



Consumer perception of entire male pork coated with spiced edible films as a new product to mask boar taint

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ARTICLE INFO

Keywords:

Edible film
Spices
Unpleasant odour
New product
Consumers

ABSTRACT

Pork production has undergone a shift towards the rearing of entire male pigs, however, its meat might carry with the presence of boar taint and it would be considered “unfit for human consumption”. To offer a new alternative to the pork sector tailored to the needs of consumers, a viable option would be the use of edible spiced gelatin films to help minimize boar taint and improve its marketability. The responses of 120 regular meat consumers to entire pork with high levels of boar taint and castrated pork free of boar taint, both coated with spiced gelatin films were evaluated. They showed a similar response between entire and castrated male pork coated with spiced films, regardless of whether consumers usually detected unpleasant odours (as farm/animal) when consuming pork or not. Therefore, the new spiced films offer a new range of products to consumers as they contribute to the improvement of the sensory quality of entire male pork, especially among consumers who tend to buy new products.

1. Introduction

The meat sector is in full commercial growth and consolidation, as global meat consumption is expected to grow 14% by 2030, compared to the base period (OECD-FAO, 2021). The most consumed meats worldwide are pork with 36.1% of world consumption, followed by poultry (35.9%), beef (20.7%) and sheep (4.6%), according to FAOSTAT (2020). In addition, world meat exports increased in 2020 by 5.7% (to 38.7 mT) more than in 2019, with the highest growth in pork, coming mainly from Spain as it is the country that exports most of this type of meat in the European Union (MAPA, 2020).

Therefore, it is a good opportunity for the development of new meat products that meet the needs, demands and expectations of consumers, as they are the final step in the production chain and it is necessary to know the factors that influence their purchase intention. Consumer behaviour is a multidisciplinary science that goes beyond the sensory properties of the product but also involves psychological and marketing aspects (Font-i-Furnols & Guerrero, 2014; Mondéjar-Jiménez, Sánchez-Cubo, & Mondéjar-Jiménez, 2022). Consumers have increasingly demanded meat products that are “ready-to-eat” (Caputo, Sacchi, & Lagoudakis, 2018), safe and with specific claims that meet their needs

without diminishing their sensory qualities (Font-i-Furnols & Guerrero, 2014; Grunert, Verbeke, Kügler, Saeed, & Scholderer, 2011; Ruiz-Capillas, Herrero, Pintado, & Delgado-Pando, 2021).

Furthermore, the development of new products is a competitive indicator for companies rivaling in well-established markets, where the creation of new products adapted to the needs of the market differentiates them from other competitors (Grunert et al., 2011). For this reason, it is important to be aware of the current problems that pork may entail in order to improve competitiveness and explore new market niches.

Following the European Declaration on alternatives to surgical castration of pigs (European Declaration on Alternatives to Surgical Castration, 2010) where it was agreed to abandon this practice gradually in all EU countries, pork production has undergone a shift towards rearing entire male pigs as it is considered the most economically profitable alternative and also guarantees animal welfare (Bonneau & Weiler, 2019). However, in most of the EU countries, pigs are still commonly surgically castrated to prevent the meat from acquiring an unpleasant odour and taste at the time of consumption, named boar taint (described as animal, urine, manure or sweat) which is related to the sexual maturity of the animals (Bonneau & Weiler, 2019).

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<https://doi.org/10.1016/j.meatsci.2023.109171>

Received 30 November 2022; Received in revised form 20 March 2023; Accepted 22 March 2023

Available online 28 March 2023

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Boar taint is an organoleptic defect that, due to its offensive odour and flavour, is the cause of the rejection of pork by consumers, who see its sensory quality reduced (Panella-Riera et al., 2016). It is mainly due to two compounds, androstenone (AND) and skatole (SKA) (Bonneau & Weiler, 2019). Moreover, fresh meat from entire animals with high levels of boar taint is considered “unfit for human consumption” (Implementing Regulation (EC) No. 2019/627, 2019). Therefore, the main challenge for the meat industry is to guarantee the sensory quality of this meat and its commercialisation both on the domestic and export markets, adapting the production chain to the new market requirements. The effect of cooking methods, spices, and smoking as strategies to minimize the boar taint of fresh entire male pork has been studied (Borrisser-Pairó et al., 2017; Egea, Linares, Gil, López, & Garrido, 2018; Lunde et al., 2008; Peñaranda et al., 2017; Škrlep et al., 2020) but they have not been entirely satisfactory.

Therefore, in order to provide an alternative to the meat sector, adapted to current market demands (products with good sensory quality and ready to eat), a viable option would be the use of edible coatings or films as a vehicle for the incorporation of spices on meat. In this sense, a new range of meat products with a longer shelf life, as they act as a barrier of solute, gas and steam, spiced and ingredients that help to preserve the safety and sensory quality of food (Khan, Adrees, Tariq, & Sohaib, 2013) can be launched and above all to mask the boar taint of the entire male pork. Therefore, the use of spicy edible films, as primary product packaging, could contribute to providing new sensory characteristics to the meat, while helping to minimize the perception of boar taint. Previous research has shown that spiced gelatin or maltodextrin and alginate edible films exhibit suitable technological properties and contribute to improving the sensory texture of castrated pork (Linares, Peñaranda, Iniesta, Egea, & Garrido, 2022). Among the food products that can be used as a gelling agent in films applied on entire male pork, gelatin stands out as it improves the organoleptic properties of foods, reduces colour deterioration in pork (Antoniewski, Barringer, Knipe, & Zerby, 2007) and helps to mask the boar taint (Aaslyng, Broge, Brockhoff, & Christensen, 2015).

In this context, the objective of this work was to evaluate consumer response to spiced films coating boar tainted entire male pork as a new product to minimize boar taint perception and to compare the sensory acceptability of them with those coating meat of boar taint free castrated pigs.

