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AVALIAÇÃO SENSORIAL DA CARNE DE SUÍNOS MACHOS INTEIROS CRIADOS COM DIFERENTES CONDIÇÕES DE ALIMENTAÇÃO E ALOJAMENTO

SENSORY EVALUATION OF MEAT FROM ENTIRE MALE PIGS RAISED WITH DIFFERENT FEEDING AND HOUSING CONDITIONS

EVALUACIÓN SENSORIAL DE LA CARNE DE CERDOS MACHOS ENTEROS CRIADOS CON DIFERENTES CONDICIONES DE ALIMENTACIÓN Y ALOJAMIENTO

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RESUMO

Introdução: O aroma a varrasco é um odor/flavour desagradável presente na carne de porcos macho não castrados, que é causado principalmente por dois compostos: a androstenona e o escatol. A incidência do odor a varrasco é de especial importância quando se considera o uso desta carne para a produção de produtos cárneos.
Objetivos: Este estudo visa a avaliação das características organoléticas da carne de porcos macho não castrados criados em condições específicas com o objetivo de reduzir ou eliminar o odor a varrasco.
Métodos: Foi analisada carne da barriga de porcos não castrados criados em seis condições diferentes (maneio normal *versus* maneio melhorado) e alimentação com níveis diferentes de inulina adicionada (0%, 3% e 6%). A análise descritiva quantitativa (QDA®) foi usada para avaliação organolética das amostras que foram previamente cozidas e apresentadas em frasco fechado ao painel composto por 10 provadores treinados, que avaliaram o odor e flavour a escatol e androstenona, a textura e o sabor doce na carne.
Resultados: Os resultados demonstraram haver diferenças significativas (p<0.05) entre as diferentes condições, nos parâmetros odor e flavour a escatol e androstenona e textura.
Conclusões: Como esperado, o odor a varrasco foi mais intenso nas amostras com a condição maneio normal e sem inulina adicionada. Tendo em conta estes resultados pode-se concluir que a adição de inulina tem efeitos positivos quando conjugada com condições de maneio melhoradas.

Palavras-chave: odor a varrasco; androstenona; escatol; análise sensorial

ABSTRACT

Introduction: Boar taint is an off-odour/off-flavour found in meat from entire male pigs due to two main compounds: androstenone and skatole. The incidence of boar taint is of concern when considering the use of entire males for pork meat production.
Objectives: This study aims at evaluating sensory characteristics of meat from entire male pigs raised under specific conditions in order to reduce or eliminate the boar taint.
Methods: Belly meat from entire male pigs raised under six different conditions (normal housing *versus* improved housing) and feeding with different levels of added inulin (0%, 3% and 6%) was analysed. A Quantitative Descriptive Analysis (QDA®) methodology was applied to samples, previously cooked and presented in closed jars, and the panel, composed by 10 trained panellists, was asked to assess odour and flavour of skatole and androstenone, texture and sweet flavour.
Results: Significant differences (p<0.05) were found between samples concerning skatole and androstenone odour and flavour, and texture compared to control samples.
Conclusions: As expected, the boar taint was stronger in samples where no addition of inulin and no improved conditions were applied. It can be concluded that the inulin addition into pig feed have positive effects when conjugated with better housing conditions.

Keywords: boar taint; skatole; androstenone; sensory analysis

RESUMEN

Introducción: El olor a verraco es un olor/flavour desagradable presente en la carne de cerdos macho no castrados, que es causado principalmente por dos compuestos: la androstenona y el escatol. La incidencia del olor a verraco es de especial importancia cuando se considera el uso de esta carne para la producción de productos cárnicos.
Objetivos: Este estudio se refiere a la evaluación de las características sensoriales de la carne de cerdos macho no castrados creados en condiciones específicas con el fin de reducir o eliminar el olor a verraco.
Métodos: Se analizó la carne de la barriga de cerdos no castrados creados en seis condiciones diferentes (manejo normal *versus* manejo mejorado) y alimentación con niveles diferentes de inulina añadida (0%, 3% y 6%). El análisis descriptivo cuantitativo (QDA®) fue utilizado para evaluar las muestras que fueron cocidas y presentadas en frasco cerrado al panel compuesto por 10 probadores entrenados, evaluando el olor y flavour del escatol y androstenona, la textura y el sabor dulce en la carne.
Resultados: Los resultados mostraron diferencias significativas (p<0.05) entre las diferentes condiciones, comparado con el control, en los parámetros olor y flavour a escatol y androstenona y en la textura.
Conclusiones: Como se esperaba, el olor a verraco fue más intenso en las muestras con la condición normal y sin inulina añadida. Teniendo en cuenta estos resultados se puede concluir que la adición de inulina tiene efectos positivos cuando se combina con condiciones de manejo mejoradas.

