

## Effect of androstenone level in characteristics of dry fermented sausage manufactured with meat from entire male pigs

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### ADDITIONAL KEYWORDS

Boar taint.  
Castration Ban.  
Chorizo.  
Fatty acids.

### SUMMARY

As a consequence of European changes in animal welfare regulations, in the near future the pork industry may face a ban on castration of male piglets which could lead to a medium and high risk of boar taint. On the other hand, physical castration affects animal fat depot and fatty acid composition of lean and fat tissues. Therefore, the use of entire male pigs in meat industry could affect the processing and quality of meat products. The objective of this study was to evaluate the effect of androstenone (AND) level on the characteristics of dry cured sausage (chorizo). For this purpose, chemical composition, fatty acid (FA) profile and sensory characteristic of dry fermented sausages from castrated pigs and from entire male pigs with two levels of AND (Medium: 0.5-0.8 µg/g fat, High: 1.1-2.9 µg/g fat) were analyzed. Medium and high AND sausages had the highest protein and the lowest fat content ( $P < 0.05$ ). Sausages from castrated pigs had the highest saturated FA and monounsaturated FA contents ( $P < 0.05$ ). An increase of polyunsaturated FA content was observed when AND level increased ( $P < 0.05$ ). In spite of these differences, the scores given by a trained sensory panel for texture parameters were similar for all sausages. For androstenone perception (odour and flavour), high AND sausages presented the highest scores, however no differences were found between medium AND sausages and those from castrated pigs. These results suggest that meat from entire pigs with medium level of androstenone could be used like the meat from castrated pigs for chorizo elaboration.

### Efecto del nivel de androstenona en chorizos elaborados a partir de cerdos enteros

### RESUMEN

Como consecuencia de los cambios en la normativa europea sobre bienestar animal, en un futuro próximo la industria porcina podría afrontar la prohibición de la castración de lechones machos, lo que implicaría un riesgo medio o alto de obtener carne con olor sexual. La castración física afecta a la cantidad de grasa de depósito y a la composición de ácidos grasos de los tejidos magro y graso. Por lo tanto, el uso de cerdos enteros en la industria podría afectar al procesado y a la calidad de los productos cárnicos. El objetivo de este estudio fue evaluar el efecto del nivel de androstenona (AND) en las características de un embutido crudo curado (chorizos). Para ello, la composición química, el perfil de ácidos grasos y las características sensoriales de chorizos de cerdos castrados y de cerdos machos enteros con dos niveles de AND (Medio: 0,5-0,8 µg/g de grasa, Alto: 1,1-2,9 µg/g de grasa). Los chorizos procedentes de cerdos con niveles de AND medio y alto presentaron el mayor contenido en proteína y el menor contenido de grasa ( $P < 0,05$ ). Los chorizos de cerdos castrados tenían mayores concentraciones de ácidos grasos saturados y monoinsaturados ( $P < 0,05$ ). Se observó un aumento del contenido de ácidos grasos poliinsaturados al aumentar el nivel de AND ( $P < 0,05$ ). A pesar de estas diferencias, las puntuaciones dadas por un panel sensorial entrenado en los parámetros de textura fueron similares en todos los chorizos. En cuanto a la percepción de la AND (olor y flavor), los chorizos con alta concentración de AND presentaron las puntuaciones más altas, sin embargo, no se encontraron diferencias entre chorizos con concentración media de AND y los procedentes de cerdos castrados. Estos resultados sugieren que la carne de cerdos enteros con nivel medio de AND podría ser utilizada de la misma forma que la de cerdos castrados para la elaboración de chorizo.

### PALABRAS CLAVE ADICIONALES

Olor sexual.  
Prohibición de la castración.  
Chorizo.  
Ácidos grasos.