2. Material and methods

2.1. Meat samples

For this work, commercial carcasses from entire male and castrated pigs have been used, complying with EU guidelines for the care and handling of research animals (Directive 2010/63/EU, 2010). A pre-selection of 31 carcasses of entire male pigs with strong boar taint was carried out after the evaluation of three hundred carcasses, which were gas stunned and slaughtered in a slaughterhouse located in Catalonia (Spain), according to Council Regulation (EC) No. 1099/2009, 2009. Pre-selection was performed on-line, by trained panelists using the human nose methodology (Font-i-Furnols et al., 2020). Subsequently, adipose tissue from the dorsal neck region of these carcasses was collected and analysed for AND by gas chromatography–mass spectrometry (Rius & García-Regueiro, 1998) and for SKA by high performance liquid chromatography (García-Regueiro & Rius, 1998). All parts of the selected carcasses were cut up and frozen until analysis was performed. After analysis, the *longissimus thoracis et lumborum* muscle of the animal with the highest boar taint level (5.511 µg/g of AND and 0.730 µg/g of SKA) was selected. Additionally, 15 *longissimus thoracis et lumborum* muscles from castrated pigs were randomly selected from a local butcher’s shop that certified the castration of these animals. All muscles were tested by a panel of boar taint experts to ensure that no unusual or anomalous odours were perceived. From all of them, one LTL

Table 1
Formulation of spiced film ingredients.

Film	g/100 g film
Gelatin ¹	3.50
Sorbitol ²	5.00
Spices	
Marjoran ³	0.08
Nutmeg ⁴	0.18
Ginger ⁴	0.10
Paprika ⁴	0.18
Salt ⁵	0.12
Mustard ³	0.14
Garlic ⁴	0.14
Black pepper ⁴	0.09
Lemon juice ¹	6.00

¹ Hacendado, Valencia, Spain.

² Natural de mezclas, Murcia, Spain.

³ Lopez Matencio - Especies y Condimentos, Murcia, Spain.

⁴ Ducros, Sabadell, Spain.

⁵ Aliada, Madrid, Spain.

muscle that did not present an abnormal odour (control) was selected and used for further processing. Both muscles (those from entire male and those from castrated pigs) were cut into 1.5 cm thick fillets and were stored frozen at $-18\text{ }^{\circ}\text{C}$ in a freezing chamber until processed. Pork steaks were thawed at $4\text{ }^{\circ}\text{C}$ for 24 h before applying the film.

2.2. Spiced films elaboration

The films were manufactured in the production plant of a local establishment with sanitary registration, according to the processing protocol described by Linares et al. (2022). For this purpose, a 3.5% neutral gelatin solution (Hacendado, Valencia, Spain) was used as edible coating (g gelatin/g water at $50\text{ }^{\circ}\text{C}$) for its good technological and sensory characteristics (Linares et al., 2022) and sorbitol (Natural de mezclas, Murcia, Spain) at 5% (w/v) was used as plasticising agent for its higher tensile and compressive strength (Bourtoom, 2008). Once the film matrix was dissolved, the spice blend was incorporated (Table 1), which was selected in previous research by a trained tasting panel due to its high masking power of boar taint (Linares et al., 2022).

After the preparation of the spiced films, they were applied to castrated and entire male pork, previously defrosted at $4\text{ }^{\circ}\text{C}$ during 24 h, by coating the pork fillets with 50 ml of film solution per 100 g of meat, about 25 ml on each side of the fillet. Once the coating had gelled, the fillets were stored in closed plastic trays for a maximum of 48 h under refrigeration at $4\text{ }^{\circ}\text{C}$ until cooking.

Two batches of film for each type of meat (castrated and entire male pork) were produced, on different days, within one-week time following the same process (two true replicates for each treatment).

2.3. Meat cooking


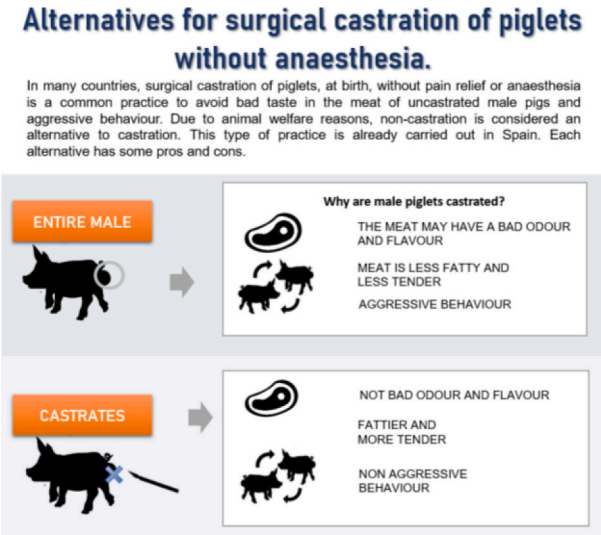
The pork fillets with the spiced gelatin film were cooked by pan-frying with 4 ml sunflower oil. The 26 cm frying pan was preheated for 1 min (oil temperature $120\text{ }^{\circ}\text{C}$) at moderate heat power before adding the loin samples. The samples were rotated every minute until a final temperature of $72\text{ }^{\circ}\text{C}$ in the core was reached (Peñaranda et al., 2017).

Once cooked, the fillets were cut into $2\text{ cm} \times 2\text{ cm}$ squares and each portion was placed in an aluminium casserole dish and kept at $60\text{ }^{\circ}\text{C}$ until tasting. Cooking and tasting were carried out in separate rooms to avoid bias due to odour perception during cooking.

2.4. Consumer study

One hundred and twenty consumers, half women and half men,

Table 2
Structure of the consumer study questionnaire.

