PRKAG3 and CAST genetic polymorphisms and quality traits of dry-cured hams—II.
Associations in French dry-cured ham Jambon de Bayonne and their dependence on salt reduction

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A B S T R A C T
This study aimed to evaluate the effects of PRKAG3 Ile199Val and CAST Arg249Lys and CAST Ser638Arg polymorphisms on the quality traits of the French dry-cured ham Jambon de Bayonne and their interaction with salt reduction. Significant (p<0.05) and suggestive associations (p<0.10) between the polymorphisms and several quality traits of dry-cured ham, mainly related to processing and textural properties, were found. PRKAG3 Ile/Val and CAST 249Lys/638Arg presented the highest scores for sensory and processing properties, whatever the salt content.

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1. Introduction
Salting has a long history as a traditional food preservation process, but consumers are now increasingly aware of the deleterious effects of salt intake on their health. Salt can increase blood pressure, thus increasing the risk of cardiovascular disease. Consequently, there is a strong demand for reduced-salt food to meet nutritional recommendations. As dry-cured ham is a popular meat product in many European countries, decreasing its salt content takes on great importance. In France, since 1998, the dry-cured ham Jambon de Bayonne has EU Protected Geographical Indication (PGI) status, which guarantees products made according to traditional methods in specific areas of origin. Moreover, this certification requires professional processors to comply with specifications that provide the consumer with a finished product of optimal quality, particularly in terms of texture.

Curing is a technological process based on adding salt and nitrate and/or nitrite on the ham's external surface to act as preserving agents, but it also has physicochemical and biochemical effects that contribute to the development of the textural and flavour properties. Salt affects muscle proteins by inducing denaturation (Adamsen, Møller, Parolari, Gabba, & Skibsted, 2006; Graiver, Pinotti, Califano, & Zaritzky, 2006), the extent of which is dependent on salt concentration (Thorarinsdottir, Arason, Geirsdottir, Bogason, & Kristbergsson, 2009) and processing yields (Santé-Lhoutellier, Candek-Potokar, Gou, Dutertre, & Robert, 2009). In dry-cured ham, proteolysis occurs throughout processing, but at different rates and to varying extents depending on salt penetration and water migration, with greater proteolytic activity in the biceps femoris muscle compared to the semimembranosus muscle ultimately affecting its texture (Parolari, Virgili, & Schivazappa, 1994; Rosell & Toldrà, 1998; Théron, Chevarin, Robert, Dutertre, & Santé-Lhoutellier, 2009a; Thorén et al., 2011; Virgili, Parolari, Schivazappa, Bordini, & Borri, 1995; Virgili, Schivazappa, Parolari, Bordini, & Degni, 1998). Proteolytic activity in dry-cured ham is essentially attributed to cathepsins, which act for a longer period (Sàrraga, Gil, Arnau, Monfort, & Cussó, 1989; Toldrà & Flores, 1998). However, the first stage of processing also involves classical muscle ageing, when calpains can act (Théron et al., 2011).

Recently, Benedini, Parolari, Toscani, and Virgili (2012) concluded that salt content in traditional Italian dry-cured ham could only be lowered by keeping strict process control over environmental...
conditions, especially temperature, in order to limit proteolytic enzyme activity.

The challenge today in pig selection is to adapt breeds and crossbreeds to ultimate meat use. Garnier, Klont, and Plastow (2003) made an inventory of genetic markers associated with certain quality traits of fresh meat. DNA markers for meat quality have been identified (Plastow et al., 2005; Stefanon et al., 2004). Stalder, Rothschild, and Lonergan (2005) evaluated the effect of calpastatin gene polymorphism on US dry-cured ham. Processing times are generally shorter in the US than in European countries. The polymorphism concerns two nucleotide mutations (Arg249Lys and Ser638Arg) of calpastatin, which were associated with pork meat texture (Ciobanu et al., 2004). The authors demonstrated that the CAST genotype marker significantly influenced cured ham moisture content, prompting them to conclude that selection for this CAST genotype would produce cured hams having more efficient moisture loss, thus requiring less processing time. Among several candidate genes, the PRKAG3 gene, and more specifically the Ile199Val polymorphism, is interesting as it affects ultimate pH in the muscle (Ciobanu et al., 2001). The PRKAG3 gene codes for the γ subunit of the adenosine monophosphate-dependent protein kinase, an enzyme that plays a key regulatory role in muscle cell energy metabolism. Škrlep et al. (2010) recently demonstrated the importance of pH of green ham for proteolysis, concluding that a lower pH would favour cathepsin activity.