### INFORMATION

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### INTRODUCTION

As a consequence of European changes in animal welfare regulations, the pork industry may, in the near future, face a ban on surgical castration of male piglets. Physical castration affects animal fat depot and fatty acid composition of lean and fat tissues and avoids

potential consumer dissatisfaction due to of boar taint. Boar taint is an unpleasant odour and flavour in the meat of entire male pigs, mainly caused by the elevation of androstenone (AND) and skatole (SKA) in fat tissue (Borrisher-Pairó et al. 2016). Skatole is perceived by 99% of consumers (Weiler et al. 1997), while AND is perceived by approximately 50% of consumers (Blanch

et al. 2012). SKA concentration can be reduced through the diet; however, AND concentration cannot be easily reduced; the only way known so far is through genetic selection or manipulation; unless immunocastration is carried out (Corral et al. 2016, p. 116). Although literature suggests that processing may decrease the negative perception of AND and skatole, consumers studies on the sensory acceptability of boar taint indicate that, processing does not achieve to solve completely the problems concerning boar taint (Font i Furnols, 2012). It is therefore necessary to evaluate if entire male pigs could be used to elaborate meat products. The objective of this study was to evaluate the effect of AND level on the characteristics of dry cured sausage (chorizo).

## MATERIAL AND METHODS

Meat and fat from castrated pigs, as well as from entire male pigs previously selected with medium and high AND levels (0.5-0.8 and 1.10-2.9 µg/g fat, respectively) and SKA levels below 0.1 µg/g (Borriser-Paró et al. 2016) were used to elaborate three different types of chorizo (a Spanish dry fermented sausage): Control, Medium AND and High AND. All the chorizos were manufactured in a pilot plant according to a traditional formulation, which consisted of 75% pork meat and 25% pork backfat. Briefly, ground lean and fat were mixed with the other ingredients (2% sodium chloride, 2% La Vera paprika, 0.15% garlic powder, 0.1% glucose, 0.1% polyphosphates, 0.045% sodium ascorbate, 0.015% sodium nitrite, 0.01% potassium nitrate) and the mixture was stuffed into 35-45 mm natural beef casings. Then, the chorizo sausages were fermented in a drying chamber (15 h at 10 °C and 90-100% relative humidity (RH), 48 h at 20-25 °C and 90% RH and 7 days at 10-15 °C and 80-90% RH), after which the RH was slowly reduced to 75% until the end of the ripening process. Weight loss reached  $38.6 \pm 2.1$  % at the end of ripening. The sausages were then vacuum-packaged and stored at 4 °C until their analysis.

Samples were analyzed for moisture (according to ISO 1442 regulation, 1997), fat (ISO 1443, 1973) and protein (990.03 AOAC method, 2000) content. Fatty acid profile were determined on the lipid extracted from ripened sausages. Fatty acid methyl esters (Morrison & Smith, 1964) were analyzed using an Agilent Technologies 6890 gas chromatograph equipped with a flame ionization detector. Sensory evaluation (ISO 4121, 2003) was carried out on chorizo slices by an experienced

sensory panel trained in AND detection (Garrido et al., 2016). The attributes AND odour, chorizo odour, AND flavour, chorizo flavour, hardness and juiciness were evaluated on an unstructured 10 cm line (0=*not perceivable*; 10=*extremely perceivable*). An ANOVA was performed to analyze the effect of the different AND levels on the chorizo' characteristic. When significant effect was detected, means were separated using the Duncan's multiple range test (95% confidence interval).

## RESULTS AND DISCUSSION

The proximate composition of chorizos is shown in **Table I**. No statistically significant differences were found among types of chorizos ( $P > 0.05$ ) for moisture content. However, although all chorizo types were made with the same lean/fat ratio, samples from castrated pigs presented lower protein content and higher fat content than samples from entire male pigs. Differences in fat content are due to castration, which increases intramuscular fat deposition (Gispert et al. 2010).

The results of the fatty acids composition are summarized in **Table II** and **Figure 1**. The adipose tissue of chorizos from castrated pigs had higher saturated (SFA) and monounsaturated (MUFA) fatty acids and lower polyunsaturated fatty acids (PUFA) contents than that of chorizos from entire pigs. As in our work, Pauly et al. (2008) associated the high fat content in castrated males with more saturated fat tissue. Our results are in line with those reported by Pauly et al. (2012, p. 860) who performed a meta-analysis, using studies from 1990 until 2010, to estimate the impact of lack of castration on pork quality traits besides boar taint. Regarding the effect of AND level, an increase of the PUFA content ( $P < 0.05$ ) was observed when increasing AND level. On the contrary, the MUFA content, especially oleic acid (C18:1n9), did not ( $P > 0.05$ ) differ between Medium and High AND chorizos. Consequently, the adipose tissue of High AND samples was more unsaturated which could lead to as soft fat with low oxidative stability.