Part	Evaluation	Questions	Response
1		Score the colour and appearance of a picture -Is it an appealing product? -Would you buy it?	9-point hedonic scale ¹ : 'dislike very much' (1) to 'like very much' (9) 'yes' and 'no' ²
2	Sensory assessment after tasting the cooked meat coated with spiced film	Score the odour, flavour, hardness, juiciness and acceptability -Have you detected any strange odour/flavour such as farm/animal? -Does this sample seem too spiced? -Do this sample not seem spiced enough to you? -Would you buy it?	9-point hedonic scale ^{3,4} : 'dislike very much' (1) to 'like very much' (9) 'yes' and 'no' ²
3		Once read, re-score the acceptability, knowing the type of animal used in each case -Would you buy it? -I knew before doing the study that male pigs are castrated to avoid unpleasant odour/flavour in the meat	9-point hedonic scale ³ : 'dislike very much' (1) to 'like very much' (9) 'yes' and 'no' ²
4	Consumption habits	-Do you usually buy new products? -Do you use spices for cooking? -Have you ever experienced an unpleasant odour/flavour when consuming pork (as farm/animal)?	'yes' and 'no' ²
5	Demographic data	Age Gender	Open answer ⁵ Woman /Man ⁵

Superscripts indicate the applied statistical analysis: ¹ one-way ANOVA and Tukey's test, ² Cochran's Q test, ³ two-way ANOVA and Tukey's test, ⁴ bivariate correlations, ⁵ correspondence analysis.

evenly distributed in four age ranges (19–29 years: 30 consumers, 30–45 years: 30 consumers, 46–60 years: 30 consumers and the range of ages >60: 30 consumers) were recruited randomly by the company Global Sensory (Barcelona, España). The inclusion criterion was that they were regular consumers of meat and meat products (frequency of meat consumption two to three times a week or several times a month). The study was conducted according to [ISO 8589, 2007](#) in a standardised room of this company and all participants gave informed written consent.

The consumer study consisted of a questionnaire with 5 independent parts ([Table 2](#)), which was developed based on a literature review on castration of entire males pigs, consumer attitudes and tools for sensory evaluation with consumers ([Aluwé et al., 2020](#); [Girolami, Napolitano, Faraone, Di Bello, & Braghieri, 2014](#); [Meier-Dinkel et al., 2013](#)), and further optimised with experts in the field.

In the first part, consumers were asked to evaluate the colour and appearance of a picture of a pork loin coated with spiced edible film codified with a random three-digit code ([Table 2](#), part 1) using a 9-point

hedonic scale anchored at 'dislike very much' (1) and 'like very much' (9) ([Wichchukit & O'Mahony, 2015](#)). They had to answer whether they found the product of the picture appealing and if they would buy it. In their case, they had two possible responses, 'yes' and 'no'.

In the second part, consumers were served two samples of pork (castrated and entire male) coated with the spiced film. Samples were randomly coded with three digits and presented randomly and monadically. Consumers were asked to score their sensory acceptability of the odour, flavour, hardness, juiciness and overall acceptability, using a 9-point hedonic scale as in part 1. In addition, they were asked if they detected any strange odour/flavour such as farm/animal, if they found it too much spiced and about their purchase intention by answering 'yes' or 'no'.

In the third part, an infographic with information about reasons for castration and entire male pigs production ([Table 2](#), part 3) was presented to the consumers. Then, they were asked to re-evaluate the acceptability and purchase intention of the meat coated with a spiced film knowing the type of animal used in each case without tasting the

Table 3

Colour and appearance ratings¹ of pork picture by consumers classified according to their habits of buying new products and their use of spices for cooking. (mean ± standard deviation).

		N	Colour	Appearance
Do you buy new products?	No	30	5.40 ± 1.16	5.37 ± 1.27
	Yes	90	6.20 ± 1.49	6.12 ± 1.49
	<i>P-value</i>		0.009	0.014
Do you use spices for cooking?	No	15	5.40 ± 1.24	5.20 ± 1.21
	Yes	105	6.09 ± 1.47	6.04 ± 1.48
	<i>P-value</i>		0.088	0.038

Values with significantly differ at $P \leq 0.05$.

¹ Scores from 1- dislike very much to 9-like very much.

meat again.

Finally, consumption habits and demographic data were collected (Table 4, parts 4 and 5). All participants completed all 5 parts of the questionnaire in the same session. The study received ethical authorisation from the ethics committee of the University of Murcia (reference number ID: 3566/2021).

2.5. Statistical analyses

For statistical analysis and processing of the consumer survey data, the statistical software package SPSS 24 (SPSS, Chicago, IL) was used. The liking of colour and appearance of the coated loin’s picture (part 1) were analysed by one-way analysis of variance (ANOVA). The analysis was performed separately by consumers who declared to buy and to not buy new products and also by consumers who declared to use and not use cooking spices. In both models, these two classification variables were included as fixed sources of variation, and consumers were adjusted as random effects. Comparisons between means were performed using a Tukey’s test and differences were considered significant at the 0.05 level. The frequency of ‘yes’ or ‘no’ to the questions: ‘would you buy it?’ and ‘is it an appetizing product?’ were also determined and Cochran’s Q test was performed to identify significant differences ($P \leq 0.05$) between these frequencies depending on the type of consumer regarding their habit to buy new products or not and their genders.

The sensory assessment of the cooked pork coated with spice edible film (part 2) was performed using a two-way ANOVA considering the type of meat where the film was applied (castrated and entire male) and

the classification of consumers according to their experience in detecting unpleasant odour/flavour when eating pork as fixed sources of variation, followed by Tukey’s test ($P \leq 0.05$). The frequency of ‘yes’ or ‘no’ answers to the questions of part 2 (see Table 2) was calculated by the type of meat and gender and they were similarly modelled using a Cochran’s Q test to identify significant differences between the type of meat. Correlation analysis, Pearson’s for numerical variables (odour, flavour, hardness, juiciness) and Spearman’s for qualitative variables (meat consumption, unpleasant odour/flavour when consuming pork, gender and meat type) were also applied to assess their effect on acceptability.

The evaluation of acceptability after providing information about castration and in informed conditions regarding the meat type evaluated (part 3) was analysed using a two-way ANOVA considering the effect of the coated with spiced edible film meat type, taster effect and repeated measures for each consumer, followed by Tukey’s test ($P \leq 0.05$). The frequency of mentioning of ‘yes’ or ‘no’ by gender to the question: would you buy it? was similarly modelled to the questions in part 3, by using a Cochran’s Q test per type of meat. All frequency analysis data is reported with graphical illustrations.

