Effect of double-muscling genotype on animal, carcass and meat quality characteristics from calves of Galician Blond breed

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Abstract- **The aim of this work is to study the effect of double-muscling genotype (dominant-homozygous: *mh/mh* or heterozygous: *mh/+*), due to the inactivation or mutation of the gene responsible for muscular hypertrophy, on animal, carcass and meat quality (physiochemical: and nutritional: GC analysis) characteristics from fifteen male calves of Galician-Blond breed. Double-muscling genotype has shown a significant positive effect on carcass characteristics. Veal from double-muscled animals has shown slightly differences on the physiochemical characteristics than the recessive-homozygous genotype animals (RHM), however double-muscling genotype showed a more beneficial fatty acids profile on the analysis of the intramuscular fat compared to recessive-homozygous genotype animals.**

Keywords-**Muscular hypertrophy, Meat quality, Fatty acids.**

I. INTRODUCTION

Galician Blond (GB) is one of the most important local beef breed in Spain with more than 50,000 animals registered in the herd book. Recognition of the unique quality of Galician beef prompted the European Union (EU) to accept, the Protected Geographical Indication (PGI) of Galician Veal "Ternera Gallega", which comprises pure GB and its crosses. This PGI classifies the 98% of the animals as calves if they are slaughtered earlier than ten months of age.

GB breed is considered a late maturating beef breed [1]which calves have shown very lean carcasses and beef with a reduced fat content [2,3]. GB breed has been characterized by showing a high proportion of double-muscle animals [4]. Most of these animals are genetically homozygous (*dominant- homozygous* DHM: mh/mh) or heterozygous (HT: *mh/+)* due to the inactivation or mutation of the gene responsible for muscular hypertrophy (myostatin, *growth differentiation factor 8:GDF-8*) with a higher muscular development on these animals.

Different carcass characteristics [5], meat quality [6] and fatty acid profile of several tissues [5], with further analysis on trans-18:1 and conjugated linoleic acid (CLA) content and isomeric composition [7] have been found in the three genotypes (DHM, HT and *recessive-homozygous* RHM: +/+) from *Asturiana de los Valles* (AV) breed (region neighboring with Galicia).

Therefore, it would be interesting to study the variation in growth rate, carcass characteristics and meat quality from GB calves with different myostatin genotypes.

II. MATERIAL AND METHODS

Fifteen Galician-Blond male calves suckling their mothers on grazing from the Mabegondo Research Centre experimental herd were classified in three groups according to the double-muscling genotype expression (DHM n=5; HT n=5; RHM n=5) by an AND extraction from blood samples in the Galician Molecular Genetic Laboratory *Xenética Fontao* (Applied Biosystems, Prefiler™ Forensic DNA Kit Applied in Mag-Max™ Express-96 Magnetic Particle Processor and with visualizing the results from Applied Biosystems 3500xL Dx Genetic Analyzer with GeneMapper™ Software 4.1).

Animals were slaughtered at ranged of ten months old. Average slaughter weight for the three genotypes was 363 kg. Animals were conventionally slaughtered at a commercial abattoir and carcass were weighted and chilled at 4 ºC in a cold chamber immediately after slaughtering for 24 h.
Data from live animals: slaughter age (SA), birth (BW) and live weight (LW), average daily gain (ADG); carcass traits: carcass weight (CW), dressing percentage (DP), conformation (CS) and fatness (FS) classification scores were recorded. *Physiochemical*: pH; water holding capacity (WHC) by pressing juice loss (PJL), drip loss (DL), thawing juice loss (TJL) and cooking juice loss (CJL; texture by Warner Bratzler Shear Force (WB-SF, Firmness (WB-F) and Work (WB-W); chemical composition by moisture (M), ash (A), crude protein (CP) and intramuscular fat content (IMF): NIRS (Near Infrared Spectrophotometer);colour by mioglobin content (MIO), luminosity (L*), yellowness (b*), redness (a*), chroma (C*) and hue (h*) and *Nutritional* (fatty acid profile by Gas Chromatography: C4-C24 including CLA and TVA): characteristics were analysed on *longissimus thoracis (L.th.)* muscle at 48h *post mortem*. Data were analyzed by ANOVA using the General Linear Model (GLM) procedure of SAS package.

The model used was: $Yij = \mu + Wi + \varepsilon ij$; where *Yij* is the observation of double-muscling genotype expression *i* and animal *j*, for any of the dependent variables such as animal live weight and age, carcass weight and classification score; FA grouped by families and main individual FA of the intramuscular fat from calves; μ is the overall mean; *W*i is the double-muscling genotype expression i (i=1, 2, 3) and εij is the residual random error associated with the observation *ij*. When differences among double-muscling genotype expression groups appeared (P<0.01) a Duncan test was done. Least-square means are presented and double-muscling genotype expression differences were considered significant at P<0.05.