The effect of AND level on different sensory parameters evaluated is presented in **Table III**. Chorizo odour and flavour was lowest ( $P < 0.05$ ) and AND odour and flavour highest ( $P < 0.05$ ) in samples with high level of AND. Increasing PUFA levels may also change flavour because of their greater susceptibility to oxidative breakdown and the generation of volatile

**Table I.** Proximate composition (mean  $\pm$  standard deviation) of the different chorizo types (Composición centesimal (media  $\pm$  desviación estándar) de los diferentes tipos de chorizo).

Composition	Control <sup>a</sup>	Medium <sup>a</sup>	High <sup>a</sup>	P value
Moisture (%)	21.85 $\pm$ 0.64	27.20 $\pm$ 2.82	25.55 $\pm$ 1.20	0.1228
Protein (%)	22.93 <sup>a</sup> $\pm$ 0.64	27.16 <sup>b</sup> $\pm$ 1.36	29.48 <sup>b</sup> $\pm$ 0.58	0.0132
Fat (%)	48.30 <sup>b</sup> $\pm$ 1.28	39.17 <sup>a</sup> $\pm$ 1.83	38.60 <sup>a</sup> $\pm$ 1.20	0.0117

<sup>a</sup>Chorizo type: Control (from castrated pigs), Medium (from entire male pigs with 0.5-0.8 µg aND (androstenone) /g fat), and High (from entire male pigs with 1.1-2.9 µg AND/g fat).

<sup>ab</sup>Means within the same row with different letters are different ( $P < 0.05$ ).

**Table II.** Fatty acid profile (mean  $\pm$  standard deviation) of the different chorizo types (g/100g of identified fatty acids) (Perfil de ácidos grasos en los diferentes tipos de chorizo (g/100g de ácidos grasos identificados)).

Fatty acid**	Control <sup>†</sup>	Medium <sup>†</sup>	High <sup>†</sup>	P-value
C14:0	1.36 <sup>c</sup> $\pm$ 0.00	1.24 <sup>a</sup> $\pm$ 0.00	1.28 <sup>b</sup> $\pm$ 0.01	0.020
C16:0	24.60 <sup>c</sup> $\pm$ 0.05	23.12 <sup>b</sup> $\pm$ 0.02	22.72 <sup>a</sup> $\pm$ 0.02	0.000
C16:1	3.17 <sup>c</sup> $\pm$ 0.01	2.47 <sup>a</sup> $\pm$ 0.02	2.72 <sup>b</sup> $\pm$ 0.01	0.001
C18:0	12.51 <sup>a</sup> $\pm$ 0.10	13.29 <sup>b</sup> $\pm$ 0.05	12.30 <sup>b</sup> $\pm$ 0.09	0.003
C18:1N9	43.03 <sup>b</sup> $\pm$ 0.15	39.60 <sup>a</sup> $\pm$ 0.81	38.25 <sup>a</sup> $\pm$ 0.11	0.005
C18:1N7	3.30 <sup>c</sup> $\pm$ 0.00	2.79 <sup>a</sup> $\pm$ 0.02	2.95 <sup>b</sup> $\pm$ 0.02	0.003
C18:2N6	8.22 <sup>a</sup> $\pm$ 0.02	13.24 <sup>b</sup> $\pm$ 0.74	15.22 <sup>c</sup> $\pm$ 0.09	0.001
C18:3N3	0.4 <sup>a</sup> $\pm$ 0.01	0.73 <sup>b</sup> $\pm$ 0.05	0.78 <sup>b</sup> $\pm$ 0.00	0.003
C20:4N6	0.29 $\pm$ 0.00	0.36 <sup>b</sup> $\pm$ 0.00	0.40 <sup>b</sup> $\pm$ 0.00	0.000

<sup>†</sup>Chorizo type: Control (from castrated pigs), Medium (from entire male pigs with 0.5-0.8  $\mu$ g AND (androstenone) /g fat), and High (from entire male pigs with 1.1-2.9  $\mu$ g AND/g fat).