Correspondence analysis (CA), using the Chi-square distance and the frequency table, was used for the graphical projection of sex and age ranges according to consumption habits (questions of parts 4 and 5) using two-dimensional maps (dimensions 1 and 2). It was performed by means of the XLSTAT 2017 package (Adinsoft, Paris, France).

3. Results and discussion

3.1. Part 1 of the questionnaire: pictures

The results of the consumers’ assessment of colour and appearance of the meat coated with spiced film are shown in Table 3. As can be seen, there were significant differences ($P \leq 0.05$) between consumers who do and do not buy new products and those who use spices for cooking for the attributes assessed, except for colour between consumers who use spices and those who do not use spices for cooking ($P > 0.05$). Consumers who usually buy new products scored higher ($P < 0.05$) on both colour and appearance than those who do not buy them. On the other hand, consumers who use spices also scored appearance slightly better ($P < 0.05$) than those who do not use them and tend ($P < 0.10$) to score colour better. This would be expected since these consumers are willing

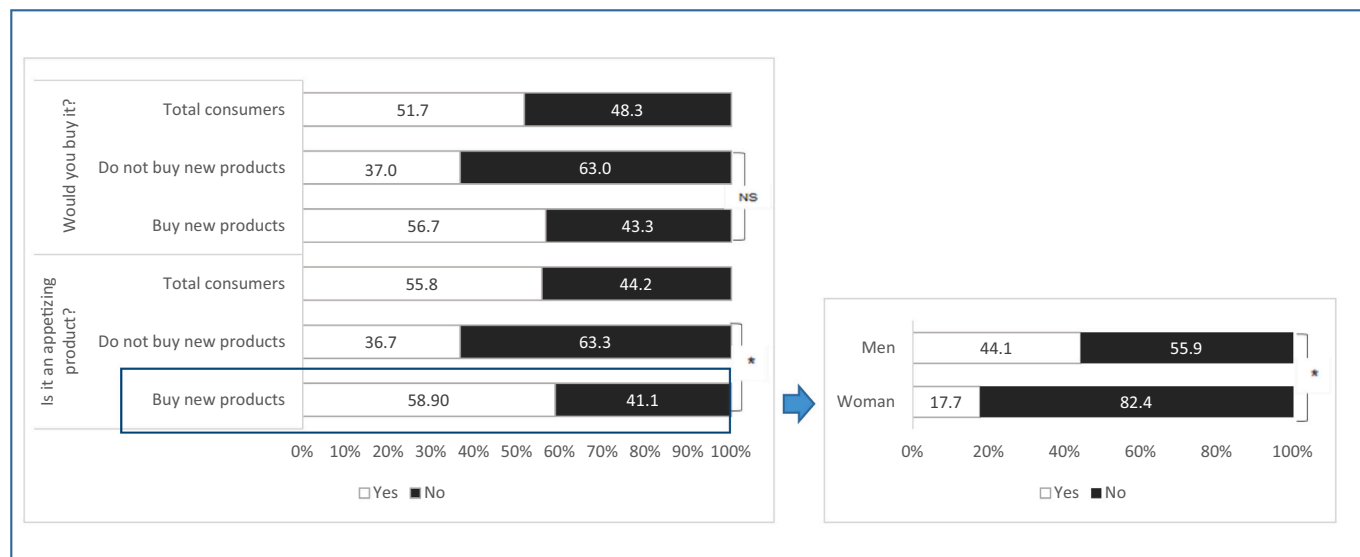


Fig. 1. Frequency of ‘yes’ and ‘no’ answers on purchase intention and finding the product appealing among consumers classified according to their habits to buy new products and their gender.

NS: non-significant differences ($P > 0.05$), *: significant differences ($P \leq 0.05$).

Table 4
Sensory assessment¹ of the cooked pork coated with spiced edible film (mean \pm standard deviation).

Type of meat	Unpleasant odour/flavour eating pork	N	Odour	Flavour	Hardness	Juiciness	Acceptability
Castrated	No	59	6.36 \pm 1.69	6.12 \pm 1.79	5.54 \pm 1.89	5.63 \pm 1.99	5.78 \pm 1.86
	Yes	61	6.52 \pm 1.51	5.72 \pm 1.72	5.01 \pm 1.80 ^a	5.41 \pm 1.85	5.30 \pm 1.79
Entire male	No	59	6.80 \pm 1.57	5.81 \pm 1.70	5.19 \pm 1.74 ^x	5.25 \pm 1.79	5.41 \pm 1.72
	Yes	61	6.75 \pm 1.36	5.62 \pm 1.68	4.49 \pm 1.46 ^{b,y}	4.98 \pm 1.58	5.03 \pm 1.58

Values with different superscripts significantly differ at $P \leq 0.05$. a,b: effect of meat type. x,y: effect of consumers who have experienced an unpleasant odour/flavour when consuming pork.

¹ scores from 1- dislike very much to 9-like very much.

to acquire new product formats (Grunert et al., 2011). Although significant differences were observed for both colour and appearance, these differences were not very relevant, probably due to the shape and amount of application of the edible coating on the fillet surface, since the films formed are normally a thin layer of a continuous, edible, transparent matrix that coats the food (Ramos, Valdes, Beltran, & Garrigós, 2016). Moreover, the addition of spices gave a heterogeneous and very dark appearance due to the use of paprika, mustard and ginger, which contributed to the intense reddish and yellowish colouring of the pork samples (Ravindran, 2017), that could have penalized consumers' appearance ratings. In contrast, no differences were observed between gender (men and woman) nor by age range, for the colour and appearance ($P > 0.05$), with scores ranging from 5.50 to 6.50 for these parameters (data not shown).