Palabras Clave: olor a verraco; androstenona; escatol; análisis sensorial

INTRODUCTION

In the European Union, pork production stakeholders have declared to ban surgical castration by 2018 for animal welfare reasons which has posed a challenge to all stakeholders involved in the pork production chain (Morlein et al., 2015). Male piglets are castrated primarily to prevent the development of the objectionable sensory perceived odour or flavour of boar taint in their carcasses (Fredriksen, Johnsen, & Skuterud, 2011; Gunn et al., 2004; Wauters et al., 2017). Available evidence suggests that castration at any age is painful (Gunn et al., 2004) and this practice is now questioned in an increasing number of countries due to animal welfare concerns (Fredriksen et al., 2011). Raising entire male pigs has some economic advantages as boars possess the advantage of superior growth over castrates, a lower feeding demand, generally leaner carcasses, and compared to castrates less feed is needed in order to achieve the same final weight, whereby also fewer nutrients are emitted to the environment (Morlein et al., 2015; Wauters et al., 2017). However, slaughtering entire male pigs implies the risk of having carcasses with the so-called boar taint (Aaslyng, Broge, Brockhoff, & Christensen, 2015) posing a risk to the entire pork supply chain therefore being a significant barrier to the banning of the undesirable practice of piglet castration (Mathur et al., 2012). Boar taint is described as a penetrating 'animal', 'urine', 'faecal' or 'sweat' like unpleasant odour which becomes especially intense when pork is cooked (Mathur et al., 2012), and is mainly associated with the presence of skatole and androstenone, but animal tissues contain varying levels of other compounds, such as indole and other steroids, that can influence the perceptions of the main contributors of boar taint (AnnorFrempong, Nute, Whittington, & Wood, 1997; Morlein et al., 2016). Skatole (3-methylindole) is a metabolite derived from the amino acid tryptophan produced in the lower gut by intestinal bacterial flora, and androstenone (5α androst-16-en-3-one) is a steroid produced in the testis (Aldal et al., 2005; Chen, Zamaratskaia, Andersson, & Lundstrom, 2007; Lunde et al., 2010). Levels of skatole are lower in castrates and gilts than in entire male pigs and the reason has not been fully elucidated (Aldal et al., 2005). High levels of skatole in pig meat can be effectively reduced by diet and keeping animals free of faecal contamination (Garrido et al., 2016). Due to the lipophilic characteristics of skatole and androstenone, redistribution from blood to fat tissue is easily occurring with prolonged accumulation in fat tissues (Aldal et al., 2005; Wauters, Vercruysse, Aluwe, Verplanken, & Vanhaecke, 2016). Sensory analysis is one of the most common tools used in meat studies (Garrido et al., 2016), and because androstenone and skatole are predominantly released when fat is heated, the sensory evaluation is carried out using heating methods (Trautmann, Meier-Dinkel, Gertheiss, & Morlein, 2016). There is evidence that management practices such as batch rearing, use of particular feed ingredients and prevention of pigs wallowing in excrement may contribute to the reduction of boar taint (Gunn et al., 2004). Several studies (Aluwe et al., 2013; Backus et al., 2016; Bilić-Šobot, Čandek-Potokar, Kubale, & Škorjanc, 2014; Byrne, Thamsborg, & Hansen, 2008; Hansen et al., 2008; Kjos, Overland, Fauske, & Sorum, 2010) have shown that fermentable carbohydrates, such as the inulin obtained from chicory, were effective in reducing the concentration of skatole in the hindgut. A possible explanation is that chicory inulin reduces the number of *Enterococcus* spp. which are important for the production of amino acid l-tryptophan in the colon (Bilić-Šobot et al., 2014). Housing conditions and genetic selection can also have a favourable effect on boar taint reduction (Backus et al., 2016). The production of pork from entire male pigs in enriched housing conditions seems also to be a promising alternative to castration, as improved husbandry aims at high standards of animal welfare and elimination of mutilations (Holinger, Fruh, & Hillmann, 2015).

The aim of this research was to study the sensory effect of improved housing and different feeding conditions in entire male's meat.