This work is part of the EC 6th Framework Programme “TRUEFOOD” project studying the effect of PRKAG3 and CAST gene polymorphisms on the quality of the dry-cured hams produced in Spain, France and Slovenia using specific raw materials and processing conditions. The aim of the paper, which is the second of a series of three papers, is to demonstrate that the CAST genotype marker significantly influenced cured ham moisture content, prompting them to conclude that selection for this CAST genotype would produce cured hams having more efficient moisture loss, thus requiring less processing time. Among several candidate genes, the PRKAG3 gene, and more specifically the Ile199Val polymorphism, is interesting as it affects ultimate pH in the muscle (Ciobanu et al., 2001). The PRKAG3 gene codes for the γ subunit of the adenosine monophosphate-dependent protein kinase, an enzyme that plays a key regulatory role in muscle cell energy metabolism. Škrlep et al. (2010) recently demonstrated the importance of pH of green ham for proteolysis, concluding that a lower pH would favour cathepsin activity.

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Descriptors of taste and texture were evaluated separately on *seminembranosus* (SM) and *bicpes femoris* (BF): easy to cut (resistance to slicing with a knife), easy to chew, tenderness, fibrousness, pastiness (mouth coating sensation produced by flour–water paste during mastication), dryness, presence of crystals (grittiness), persistence of fat, salty taste, acid taste, bitter taste, global taste intensity, rancid flavour, and lingering of the taste.

### 2.6. Statistical analysis

An analysis of variance was performed using the MIXED procedure of SAS. The linear model included the gene polymorphisms and salt (normal and low) as fixed effects, batch and carcass as random effects. Where there was a significant effect of gene polymorphism, least squares means were compared using LSMEANS with Tukey’s test option. Genotype and salt effects are presented separately in tables when no interactions were significant.

CAST haplotypes were also compared. The haplotypes inferred between CAST249 and CAST638, i.e. 249Ile–638Arg, 249Arg–638Arg, 249Arg–638Ser and 249Ile–638Ser, were analysed by considering animals (hams) as having 0, 1 or 2 copies of the haplotype-of-interest. The models used were equivalent to those applied for single polymorphisms, including the combined CAST249–CAST638 genotype instead of the single CAST gene polymorphisms.

### 3. Results and discussion

#### 3.1. PRKAG3 Ile199Val, CAST Arg249Ile and CAST Ser638Arg distribution

Genotype distribution by gene markers is presented in Table 2. For PRKAG3, Ile/Ile and Val/Val. Similarly, for CAST at locus 249 and CAST at locus 638, Arg/Arg and Ser/Ser were underrepresented, respectively.

#### 3.2. Effect of salt reduction in dry cured hams

Salt reduction had effects on practically every item studied except lipid and protein contents (Table 3). The average salt reduction achieved was 15 to 20%. Higher moisture and proteolysis indexes were noted in dry cured hams with less salt.

Lipid oxidation was lower in the reduced–salt-content ham. Most of the lipolysis takes place during the first 5 months of dry-cured ham production, generating free fatty acids and especially mono- or polyunsaturated fatty acids prone to oxidation (Ripolles, Campagnol, Armenteros, Ariostoy, & Toldrá, 2011). Salt plays an important role in controlling enzyme activity, as less salt leads to increased water activity in the product. However, unlike mainly muscle enzymes, lysosomal acid lipase showed higher activity with higher salt concentration and lower water activity (Motilva & Toldrá, 1993). Recently, Ripolles et al. (2011) reported that partially replacing the sodium chloride in dry-cured ham resulted in almost equal lipid oxidation. Proteolysis index was higher in dry-cured ham with reduced salt content, as expected, but interestingly, salt reduction did not impact processing yield or quantity of saleable product.