Regarding the frequency of purchase intention and appealing of the product, no differences were observed ($P > 0.05$) when consumers surveyed were considered globally. In this case, 56% of consumers found the pork coated with film appetizing and 52% reported that they would buy it (Fig. 1). Among consumers who buy new products, no statistically significant differences in purchase intention were found, but differences were observed when they were asked about the appetizing of the product ($P \leq 0.05$). In this sense, respondents who buy new products found the product more appetizing (59%) and, within these, men found it more appetizing than women ($P \leq 0.05$). The visual appearance of a new product is paramount when purchasing it for the first time and it has a big influence on the expectations created by the consumer at the point of purchase (Font-i-Furnols & Guerrero, 2014). Because the sensory properties of the product are unknown, consumers' expectations and the appearance of the product are crucial in the final decision when purchasing a new product (Grunert et al., 2011), hence the similar scores for both questions among all consumers. The main motive driving pork consumption is still pleasure, being especially higher among men (AECOC, 2021; Font-i-Furnols & Guerrero, 2022). In addition, men are more attracted to novelty products with some type of processing, as their behaviour is more towards ready-to-eat products (Udomkun et al., 2018). However, women give more priority to changes in the intrinsic characteristics of the product (appearance, smell, taste, texture), since they are more sensitive to changes in the attributes of the food itself (Felderhoff et al., 2020). Hence, women found the pork coated with the film less appetizing than men.

3.2. Part 2 of the questionnaire: films sensory evaluation

Table 4 shows the results of the consumers' sensory evaluation of entire male pork with high levels of boar taint and castrated pork, both coated with spiced edible films. No statistically significant differences were observed for any of the attributes evaluated neither for the type of meat nor for the previous consumers' experience in perceiving unpleasant odour/flavour when consuming pork ($P > 0.05$), except for hardness ($P \leq 0.05$). Consumers who had experienced an unpleasant odour when consuming pork, scored lower on the hardness acceptability of meat from entire male pigs than those from castrated animals. This difference was not found by consumers who reported not having experienced an unpleasant odour. Moreover, in coated loins from entire male

pigs, consumers that had experienced an unpleasant odour when consuming pork, scored lower the hardness acceptability than those who have not. No differences between consumer classifications were observed when coated loins from castrated pigs were evaluated. Therefore, since no differences in odour, flavour, juiciness and overall acceptability were found, the use of the spiced gelatin film ensured a good sensory quality of entire male pork, giving similar scores to meat from castrated pigs, both among consumers who detect unpleasant odours when consuming pork and those who do not. Thus, the spiced film strategy allows for masking high levels of boar taint in pork loins.

Many factors can influence to get a good strategy for masking boar taint in fresh pork. High-temperature open cooking methods, such as in our case frying which is a cooking process in hot oil at high temperature with simultaneous mass and energy transfer (Zhang, Saleh, Chen, & Shen, 2012), are more effective as the aromas are released during the heating process (Peñaranda et al., 2017). Both AND and SKA are volatile compounds that can evaporate during heating, and although they do not start to volatilise until 250 °C, they start to degrade when heated, at 143 °C and 95 °C, respectively. Furthermore, these compounds are fat-soluble, so once they reach their melting point, they can be diluted with the frying oil and thus decrease their perception (De Kock, Heinze, Potgieter, Dijksterhuis, & Minnaar, 2001). In addition, high temperatures could increase the speed of Maillard reactions between amino acids and sugars, producing a large amount of aromatic compounds responsible for the meat odour and flavour that also could contribute to mask the boar taint (Bejerholm & Aaslyng, 2004).

It has also been shown that the additional use of spices and aromatic herbs with a low detection threshold, such as nutmeg, would help to improve the sensory quality of entire male pork when cooked (Egea et al., 2018; Lunde et al., 2008). The odour of nutmeg has been described as warm, camphoraceous, sweet and very pervasive, mainly caused by monoterpenes (sabinene and pinene) that contribute to enhancing or masking aromas and flavours (Chatterjee, Gupta, & Variyar, 2015). Therefore, it is important to know the technological properties of gelatin and its interactions with other food components. Gelatin, being a protein additive, has a high penetration capacity into the meat, so it can act as a vehicle for the incorporation of spice flavours into the loin sample (Wang et al., 2018), and it has also been found to contribute to the masking of boar taint together with the mixture of other spices (pepper, cloves, marjoram, thyme, mustard) and smoke in bacon (Aaslyng et al., 2015).

Regarding hardness values, castration is known to increase the fat deposition of pigs therefore entire male pork is usually leaner if the animals are reared under the same conditions (Škrlep et al., 2020). However, there are other influencing factors such as breed, intramuscular fat content, age and slaughter weight and diet of the animal that can influence in the harness of the meat. It has been studied how reducing the protein/lysine ratio of the diet below the requirement during the pre-slaughter period increases the amount of intramuscular fat deposited in the meat of entire male pigs (Stoll, 2016). However, in this work, since meat came from a commercial slaughterplant, the origin and diet of the pigs are not known. Thus, differences in hardness between meat from castrated and entire male pigs could be related to the intrinsic and extrinsic characteristics of the animals that could not be

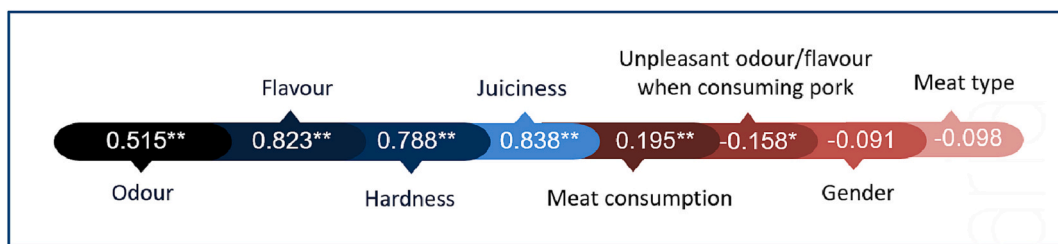


Fig. 2. Graphic representation of the correlation of sensory attributes scores (1-dislike very much to 9 like very much) and parameters of consumers with overall sensory acceptability scores.