III. RESULTS

Double-muscling genotype has shown a significant positive effect on dressing percentage (DP) (56.53 (DHM) *vs* 52.35 (HT) *vs* 49.67 (HMR), p<0.001) and a very good conformation score (CS) (U (DHM) *vs* R (HT) *vs* O^+ (HMR), p<0.001) in *Table 1*. Therefore, *L.th*.weight (p<0.01) and loin piece performance (p<0.05) were also bigger in double-muscling animals than the others.

Veal from double-muscled animals has shown lower water-holding capacity by showing higher thawing juice losses (TJL) (p<0.1) and cooking juice losses (CJL) (NS) values, than the recessive-homozygous genotype animals (RHM), in *Table 2*. As a result of that, DHM animals have shown higher but not-significant values in Warner–Bratzler shear force, firmness and work than the other calves.

Chemical composition of veal from double-muscling genotype (DHM and HT) has shown a no significant lower fat content and higher protein content (CP), and also a higher (p<0.05) ash content (A) compared with RHM animals which have a faster growth rate of adipose tissue in *Table 2*.

No significant differences were found in colour parameters among GB calves with different myostatin genotypes, although there was a significant trend towards lower mioglobin content and higher hue values in HDM compared to RHM animals in *Table 2*.

Table 1.-Least square means (standard error in parenthesis) of the genotype expression effects on animal live and carcass characteristics. F-tests.

	RHM	HT	DHM	F-tests
Nº Animals	5	5	5	
SA (days)	298(1.34)	292.4(1.83)	301.8(5.15)	n.s.
BW (kg)	42.3(3.33)	47.8(1.08)	50.0(3.68)	n.s.
LW (kg)	350.0(17.04)	374.2(14.33)	364.4(21.44)	n.s.
ADG	1.03(0.06)	1.12(0.05)	1.04(0.06)	n.s.
CW (kg)	174.20(10.69)	196.20(10.28)	206.20(12.97)	n.s.
DP (%)	49.67(0.98)c	52.35(1.05)b	56.53(0.31)a	***
CS	6.2(0.74)c	8.0(0)b	11.0(0)a	***
FS	4.6(0.25)	4.8(0.20)	4.6(0.25)	n.s.
L.th weight (kg)	1.11(0.07)b	1.26(0.08)b	1.52(0.06)a	**

Loin piece performance (%)	72.23(0.95)b	74.42(0.20)ab	76.05(0.69)a	*

+, *, **, *** refer to significant at the 10, 5, 1 and 0.1% probability levels, respectively; NS refers to not significant.
Means in the same column bearing different letters are significantly different under the Duncan test.

Table 2.-Least square means (standard error in parenthesis) of the genotype expression effects on meat physiochemical analysis. F-tests.

	RHM	HT	DHM	F-test
Nº Animals	5	5	5	
pH	5.65(0.12)	5.73(0.11)	5.55(0.02)	n.s.
PJL	28.09(1.55)	25.69(1.04)	29.02(0.48)	n.s.
DL	3.81(0.30)	3.39(0.09)	3.48(0.17)	n.s.
TJL	6.34(1.22)b	7.19(1.49)ab	10.82(1.09)a	+
CJL	19.14(1.78)	23.10(1.05)	23.81(4.31)	n.s.
WB-SF	4.79(0.32)	4.59(0.50)	5.12(0.44)	n.s.
WB-F	1.99(0.21)	1.97(0.36)	2.14(0.16)	n.s.
WB-W	12.26(0.98)	12.48(1.32)	13.50(81.46)	n.s.
M (%)	78.26(0.41)	78.12(0.39)	77.79(0.19)	n.s.
A (%)	1.19(0.01)b	1.20(0.01)ba	1.21(0.01)a	*
IMF (%)	0.75(0.22)	0.52(0.14)	0.53(0.07)	n.s.
CP (%)	21.74(0.35)	22.15(0.32)	22.55(0.14)	n.s.
MIO	3.45(0.27)a	3.32(0.29)ab	2.57(0.17)b	+
L*	39.01(1.49)ab	37.20(0.64)b	40.77(0.90)a	n.s.
a*	15.57(0.80)	13.38(0.99)	14.57(0.65)	n.s.
b*	7.62(0.50)	5.85(0.82)	7.31(0.54)	n.s.
Chroma (C*)	17.34(0.94)	14.63(1.23)	16.31(0.81)	n.s.
Hue (h*)	25.98(0.52)	23.11(1.51)	26.50(0.91)	+

Double-muscling genotype had a positive effect on the fatty acid profile as result of a higher percentage in n-6PUFA ($p<0.001$), PUFA ($p<0.001$) and PUFA:SFA ratio ($p<0.001$) and a lower percentage in SFA ($p<0.001$) and MUFA ($p<0.001$) compared to recessive-homozygous genotype in *Table 3.*

Table 3.-Least square means (standard error in parenthesis) of the genotype expression effects on meat nutritional analysis (FA percentage). F-tests.