1. METHODS

The experimental design included a total of 60 entire male pigs of a crossbreed (progeny of Large White x Landrace dams sired by Pietrain boars), raised in a pig farm in Vila Nova de Poiares, Coimbra, Portugal. The same commercial diet, *ad libitum* access, was given to the animals until 5.5 months age. Then, pigs were separated into six treatment groups, varying the type of housing and percentage of inulin added in feeding portions, as described in Table 1. All received commercial feed (produced by Cevargado) 2.8 kg per pig per day and the diet of four groups included 3% or 6% inulin, for 2 months prior to slaughter. Improved housing conditions consisted in a larger area, easier access to water and environmental enrichment accessories (toys). The shipment and transportation of the improved housing group to the slaughterhouse was carried out with procedures aimed at reducing stress. Pigs were slaughtered in the same day, and carcasses were transported to a meat processing factory, where meat cuts were kept at - 18 °C.

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Table 1 – Housing conditions and inulin feed composition.

Pen	Housing	Added inulin in feed (%)	Number of pigs
A	Normal	0	10
B	Normal	3	10
C	Normal	6	10
D	Improved (+Care)	0	10
E	Improved (+Care)	3	10
F	Improved (+Care)	6	10

Samples were coded as N0% (control), N3%, N6%, C0%, C3% and C6%, where "N" means normal housing, "C" improved housing and 0, 3 and 6 correspond to percentage of added inulin in animal feed.

1.1. Sample preparation

For this experiment, the selected meat cut was the belly. On the day prior to the sensory analysis, 8 samples of meat, corresponding to the six groups (plus two replicates to evaluate repeatability) were randomly selected and placed to thaw at 4 °C. Samples were cut into cubes (4 cm) and cooked in boiling water until internal temperature of meat reached 80 °C. They were immediately closed in glass jars with its broth and transferred to the sensory analysis laboratory and kept in a 60 °C bath in the cabinet booths.

1.2. Sensory analysis

The sensory evaluation was conducted in a sensory evaluation laboratory that has eight individual booths and an adequate ventilation system, with positive pressure atmosphere. The sensory panel consisted of 10 assessors, selected on the basis of their sensory performance and afterwards trained for boar taint evaluation. This training process focused on the ability to detect both androstenone and skatole, adapting a procedure from Garrido et al. (2016), in which they presented to panellists standards using Vaseline oil media as carriers of androstenone and skatole. A quantitative descriptive analysis (QDA®) methodology was selected to evaluate samples. Sensory attributes were defined previously in group as recommended by ISO:6658 (2005) and after consensus, anchors and scales were set and panellist trained with standards adapted to each anchor. Pre-defined attributes such as: androstenone odour and flavour, skatole odour and flavour, sweet flavour and texture were rated on the agreed intensity scale. Generally, odour/flavour attributes, scales ranged from 1 to 10, where for score 1 was *absent* and score 10 was *very intense*, for sweet flavour anchors were *no sweet* to *very sweet* and for texture, intensity scale anchors were *very soft/moisty* to *fibrous/dry*. A total of 8 glass jars, with three-digit codes, containing meat samples were presented in a random order to the panellists, that were instructed to pause at least 5 minutes between each sample. Panellists were free to check previous opened jars in order to compare samples and correct their evaluation if necessary. Within the 8 samples 2 of them were replicates in order to evaluate repeatability.

1.3. Statistical analysis

In order to investigate differences, it was performed variance analysis (One-way ANOVA) with repeated measures followed by *post hoc* Fisher's Least Significant Difference (LSD). The groups of treatments, housing conditions and feeding conditions were set as the independent variables and the sensory attributes (androstenone odour, skatole odour, androstenone flavour, skatole flavour, sweet flavour and texture) defined as dependent variables. Significant differences were set at $p<0.05$.
Canonical Variates Analysis (CVA) with judges as replicates, was carried out to discriminate groups of samples. Principal Component Analysis (PCA) based on correlations using all cases using the means was carried out to check if there were patterns in the dataset. These analyses were carried out using SPSS v.25.0 software.