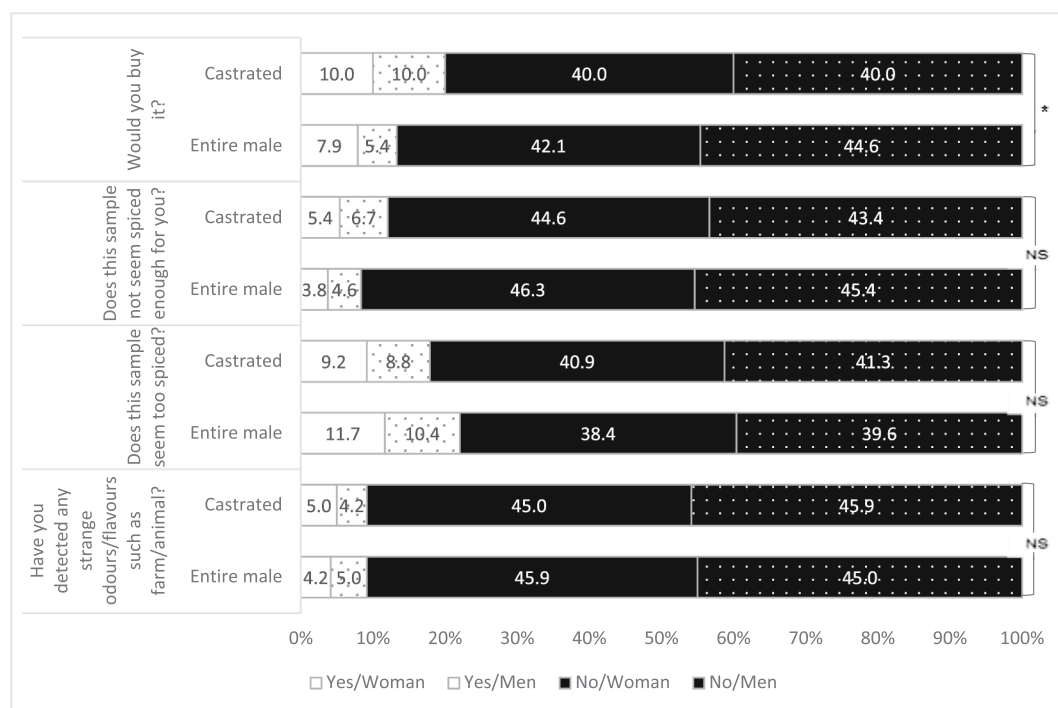


Fig. 3. Classification of consumer responses (%) to questions regarding the pork evaluated sensorially by gender and type of meat. NS: non-significant differences between type of meat ($P > 0.05$), *: significant differences between type of meat ($P \leq 0.05$).

controlled in this work, due to a bias in the selection of raw material. In addition, consumers who experienced an unpleasant odour/flavour while eating meat may have developed a habit of buying castrated meat (Aluwé et al., 2022) and may therefore prefer meat with higher fat deposits (Škrlep et al., 2020), making entire male pork less acceptable due to its hardness.

For pork coated with spiced edible film acceptability, similar scores were obtained regardless of meat type and consumer classification, with scores between 5.03 and 5.78 out of 9 points ($P > 0.05$). Considering the product to be acceptable from a score of 4.5, the spiced films obtained a higher score. Product overall sensory acceptability was found to be closely related to the other sensory attributes evaluated like juiciness and flavour (positive correlation closer to 1, Fig. 2), followed by hardness and odour. Although the higher the meat consumption the higher the overall acceptability, the correlation was quite low ($r = 0.195$; $P < 0.01$). Similar results were obtained in a previous work, where liking of chorizo made from entire male pork was mainly influenced by flavour, followed by odour and juiciness (Peñaranda, Garrido, Moumeh, & Linares, 2020). Felderhoff et al. (2020) also concluded that consumer acceptance of meat products was mostly influenced by the attributes of juiciness, tenderness and flavour, the latter making the difference in overall acceptance. Both texture and flavour are determining factors influencing the preference for meat products (Udomkun et al., 2018).

It can also be seen how the acceptability decreases if the consumer is declared to have detected an unpleasant odour/flavour during meat consumption. Although the correlation is significant ($P < 0.05$), it is low ($r = 0.158$), but it might indicate that consumers who are potentially sensitive to unpleasant pork odour, score lower pork acceptability.

This sensitivity to unpleasant odours could be related to their sensitivity to androstenone and skatole. Although sensitivity to those compounds was not evaluated in this work, other papers reported that it decreased the sensory acceptability of pork (Font-i-Furnols, Gispert, Diestre, & Oliver, 2003). Therefore, consumers who detect an unpleasant odour during meat consumption could be sensitive to the compounds responsible for the boar taint and reject or penalise this meat (Borri-ser-Pairó et al., 2017). Although some studies reported that women are more sensitive to men (Font-i-Furnols et al., 2003), and in the present work women have experienced more frequently unpleasant odour and flavour when eating pork than men, no significant correlations have been found between overall acceptability and gender ($r = -0.091$; $P > 0.05$). Moreover, since the type of meat did not influence the acceptability scores of the respondents ($r = -0.098$; $P > 0.05$), this indicates that the masking strategy was efficient.

Consumer responses, by gender and type of meat, to the questions carried out in the questionnaire after tasting the meat samples are presented in Fig. 3. No significant differences ($P > 0.05$) by type of meat and