Generally speaking, the effect of salt reduction on sensory traits affected both SM and BF muscles in much the same way, independently of muscle structure and salt/water dynamics. Higher salt content was always associated with greater intensity and duration of overall taste in dry-cured ham. Conversely, lower salt content reduced the effort needed to chew the dry-cured ham, and consequently increased product tenderness and, to some extent, pastiness. Fibrousness was also slightly reduced in lower-salt ham. Benedini et al. (2012) recently demonstrated the role of salt content as a promoter of odour and taste by evaluating the impact of salt content (low, intermediate and high) on the sensory traits of dry-cured ham. To avoid mixed effects of volatile compounds coming from intramuscular fat oxidation, the fat trait was included in the model as a covariate. Matured odour and taste increased with salt content, whereas green meat odour or taste was unaffected by salt content. The disappearance of the sensory item associated to raw meat is largely dependent on the duration of meat ageing. Here, all the dry-cured hams were ripened for a similar 12-month period. The grittiness was less important in the reduced-salt-content hams, but only in the SM muscle. The presence of crystals is often attributed to the release of free amino acids, especially tyrosine due to excess of proteolysis. Another source of crystal formation is often attributed to the release of free amino acids, especially tyrosine due to excess of proteolysis. Another source of crystal formation is often attributed to the release of free amino acids, especially tyrosine due to excess of proteolysis.

#### Table 3

Association between salt content and physicochemical, processing and sensory traits. For sensory traits only significant (p<0.05) or suggestive (p<0.10) associations are shown. Least squares means ± standard error.

<table>
<thead>
<tr>
<th>Physicochemical traits</th>
<th>Low salt</th>
<th>Normal salt</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>60.40 ± 0.26</td>
<td>59.57 ± 0.25</td>
<td>0.001</td>
</tr>
<tr>
<td>Chloride (%)</td>
<td>5.37 ± 0.15</td>
<td>6.16 ± 0.15</td>
<td>0.001</td>
</tr>
<tr>
<td>Protein content (%)</td>
<td>28.34 ± 0.23</td>
<td>29.55 ± 0.22</td>
<td>NS</td>
</tr>
<tr>
<td>Lipid (%)</td>
<td>3.24 ± 0.32</td>
<td>3.28 ± 0.31</td>
<td>NS</td>
</tr>
<tr>
<td>Proteolysis index (%)</td>
<td>29.40 ± 0.61</td>
<td>28.32 ± 0.60</td>
<td>0.007</td>
</tr>
<tr>
<td>TBars (mg MDA/kg)</td>
<td>0.59 ± 0.08</td>
<td>0.74 ± 0.07</td>
<td>0.047</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Processing traits</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Salting loss (%)</td>
<td>3.90 ± 0.12</td>
<td>4.60 ± 0.11</td>
<td>0.001</td>
</tr>
<tr>
<td>Resting loss (%)</td>
<td>20.70 ± 0.50</td>
<td>21.24 ± 0.50</td>
<td>0.008</td>
</tr>
<tr>
<td>Ripening loss (%)</td>
<td>31.49 ± 0.72</td>
<td>31.85 ± 0.71</td>
<td>0.088</td>
</tr>
<tr>
<td>Processing yield (%)</td>
<td>68.85 ± 0.59</td>
<td>68.77 ± 0.57</td>
<td>NS</td>
</tr>
<tr>
<td>Slicing yield (%)</td>
<td>87.23 ± 0.52</td>
<td>88.60 ± 0.49</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensory traits</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grittiness</td>
<td>0.11 ± 0.01</td>
<td>0.15 ± 0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Persistence of fat</td>
<td>3.03 ± 0.09</td>
<td>3.17 ± 0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Global taste intensity</td>
<td>3.71 ± 0.06</td>
<td>3.89 ± 0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>Rancid flavour</td>
<td>0.21 ± 0.02</td>
<td>0.16 ± 0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Fibrousness</td>
<td>1.61 ± 0.09</td>
<td>1.72 ± 0.09</td>
<td>0.10</td>
</tr>
<tr>
<td>Salty taste</td>
<td>2.71 ± 0.07</td>
<td>3.03 ± 0.06</td>
<td>0.001</td>
</tr>
<tr>
<td>Pastiness</td>
<td>2.70 ± 0.54</td>
<td>2.11 ± 0.55</td>
<td>0.019</td>
</tr>
<tr>
<td>Tenderness</td>
<td>3.83 ± 0.10</td>
<td>3.64 ± 0.10</td>
<td>0.019</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Biceps femoris muscle</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to chew</td>
<td>4.36 ± 0.09</td>
<td>4.13 ± 0.09</td>
<td>0.004</td>
</tr>
<tr>
<td>Persistence of fat</td>
<td>3.04 ± 0.09</td>
<td>3.21 ± 0.09</td>
<td>0.01</td>
</tr>
<tr>
<td>Dryness</td>
<td>2.51 ± 0.10</td>
<td>2.80 ± 0.09</td>
<td>0.0006</td>
</tr>
<tr>
<td>Fibrousness</td>
<td>0.94 ± 0.10</td>
<td>1.10 ± 0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>Rancid flavour</td>
<td>0.32 ± 0.04</td>
<td>0.26 ± 0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>Salty taste</td>
<td>2.66 ± 0.08</td>
<td>3.01 ± 0.08</td>
<td>0.0001</td>
</tr>
<tr>
<td>Pastiness</td>
<td>1.71 ± 0.46</td>
<td>1.36 ± 0.45</td>
<td>0.07</td>
</tr>
<tr>
<td>Tenderness</td>
<td>4.14 ± 0.11</td>
<td>3.91 ± 0.10</td>
<td>0.008</td>
</tr>
</tbody>
</table>

