extreme values of pH_{24} the highest values of proteolysis indexes were found. As reviewed by Čandek-Potokar and Škrlep (2012) a lower pH causes the breakdown of lysosomes and the subsequent release of proteolytic enzymes into the muscular tissue, the enhancement of the activity of certain enzymes (cathepsins), which can lead to excessive proteolysis and pastiness problems. Higher pH can also cause the release of lower amounts of water, less intake of salt and, subsequently, pastiness and softness due to higher water activity (aw) and less inhibition of enzymatic activity.

In regard to IMF a significant trend according to

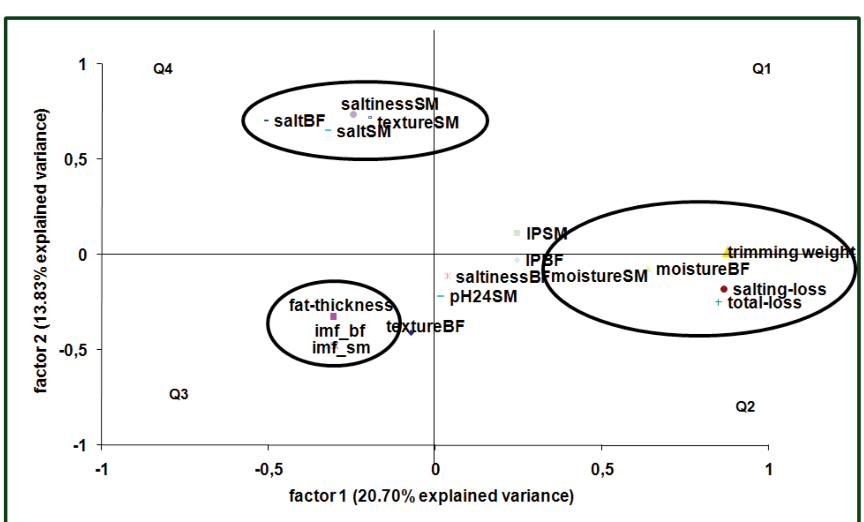

Figure 10: Loading plot of the main quality traits

Table 1: *Equations of regression*

		Significance of linear regression (X)*	Significance of quadratic regression (X^2)*
Regressions on pH_{24}			
L*BF	$= 16.9411736 + 8.82053986 * X - 0.79515801 * X^2$	ns	ns
L* SM	$= -76.6303595 + 38.7964862 * X - 3.37656203 * X^2$	*	*
Chroma BF	$= -16.134685 + 11.00971912 * X - 0.96984462 * X^2$	ns	ns
Chroma SM	$= -68.824103 + 28.22346661 * X - 2.41935589 * X^2$	*	*
Hue BF	$= -2.31661817 + 0.933698715 * X - 0.080406246 * X^2$	*	*
Hue SM	$= -5.51165138 + 2.085860918 * X - 0.175583943 * X^2$	*	*
IP BF	$= 121.175309 - 30.4875067 * X + 2.3964874 * X^2$	ns	ns
IP SM	$= 148.410825 - 41.6389578 * X + 3.2841524 * X^2$	*	*
IMF % BF	$= -13.737773 + 5.30853305 * X - 0.44008552 * X^2$	ns	ns
IMF % SM	$= -35.2581497 + 12.23211065 * X - 0.99475766 * X^2$	*	*
Salt % BF	$= 23.3555643 - 5.34031822 * X + 0.45946637 * X^2$	ns	ns
Salt % SM	$= 40.617222 - 11.28908376 * X + 0.93159937 * X^2$	*	*
Texture BF	$= 23.5397297 - 6.54899837 * X + 0.53284923 * X^2$	*	*
Texture SM	$= 20.3760557 - 5.28923335 * X + 0.43697675 * X^2$	*	*
Regressions on fat thickness			
Salting loss %	$= 6.91562413 - 0.189775568 * X + 0.002269871 * X^2$	*	*
Total loss %	$= 43.9943279 - 0.61501735 * X + 0.00699108 * X^2$	*	*

* the regression coefficients were significant for $P < 0.05$.

variation of pH_{24} was found on SM muscle (Fig. 5). IMF increased with the increase of the pH_{24}, at least within the range of values considered normal for this parameter. Probably, this trend is not related directly to pH_{24} but to the variation in salt percentage (affected by pH), in particular on SM muscle (Fig. 6). Similar results were found by Ruiz-Ramírez *et al.* (2005) in a study on the effect of different level oh pH_{24} on dry-cured traits. They also explained the inverse relationship between salt and IMF percentage according to differences between tissues, in diffusivity of NaCl that is eight times lower in subcutaneous fat than in lean meat.

In Figure 7 the relationship between texture and pH_{24} values is reported. Texture (higher score denotes harder and drier texture) was the only sensorial parameter significantly affected by pH_{24}. In both muscles it was positively correlated to pH value. This result is in contrast with what is known about the relationship between the two parameters (at least in fresh meat), namely that lower meat pH, closer to the isoelectric point of myosin, increases intermolecular linkages between negatively and positively charged groups (Hamm, 1986) and thus hardness. It is probable that the trend of texture values found in this study is related to salt content evolution (both were very similar). In fact, as reported in the above mentioned study (Ruiz-Ramírez *et al.,* 2005) at high NaCl concentration, the myofibrillar structure gets more compact, along with an inhibitory effect of NaCl on the enzyme activities.

As regards the effect of fat thickness, it significantly affected salting and seasoning losses (Fig. 8, 9) which, as expected, decreased with an increase of fat thickness. As reported by Bosi and Russo (2004) a sufficient subcutaneous fat layer is necessary to prevent rapid desiccation and reduction of processing losses. Fat thickness significantly affected only two sensorial traits: texture and saltiness. The former decreased, in particular in BF, according to the increase of fatness. Fat thickness and texture are thus indirectly correlated, due to the positive correlation between texture and intramuscular fat (Ruiz-Carrascal *et al.*, 2000) the latest being positively related to fat thickness (Bahelka *et al.*, 2007). As regard saltiness it was only slightly affected by fat thickness in the case of SM, demonstrating lower saltiness with increasing fatness.

No significant effect of green ham weight was found for any of the parameters considered in this study. This can be explained by the fact that the effect of weight on the qualitative characteristics of dry-cured ham is basically included in the effect of adiposity.

In the loading plot generated by the PCA analysis (Fig. 10), the differences and the similarity between traits are reported. The first component, that explained 20.7% of variance, could be considered as "technological latent variable", where parameters such as trimmed weight, salting and seasoning losses, moisture of BF and SM, showed the highest loading values. The second component, that explained the 13.83% of variance, could be considered as "sensorial latent variable" where, on both muscles, saltiness, texture, IMF content showed the highest loading absolute values. As regard the relationship among variables, almost all the technological variables are placed in the second quadrant at the opposite of those related to salt and saltiness placed in the fourth quadrant, which testifies the inverse relationship among them. Finally, in the third quadrant, the adiposity variables are placed. The low relationship observed between BF and SM demonstrates important differences between the two muscles.

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