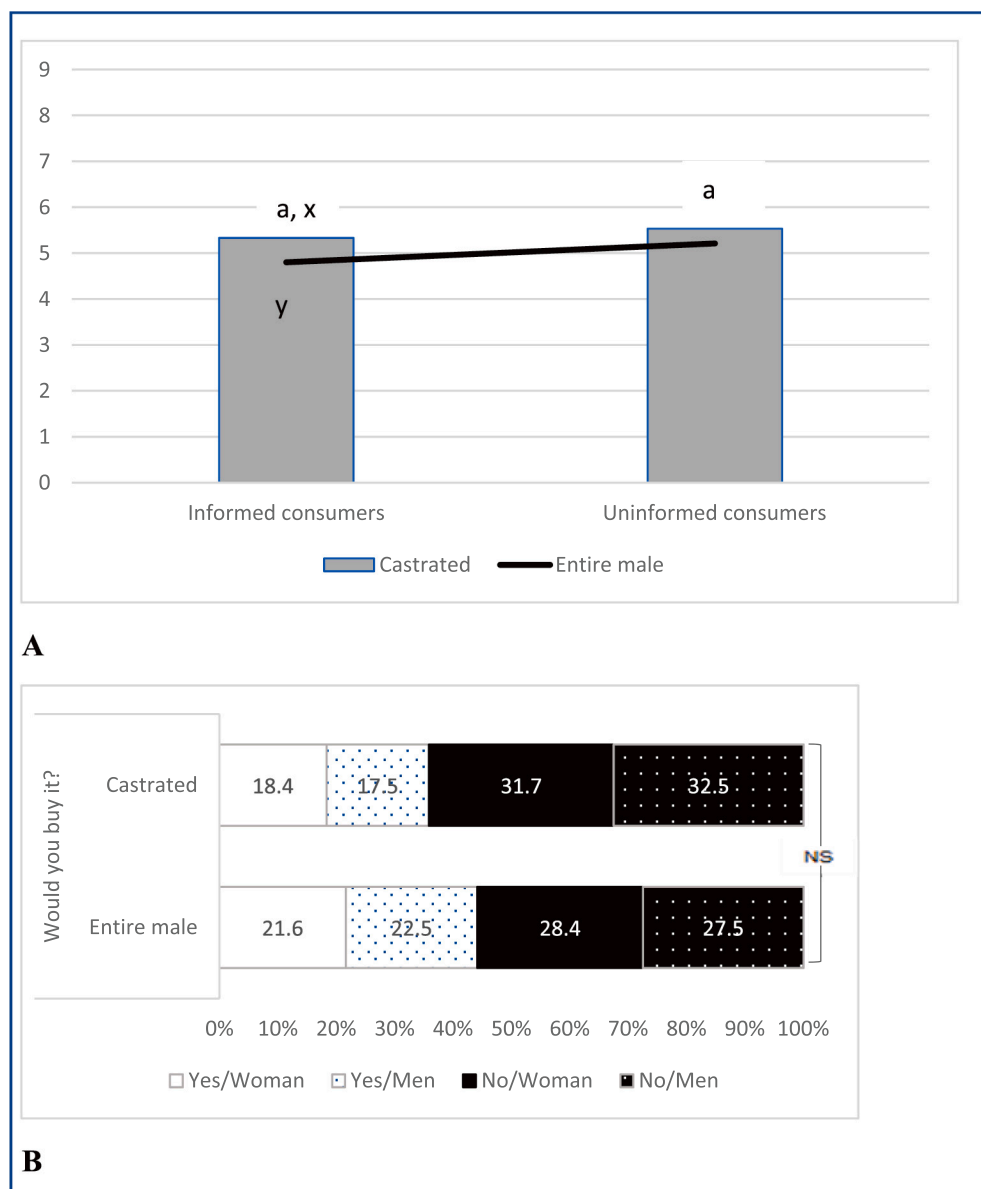


Fig. 4. Graphic representation. A: acceptability scores of pork from castrated and entire male coated with spiced edible film by consumers in uninformed and informed conditions (scale 1: dislike very much to 9: like very much).

B: frequency of consumers' intention to buy meat (yes or no) by gender and type of meat. Different superscripts significantly differ at $P \leq 0.05$. a,b: effect of tasters. x,y: effect of meat type.

NS: non-significant differences ($P > 0.05$).

gender were obtained for the questions on whether the meat samples had a strange odour and whether it seemed too spiced or not spiced enough. As for the question of whether they would buy it or not, significant differences were seen by meat type ($P \leq 0.05$), showing a higher purchase intention for the spiced film coated castrated pork (20%) than entire male pork (13%). As found in the correlation analysis, consumers sensitive to boar taint would avoid consuming this type of meat (Borriquer-Pairó et al., 2017). Since no differences between the type of meat were found regarding the detection of strange odours/flavour and spicing level, probably this difference between the type of meat regarding willingness to purchase is due to some characteristics of the meat different from the odour/flavour, corroborating the efficiency of the masking strategy. This difference could be related to differences in hardness between meat from castrated and entire males found by consumers who have detected unpleasant other on some occasions, as reported in Table 3. Overall, the frequency of answering “no” for all questions in the questionnaire was higher than “yes”, with a mentioned rate of 80–90%. This is probably due to the fact that only 34% of Spanish consumers, especially younger consumers, tend to value and buy new products (AECOC, 2021).

3.3. Part 3 of the questionnaire: infogram

Once the information on castration of male piglets was provided, consumers re-evaluated the acceptability of the two samples without tasting the meat again (Fig. 4A). Uninformed consumers did not find significant differences in acceptability of meat from entire males and castrated pigs, indicating the effectiveness of the masking strategy for the entire male pork. However, informed consumers scored slightly better the meat from castrated pigs than those from immunocastrated pigs. This would show the influence of the information in the opinion of the consumers as reported previously (Aluwé et al., 2022; Font-i-Furnols & Guerrero, 2022). However, even the difference was significant ($P \leq 0.05$) it was not very relevant, as the difference between the scores for castrated and entire pork was minimum. Moreover, appearance and colour may have conditioned consumers' acceptability scores because if consumers were not familiar with the product and have only tasted it once, these attributes may be penalized. In fact, fresh meat appearance is paramount for consumers and influences their purchasing decision (AECOC, 2021). Normally, consumers who are more familiar with a type of product tend to look more at intrinsic factors such as colour to assess quality when choosing a product, and unfamiliar consumers tend to