# Table 2

Genotype distribution by gene markers in the genotyped population (n = 559) and distribution breakdown.

<table>
<thead>
<tr>
<th>Genotype frequencies</th>
<th>Ile/Ile</th>
<th>Ile/Val</th>
<th>Val/Val</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRKAG3 Ile199Val</td>
<td>0.038</td>
<td>0.566</td>
<td>0.395</td>
</tr>
<tr>
<td>CAST Arg249Ile</td>
<td>0.081</td>
<td>0.555</td>
<td>0.363</td>
</tr>
<tr>
<td>CAST Ser638Arg</td>
<td>0.015</td>
<td>0.455</td>
<td>0.530</td>
</tr>
</tbody>
</table>

# Table 3

Genotype distribution by gene markers in the genotyped population (n = 559) and distribution breakdown.
Antequera, Timon, and Ventanas (1998) and Virgili et al. (1995) highlighted the side effects of lower salt, especially an increase in non-protein nitrogen which is often associated with defective appearance (presence of a white surface film) and an increased percentage of mushy mouthfeel.

3.3. Association between PRKAG3 Ile199Val and physicochemical, processing and sensory traits

Table 4 reports the association of PRKAG3 with physicochemical and processing traits, which in both cases remained very limited. Ile/Ile homozygotes presented a slightly higher moisture content compared to Val/Val homozygotes. Stalder et al. (2005) did not report differences in moisture content, probably because country-style dry-cured ham is processed differently from Mediterranean-style dry-cured ham which is ripened for longer periods. Processing traits were unaffected by PRKAG3 polymorphism. The PRKAG3 gene had no effect on weight loss during processing or on processing and slicing yields. Such processing traits are generally correlated to several fresh pork quality traits (Ramos, Serenius, Stalder, & Rothschild, 2007). Fontanesi et al. (2008) previously reported an absence of effect on ultimate pH of the PRKAG3 gene mutation at locus 199, but they also found that PRKAG3 significantly affected the rate of pH drop in Val/Val genotype animals. They also tested other mutations for PRKAG3, i.e. T30N and G52S, but neither of them were associated with the extent of pH decline. In general, the Ile/Ile homozygotes yield a slightly higher ultimate pH, which is not different from the Ile/Val heterozygotes or Val/Val homozygotes (Otto et al., 2007; Stalder et al., 2005). Skrlep et al. (2010) recently highlighted the importance of the site of measurement for ultimate pH in the semimembranosus from Slovenian dry-cured ham Krški pršut. The authors demonstrated a PRKAG3 gene effect on ultimate pH (pHu) when the measurements were taken at the part adjacent to the femur bone, while in the Spanish line used for Serrano ham, they reported that the homogenous Ile/Ile line led to a slightly but significantly higher pHu (5.61 vs. 5.54 for Ile/Val). Our purpose was to evaluate the possible use of the PRKAG3 Ile199Val polymorphism to select animals that perform better in dry-cured ham production without any detrimental effect on technological traits.