	RHM	HT	DHM	F-test
Nº Animals	5	5	5	
%C14:0	2.04 (0.26)a	1.67(0.31)ab	1.10(0.20)b	+
%C14:1	0.32(0.22)b	1.01(0.14)a	0.77(0.19)ab	+
%C16:0	24.96(0.46)a	22.54(0.52)b	22.84(0.41)b	**
%C16:1	2.23 (0.11)a	2.05 (0.20)ab	1.71(0.12)b	+
%C17:0	1.22 (0.14)a	0.85(0.04)b	0.84(0.08)b	*
%C17:1	0.25(0.15)	0.55(0.07)	0.33(0.06)	n.s.
%C18:0	20.15(1.30)	17.71(0.43)	17.78(0.55)	n.s.
%TVA	0.56(0.07)	0.60(0.07)	0.67(0.10)	n.s.
%C18:1n-9c	31.24(0.83)a	26.81(0.84)b	25.22(1.09)b	**
%C18:2n-6c	6.81(1.92)b	11.80(0.48)a	14.07(0.92)a	**
%C18:3n-3	3.79(1.11)	5.41(0.29)	5.81(0.33)	n.s.
%CLA	0.40(0.10)	0.58(0.15)	0.38(0.11)	n.s.
%C20:3n-6	0.30(0.09)b	0.77(0.10)a	0.83(0.08)a	**
%C20:4n-6	3.46(0.71)	4.55(0.41)	4.71(0.41)	n.s.
%C20:5n-3	1.87(0.45)	2.64(0.35)	2.59(0.21)	n.s.
%SFA	48.76(1.75)a	43.09(0.81)b	42.85(0.87)b	**
%MUFA	34.61(0.71)a	31.02(0.89)b	28.72(1.41)b	**
%TFA	0.59(0.07)	0.60(0.07)	0.69(0.11)	n.s.
%PUFA	16.62(2.13)b	25.89(1.13)a	28.43(1.60)a	***
%n-6	10.56(1.67)b	17.13(0.74)a	19.61(1.28)a	***
%n-3	5.66(1.49)	8.18(0.56)	8.44(0.52)	n.s.
n-6:n3	3.10(1.29)	2.11(0.07)	2.33(0.11)	n.s.
PUFA:SFA	0.35(0.06)b	0.60(0.03)a	0.67(0.04)a	***

IV. DISCUSSION

The double-muscling genotype produced a significant increase in carcass conformation score, as widely reported in AV [5] and Belgian Blue breeds [8].

Our results in chemical composition are in accordance with recent works from the mutation of the gene responsible for muscular hypertrophy in other breeds which had found low IMF values in muscle [9].

Veal from animals with muscular hypertrophy (*mh/mh*) and (*mh*/+) showed lower water-holding capacity measured as increased thawing (TJL) and cooking juice losses (CJL). These results are in accordance with other studies which showed a higher glycolytic metabolism in animals with muscular hypertrophy [6] in AV breed. A significant positive relationship between IMF content and water holding capacity (lower juice losses values) were found when comparing animals from different *mh*-genotype [5]. In relation to colour parameters, our results agree with earlier studies that described a decrease in haem pigment content in double-muscling animals from AV breed [6].

Double-muscling genotype has shown a significantly increased in PUFA percentage with increasing *mh* alleles, as another studies in AV breed [5] and Belgian Blue breed [10]. Furthermore, the higher percentages of SFA and MUFA from calves of the +/+ genotype compared with the *mh/mh* genotype is mainly due to the higher intramuscular fat content from the free myostatin mutation animals [10]. The PUFA/SFA ratio increased significantly as the number of *mh* alleles increased mainly due to the higher percentage of PUFA and lower of SFA in this type of animals. This result is in accordance with other double-muscling breeds [5, 10]. Veal from *mh* genotypes approached the recommendations of nutritional guidelines for PUFA/SFA of 0.45 or higher. Some previous reports [11] showed that the PUFA/SFA ratio of meat can rise to >0.5 values in very lean meats as double-muscled animals.

V. CONCLUSIONS

The double-muscling genotype expression on Galician-Blond calves has been proved to be beneficial on animal and carcass performance even on the fatty acid profile.

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