2. RESULTS AND DISCUSSION

In this study, cooked belly meat from uncastrated pigs raised under different levels of housing and feeding, was analysed to verify if there was sensory perception of different levels of androstenone and skatole.
There is little data available concerning boar taint evaluation with regard to assessor reliability (Morlein et al., 2016). However, to evaluate the repeatability of panellists, two samples of the same condition groups were served twice with different codes. Results of this evaluation showed that panellists had a 1.2 mean deviation of its scores. Canonical Variates Analysis (CVA) was carried out to find out if the panel data discriminate groups of samples. As seen in Figure 1, although groups are very next to each other it is possible to verify that there are some patterns in their distribution, namely by type of housing or value of added inulin. It is also important to take into consideration the fact that in biological samples not only androstenone and skatole levels

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vary a lot but also that there are other factors affecting this scent, for example, the fat content and matrix itself also differ between animals (Morlein et al., 2016).

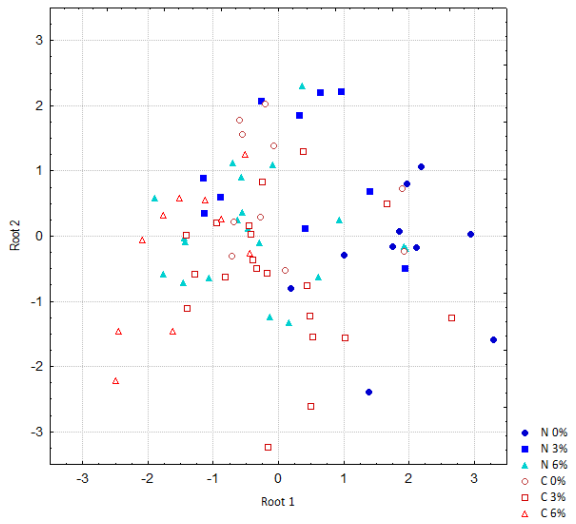

Figure 1. Canonical Variates Analysis graph for panellists. N-normal housing; C-improved housing. 0, 3 and 6% is the value of added inulin in feed.

Results showed that panellists discriminate meat samples from animals with inulin addition in its feeding portions. Table 2 shows the scores of sensory evaluations performed by panellists, and it is possible to outline that only attribute "sweet flavour" showed no significant differences. Concerning to androstenone odour, panellists stated that it was immediately perceived after the opening of the jar. They have noticed that meat from pigs that had received normal treatment (0% inulin added, normal housing) had the most intense androstenone odour ($p<0.05$), and in meat from pigs with improved housing (+Care) and 6% of inulin added was less perceived, having the lowest score ($p<0.05$). In the other three attributes (skatole odour, androstenone flavour and odour), although there were some significant differences between groups ($p<0.05$ in all cases), the stronger sample was always the control (Normal 0%).

Table 2 – Cooked belly meat sensory attributes (mean and standard deviation) scored by a trained panel, by condition (AND=androstenone; SKA=skatole). Different letters in the same row indicate a statistical difference ($p<0.05$) using LSD test.

Attributes	Condition groups					
	Normal 0% n=10	Normal 3% n=10	Normal 6% n=20	+Care 0% n=10	+Care 3% n=20	+Care 6% n=10
AND odour	6.5 ± 1.4^{a}	4.4 ± 1.9^{b}	4.0 ± 1.5^{b}	4.8 ± 1.9^{b}	4.5 ± 2.0^{b}	2.4 ± 1.3^{c}
SKA odour	6.4 ± 1.5^{a}	2.8 ± 1.7^{cd}	3.7 ± 1.9^{bcd}	3.0 ± 1.8^{c}	4.7 ± 1.7^{b}	2.7 ± 1.2^{d}
AND flavour	5.3 ± 1.7^{a}	2.9 ± 1.9^{c}	3.0 ± 1.3^{c}	3.6 ± 2.2^{abcd}	4.6 ± 2.8^{ab}	2.7 ± 0.9^{cd}
SKA flavour	5.5 ± 1.7^{a}	2.5 ± 1.4^{c}	2.8 ± 1.0^{c}	2.5 ± 1.4^{c}	3.8 ± 2.2^{bc}	1.9 ± 0.9^{c}
Sweet flavour	5.1 ± 0.9^{a}	5.1 ± 0.8^{a}	4.8 ± 0.9^{a}	4.7 ± 1.3^{a}	4.8 ± 1.4^{a}	4.5 ± 1.3^{a}
Texture	4.8 ± 1.5^{bc}	4.6 ± 2.0^{bc}	6.5 ± 1.8^{a}	5.4 ± 1.6^{b}	5.3 ± 1.5^{b}	5.9 ± 1.3^{abc}