The significant associations between sensory traits and the PRKAG3 gene are presented in Table 4. Several gene effects were observed on textural items on both semimembranosus and biceps femoris. The Ile/Val heterozygote and the Val/Val homozygote were systematically much more tender or easy to chew. Tenderness is an appreciated and desirable characteristic of dry-cured ham, but an excessive degree of proteolysis can reduce meat texture down to a point that impacts consumer acceptability. In this study, PRKAG3 affected pastiness, as Ile/Val heterozygotes differed from Ile/Ile homozygotes. The persistent fat taste tended to be less intense in Ile/Val heterozygotes. A higher tenderness of the product might have modified the time of contact in the mouth, thereby minimising the perception of persistent fat for the semimembranosus muscle.

3.4. Association between CAST gene polymorphism (loci 249 and 638) and physicochemical, processing and sensory traits

The chemical parameters and processing yields analysed for CAST249 and CAST638 genotypes are given in Tables 5 and 6. None of the physicochemical traits were affected by CAST genotype at the two loci. These results differed from those reported in Stalder et al. (2005). Salting loss was affected by CAST genotype at locus 249, with Lys/Lys homozygotes presenting lower losses after the salting period. This could not be explained by the higher pHu in these hams. This slower water dynamics proved persistent, as demonstrated by the lower weight losses found at the resting period and until the end of the processing phase. Indeed, processing yields were higher for Lys/Lys homozygotes, although without differences in slicing ability. For CAST at locus 638, similar results were found for processing traits, except for salting losses. The CAST gene seems to have a positive effect on overall processing yield of dry-cured ham without any concomitant detrimental effects such as reduced sliceability. In fresh meat, Ciobanu et al. (2004) considered the CAST249 Lys/Arg haplotype as optimal in terms of ultimate pH, cooking loss and juiciness. The results are in accordance with the Slovenian study on Krški pršut showing highest processing losses.
Table 6

<table>
<thead>
<tr>
<th>CAST Ser638Arg genotypes</th>
<th>Sensory traits</th>
<th>Processing traits</th>
<th>Physicochemical traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAST Ser638Arg genotypes</td>
<td>Whole slice</td>
<td>Pungent odour</td>
<td>Lipid</td>
</tr>
<tr>
<td>Ser/Ser</td>
<td>Arg/Ser</td>
<td>Arg/Arg</td>
<td>p Value</td>
</tr>
<tr>
<td>n = 14</td>
<td>n = 40</td>
<td>n = 66</td>
<td></td>
</tr>
</tbody>
</table>

- **Physicochemical traits**
  - Moisture (%): 59.25 ± 0.59; 60.16 ± 0.35; 60.54 ± 0.34; NS
  - Chloride (%): 5.39 ± 0.30; 5.70 ± 0.19; 5.60 ± 0.18; NS
  - Protein content (%): 30.05 ± 0.52; 29.35 ± 0.31; 28.94 ± 0.30; NS
  - Lipid (%): 3.44 ± 0.68; 2.84 ± 0.42; 3.46 ± 0.40; NS
  - Protoprotease index (%): 28.77 ± 1.13; 29.50 ± 0.73; 28.32 ± 0.72; NS
  - TBARS (mg MDA/kg): 0.70 ± 0.16; 0.63 ± 0.10; 0.67 ± 0.09; NS

- **Processing traits**
  - Salting loss (%): 4.39 ± 0.28; 4.06 ± 0.16; 4.31 ± 0.16; NS
  - Ripening loss (%): 21.13 ± 1.04; 20.35 ± 0.72; 21.43 ± 0.76; NS
  - Processing yield (%): 68.36 ± 1.25; 69.89 ± 0.79; 68.18 ± 0.75; NS
  - Slicing yield (%): 87.86 ± 1.17; 86.90 ± 0.70; 86.30 ± 0.65; NS