\*\* Main fatty acids identified.

<sup>abc</sup> Means within the same row with different letters are different (P<0.05).

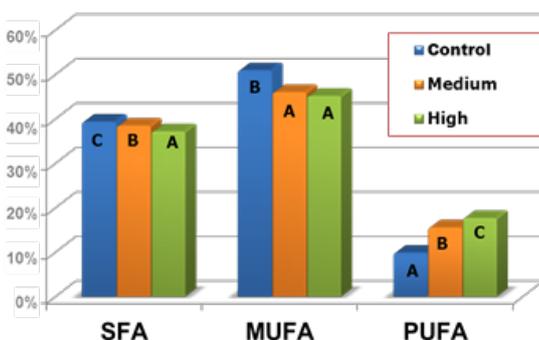
**Table III.** Mean  $\pm$  standard deviation of sensory attributes evaluated by the panel for the different chorizo types (Valor medio  $\pm$  desviación estándar obtenido en los parámetros sensoriales evaluados por el panel en los diferentes tipos de chorizos).

Sensory attributes	Control <sup>†</sup>	Medium <sup>†</sup>	High <sup>†</sup>	P-value
AND odour	0.19 <sup>a</sup> $\pm$ 0.16	0.43 <sup>a</sup> $\pm$ 0.40	1.46 <sup>b</sup> $\pm$ 0.66	0.000
Chorizo odour	7.95 <sup>b</sup> $\pm$ 1.63	8.09 <sup>b</sup> $\pm$ 1.18	6.42 <sup>a</sup> $\pm$ 0.68	0.015
AND flavour	0.29 <sup>a</sup> $\pm$ 0.16	0.87 <sup>a</sup> $\pm$ 0.59	4.33 <sup>b</sup> $\pm$ 1.30	0.000
Chorizo flavour	7.82 <sup>b</sup> $\pm$ 1.16	7.78 <sup>b</sup> $\pm$ 1.12	5.94 <sup>a</sup> $\pm$ 0.82	0.000
Hardness	4.55 $\pm$ 0.57	4.52 $\pm$ 0.75	5.03 $\pm$ 0.53	0.175
Juiciness	5.31 $\pm$ 0.55	5.15 $\pm$ 0.78	4.69 $\pm$ 0.31	0.076

<sup>†</sup>Chorizo type: Control (from castrated pigs), Medium (from entire male pigs with 0.5-0.8  $\mu$ g AND (androstenone) /g fat), and High (from entire male pigs with 1.1-2.9  $\mu$ g AND/g fat).

<sup>ab</sup>Means within the same row with different letters are different (P<0.05).

0=not perceivable, 10= extremely perceivable.



**Figure 1.** Proportion (%) of saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), in different chorizo types (Control: from castrated pigs, Medium: from entire male pigs with 0.5-0.8  $\mu$ g AND/g fat, and High: from entire male pigs with 1.1-2.9  $\mu$ g AND/g fat). <sup>ABC</sup>different bar letters indicate differences (P<0.05) among chorizo types within each type of fatty acid. (Proporción de ácidos grasos saturados, monoinsaturados y poliinsaturados en los diferentes tipos de chorizo).

compounds (Wood et al. 2003). On the contrary, no differences (P>0.05) were found between chorizos from entire male pigs with medium AND level and those elaborated from castrated pigs. Conventional additives for meat products (garlic, spices, polyphosphates), the long ripening time and cold consumption may help to mask AND perception in dry fermented sausages. However, in meat products from pigs with high levels of AND, the manufacturing process did not totally mask the boar taint (Heid & Hamm 2013; Martínez et al. 2016; Tongberg et al. 2011, 2012). Regarding texture attributes, in our study no differences were found between the three chorizo types (P>0.05). However, Corral et al. (2016, p.145) observed that the use of entire male back fat in a dry fermented sausage produced a higher hardness. These authors attributed this result to a highest weight losses during manufacturing. In our study, all chorizos were dried to similar weight losses. The obtained results suggest that meat from entire pigs

with medium level of androstenone could be used like the meat from castrated pigs for “chorizo” elaboration.

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