Concerning texture, samples with the scored with highest values were the ones with 6% of added inulin in feed, meaning that panellist found this meat more fibrous and dry.
Although +Care condition had always lower boar taint scores, ANOVA analysis applied only to the housing conditions revealed no significant differences between attributes. On the other hand, ANOVA applied to inulin levels showed that androstenone odour was the strongest in 0% inulin samples ($p<0.05$). By the contrary, addition of 6% of inulin leads to the lower scores of androstenone odour and flavour perception ($p<0.05$) as well as skatole odour and flavour. In meat samples with 3% of inulin no significant differences were found concerning skatole odour and flavour. Similar findings were also reported by Byrne et al. (2008) and Hansen et al. (2008), where chicory (inulin is mostly extracted from chicory roots) reduced boar taint since odour and

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flavour of manure related to skatole and urine associated to androstenone. Aluwe et al. (2013) and Kjos et al. (2010) also stated that chicory feed supplemented in boar feed decreased skatole concentration in adipose tissue.
In order to study the relation between attributes and to investigate patterns within the samples and pigs raising conditions, a PCA was carried out (Figure 2). Boar taint variables (skatole flavour/odour and androstenone flavour/odour) have the highest values on PC1, which represents 74,75% of the total data. From this output, it is possible to observe that N0% samples are projected to the end of the left side in PC1 axis meaning that is highly correlated with the highest scores of boar taint related attributes. In the opposite side (from the centre to the right) of the PCA output are projected the samples from animals fed with 6% of inulin, being perceived as more fibrous and dry (texture). PC2 does not have great meaning in this analysis.

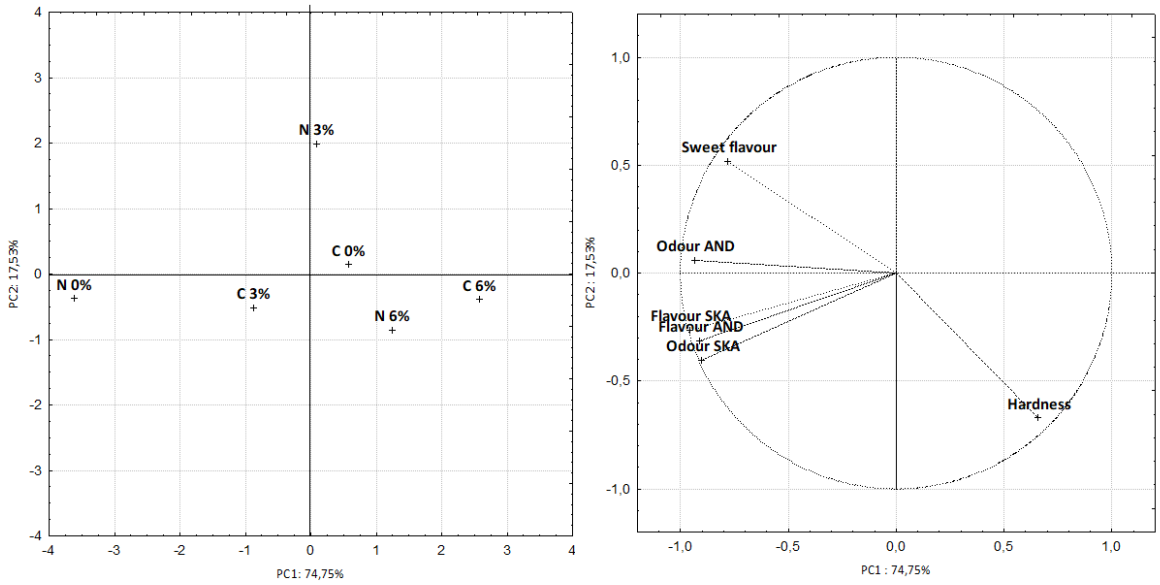

Figure 2. Principal component analysis of sensory evaluation: score plot for the mean classification of condition groups (left) and loading plot of different attributes (right). N-normal housing; C-improved housing. 0, 3 and 6% is the value of added inulin in feed.

CONCLUSIONS

From this study, it is possible to conclude that samples of belly meat from entire male pigs raised under different condition were considered different. When submitted to sensory analysis by a trained panel it was perceived some differences mainly related to boar taint. The main effect was the reduction of boar taint caused by addition of inulin in the pigs feed. Despite of housing conditions had no significant effect on reduction of boar taint, androstenone and skatole flavour and odour were stronger in samples where no improved conditions were applied and no inulin added. It can be concluded that the effect of inulin addition into pig feeding portions have positive effects when conjugated with better housing conditions.

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