- **Sensory traits**
  - Whole slice
    - Total odour intensity: 32.49 ± 1.25; 31.36 ± 0.86; 31.16 ± 0.84; 0.06
    - Pungent odour intensity: 29.15 ± 1.04; 28.60 ± 0.75; 28.32 ± 0.72; 0.08
    - Rancid flavour: 0.11 ± 0.05; 0.26 ± 0.03; 0.19 ± 0.03; 0.007
    - Tenderness: 3.61 ± 0.19; 3.99 ± 0.12; 3.59 ± 0.11; 0.014

- **Contrasts**
  - CAST Ser638Arg genotype estimates to estimate CAST haplotype differences.
  - Number of hams
    - 249lys–638Arg vs. 249lys–638Ser: 36, 30, 14, 26, 14
    - 249lys–638Arg vs. 249lys–638Ser
      - Contrast 1: 1, 1, 0, 0, 0
      - Contrast 2: 0, 1, 0, 1, 0
  - Weighted mean contrast
    - 249lys–638Arg vs. 249lys–638Ser: 0.21, 0.58, –0.58, –0.21
  - Contrast
    - 0, 0, 0, 1, –1

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3.5. CAST haplotype associations

To study the CAST haplotype associations, combined CAST249–CAST638 genotypes were used which were represented by a minimum of five animals, avoiding those animals that were heterozygotes for both CAST249 and CAST638. Thus the following genotypes were used: 249lys/249lys–638Arg/638Ser (C1), 249lys/249Arg–638Arg/638Arg (C2), 249Arg/249Arg–638Arg/638Arg (C3), 249Arg/249Arg–638Arg/638Ser (C4) and 249Arg/249Arg–638Ser/638Ser (C5). These genotypes allowed estimation of three CAST haplotype differences: 249lys–638Arg vs. 249lys–638Arg, 249lys–638Arg vs. 249Arg–638Ser and 249Arg–638Arg vs. 249Arg–638Ser.

To estimate each haplotype difference, different individual contrasts were used by considering the animals as having 0, 1 or 2 copies of each haplotype (Table 5). The arithmetic mean of the individual contrasts does not take into account the fact that the number of animals compared to the mean contrast (Table 7). In this weighted mean contrast set-up, only two salt×gene interactions were found, both with CAST638 Ser/Ser, but only in normal-salt-content dry-cured ham. Moreover, in these dry-cured hams (normal salt/CAST638 Ser/Ser), pungent odour was more than doubled. The more intense taste might be due to this more marked unpleasant sensation. Salt reduction effectively limited this gene effect.
monophosphate-activated g3-subunit gene associated with low glycogen content in pig skeletal muscle and improved meat quality. Genetics, 159, 1151–1162.


### Acknowledgments

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### References


### Table 8

<table>
<thead>
<tr>
<th>Haplotypes</th>
<th>H1–H2</th>
<th>H1–H3</th>
<th>H2–H3</th>
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<tr>
<td>Moisture (%)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>(p = 0.0835)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p value</td>
<td>0.97</td>
<td>0.51</td>
<td>0.92</td>
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</table>

### 4. Conclusion

This study demonstrated differences in the impacts of PRKAG3 and CAST genes on the selected hams, and underlined the important effects of the CAST gene at loci 249 and 638 on several fresh and dry-cured ham traits in the pig line used. However, the significant linkage disequilibrium between CAST polymorphisms observed in the population weakened, to some extent, the impact of the study. The PRKAG3 le/Val heterozygote was associated with suitable sensory properties. The 249Lys/638Arg haplotype presented the highest scores for sensory and processing traits whatever the salt content. In conclusion, this study identified the genotype (PRKAG3 and CAST) that is best adapted to producing French Bayonne dry-cured hams with reduced salt content without any deleterious effects on processing and sensory qualities.

SM: semimembranosus muscle; BF: biceps femoris muscle.

* 0–10 points non-structured scale (0: absence; 10: maximum intensity).