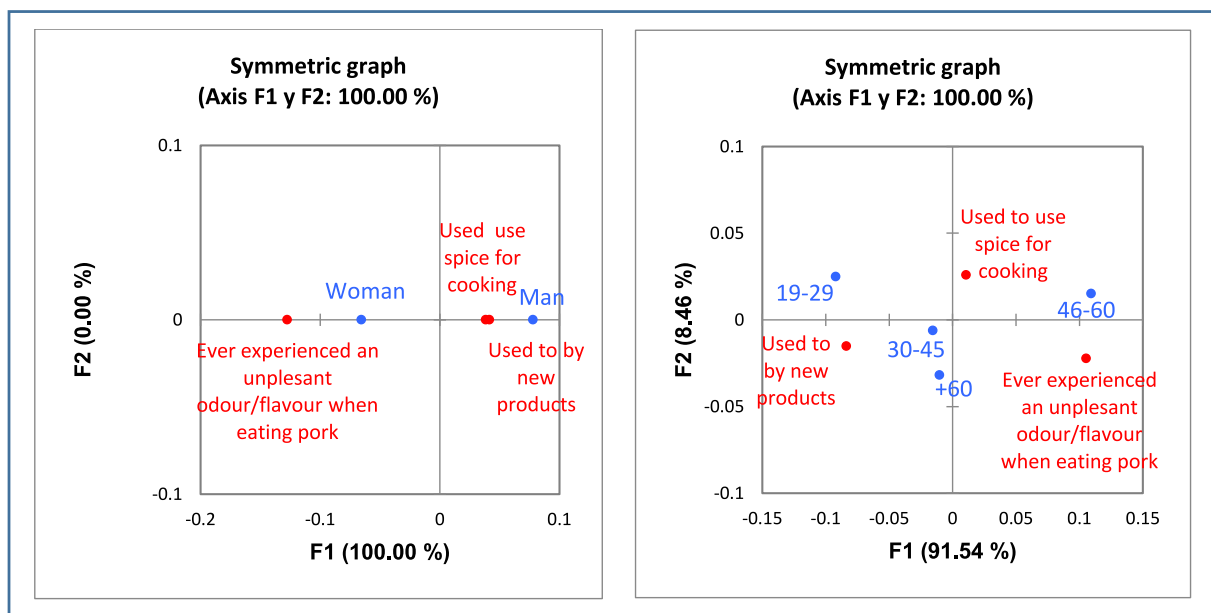


Fig. 5. Graphic projection of gender and age ranges according to consumption habits of the consumers.

focus on product-specific claims (extrinsic factors) (Aboah & Lees, 2020).

In terms of purchase intention, no differences ($P > 0.05$) were obtained by type of meat or by gender (Fig. 4B), with a purchase intention of 64% for pork from castrated pig coated with spiced edible film and 55% for those from entire male pork, much higher than when consumers were unaware of the information. This shows that most consumers do not have sufficient information about castration and animal welfare (Aluwé et al., 2020), as animal welfare has become a consumer priority (AECOC, 2021). However, although consumer trends are increasingly moving towards meat products with specific claims, such as that they guarantee animal welfare or are environmentally friendly, they are not entirely effective if they can be detrimental to their sensory properties (Font-i-Furnols & Guerrero, 2014; Ruiz-Capillas et al., 2021). It is therefore essential to take care of the appearance and organoleptic quality of the product in order to ensure that it is well received on the market, but this should be combined with marketing strategies enhancing the properties of the meat and its production.

3.4. Part 4 of the questionnaire: consumption habits

The results of consumption habits, by gender and age range, are shown in the two-dimensional map obtained after the correspondence analysis [the first axis explains most of the variance (100% and 91.54%), Fig. 5]. In relation to gender, it can be seen that men buy more new products and use more spices during cooking than women who experiencing an unpleasant odour/flavour during pork consumption more often than men. While the vast majority of people are sensitive to the odour of skatole, a significant proportion of consumers can not perceive the odour of androstenone, making it detectable by 40–50% of users, particularly women (Borrissier-Paró et al., 2017). Previous studies found a relationship between gender and sensitivity, showing that women were significantly more sensitive than men, as there is a genetic predisposition to be able to smell it that is related to the human olfactory receptor OR7D4 (Voznessenskaya & Klyuchnikova, 2017). In contrast, the work of Borrissier-Paró et al. (2017) and Peñaranda et al. (2020) found no significant differences between the two genders, although there was a trend towards a greater sensitivity to androstenone in women. In addition, men tend to be more likely to buy new products, as they look for ready-to-eat foods that required less preparation, so they are more willing to take more risks in purchasing than women

(Udomkun et al., 2018).

By age range, it could be observed that consumers between 19 and 45 years old are more likely to buy new products and use spices. Consumers are increasingly looking for new products that surprise them, especially younger consumers (AECOC, 2021). Consumers between 46 and 60 years old were reported to have experienced unpleasant odours during meat consumption. Furthermore, it can be seen that from the age of 61 onwards consumers tend to try new products. With age, taste buds atrophy, causing an alteration in taste and additionally protein needs increases, and, these two factors might influence these consumers to look for new alternatives that are more attractive to them to increase their dietary intake (Baugreet, Hamill, Kerry, & McCarthy, 2017).

4. Conclusion

The development of spiced films on meat products is a good technological and commercial strategy for the meat sector, as it contributes to the improvement of the sensory quality of entire male pork with high levels of AND (5.51 ppm) and SKA (0.73 ppm) and ensures good acceptability by consumers (55% of them were willing to purchase). Marketing strategies are important to be considered because the purchase intention for entire male pork increases when consumers are provided with additional information of this type of meat on the label.

Above all, the spiced film on entire pork offers a new product for consumers who tend to use spices during cooking and who are looking for new products. In particular among the younger population and those over 61 years of age who demand more attractive prepared meat products that meet their nutritional requirements.

Consequently, spiced films are a good strategy to revalue fresh entire male pork, but it would be interesting to look more closely at the appearance of the films to make them more appealing to the consumer and they not diminish their visual quality.

CRedit authorship contribution statement

M Dolores Garrido: Conceptualization, Formal analysis, Fund acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing - review and editing. **Macarena Egea:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Validation, Data curation, Writing - review and editing. **Maria Font-i-Furnols:** Conceptualization, Formal analysis,

Investigation, Methodology, Visualization, Validation, Writing - review and editing. **M Belén Linares**: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Data curation, Supervision, Validation, Writing - review and editing. **Irene Peñaranda**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing - original draft and editing.

Funding

Agreements to MCI (Ministerio de Ciencias e innovación: RTA 2017–00039–02-02), AEI (Agencia Estatal de Investigación) and INIA (Instituto Nacional de Investigación Agraria) of Spain by their financial support.

Declaration of Competing Interest

The authors declare no conflict of interest.

Data availability

Data will be made available on request.

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