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Do experts' sensory assessment match consumers' hedonic valuations? An exploratory analysis on cured ham

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SUMMARY – The agrofood industry is interested in the control and conformity of their products to the quality standards while also matching consumers' preferences. Sensory analysis provides a common framework to address both goals. The primary objective of this paper is to investigate to what extent the overall sensory valuations of experts coincide with consumers' preferences; and secondary, which are the sensory attributes that better match consumers' acceptability of cured ham. To fulfil these objectives, a total of 8 samples of cured ham was analysed by 14 trained experts and 213 consumers. The main method applied is Principal Components Analysis (PCA). In order to answer the second objective, we apply an extended PCA on consumers' scores where the attributes' ratings made by experts are also projected. To answer the first objective, the PCA on consumers' scores is compared with the PCA on assessors' scores. Both of them include the attributes' ratings made by experts.

Key words: Principal component analysis, cured ham, trained assessors, consumers, sensory valuations.

RESUME – *"L'évaluation des experts coïncide-t-elle avec les évaluations hédonistes des consommateurs ? Une analyse exploratoire du jambon sec". L'industrie agroalimentaire a examiné le contrôle et la conformité de ses produits par rapport aux standards de qualité, en même temps que la satisfaction des préférences des consommateurs. L'analyse sensorielle apporte un cadre commun pour atteindre ces deux buts. Le premier objectif de ce travail est de rechercher quel est le degré de coïncidence entre les évaluations sensorielles menées par les experts et les préférences exprimées par les consommateurs. Et en second lieu, quels sont les attributs sensoriels qui correspondent le mieux à l'acceptabilité du jambon sec évaluée par les consommateurs. Pour accomplir ces objectifs, 8 échantillons de jambon sec ont été analysés par les 14 membres entraînés d'un jury de dégustation et par 214 consommateurs. Les résultats ont été analysés par une Analyse en Composantes Principales (PCA). Afin de répondre au second objectif, on a appliqué une PCA élargie aux résultats des consommateurs, dans laquelle on a aussi projeté les résultats des attributs du jury de dégustation. Pour accomplir le premier objectif, la PCA des résultats des consommateurs est simplement comparée à celle des dégustateurs. Toutes deux ont également pris en compte les valeurs accordées par le jury entraîné aux attributs sensoriels.*

Mots-clés : *Analyse en composantes principales, jambon sec, dégustateurs entraînés, consommateurs, évaluation sensorielle.*

Introduction

The agro-food industry is interested in the control and conformity of their products to the quality standards. In this respect, trained panels may assess the conformity of an array of sensory descriptors to predetermined quality standards. Nevertheless, acceptability by trained panels may diverge from acceptability by final consumers, and matching consumers' needs is a priority in market oriented firms which intend to be successful in the long-run.

Therefore, a first objective of this paper is to investigate to what extent sensory acceptability by a trained panel differs from consumers' global acceptability, and as a second objective, to identify which sensory attributes better match consumers' overall acceptability. Both sensory assessments are referred to cured ham of white breeds.

Spain is the main consumer and producer country of cured ham in the world. *Per capita* consumption was 4.5 kg in 2003 (Cruz, 2005), and the total production amounted to 249,400 t in

2004. Cured ham accounted for 20% and 37% of processed meat production and sales, respectively (Asociación de Industrias de la Carne de España, 2005).

The European Union defined Protected Designations of Origin (PDO), Protected Geographical Indications (PGI) and Traditional Speciality Guaranteed (TSG) in 1992 [Council Regulations 2081/92 and 2082/92 (European Commission, 2006)]. However, in Spain, as in other Mediterranean countries, these protection squemes were already in place. In fact, the first PDO in ham dates back to 1985, when PDO Teruel was officially recognized. At this moment, besides Teruel ham, there are 5 protected labels by the European legislation, from which three are PDOs on ham from Iberian breed, one is a PGI and another one is Jamón Serrano, which is protected as a TSG. In this research, we were mainly interested in white cured ham because is the one with a larger customer base in Zaragoza, the city where the collection of data took place. Likewise, as this research was part of a pan-European project, some samples of French ham were also considered, in order to assess the acceptability of foreign traditional specialities by Spanish assessors.

Materials and methods

Samples

Eight samples of ham, corresponding to eight different commercial brands, were tasted by both, consumers and trained assessors. These samples differ by the following extrinsic attributes: origin, which could be from Teruel, any other region in Spain and France; quality certified labels: with PDO Jamón de Teruel, with TSG Jamón Serrano, with PGI Jambon de Bayonne, candidate to PGI or without any quality label; and brand, which could be owned either by the producer (firm) or by the distributor. A list of the samples and their extrinsic characteristics is presented in the first three columns of Table 1.

Table 1. Descriptive statistics of the overall acceptability of the samples analysed during the blind test by the consumers and the trained panel

Description of samples					Consumers		Trained panel	
Sample code	Country of origin	Region of origin	Certification	Brand	Mean scale 0-10 (Ranking)	St. deviation scale 0-10	Mean scale 0-10† (Ranking)	St. deviation scale 0-10†
s07	Spain	Undetermined	No	Producer's	6.03 (1)	1.79	6.66 (2)	1.09
s17	Spain	Teruel	No	Producer's	5.77 (2)	1.84	5.55 (3)	1.41
s16	Spain	Teruel	PDO Teruel	Producer's	5.50*** (3)	2.02	6.73*** (1)	1.15
s21	Spain	Undetermined	TSG Jamón Serrano	Producer's	5.32 (4)	1.85	5.06 (4)	1.13
s20	Spain	Undetermined	No	Distributor's	5.03** (5)	1.86	3.05** (7)	1.41
f17	France	Bayonne	PGI Bayonne	Distributor's	4.85 (6)	2.01	4.45 (5)	1.55
f16	France	Aveyron	No	Producer's	4.76*** (7)	2.06	3.51*** (6)	0.94
f15	France	Auvergne	PGI candidate	Producer's	3.92 (8)	2.18	2.89 (8)	0.88

†The trained panel's scale of 1 to 9 has been converted into a scale of 0 to 10.
** and *** indicates significant difference at 1 and 5% level of significance, respectively, between consumers' and trained panel's mean score.

Design of trained assessors' sensory evaluation

Ham samples were assessed by a trained panel of 14 members [who also participated in the research by Cilla *et al*. (2005)]. To acquaint panellists with product attributes and intensities, six 1 hour training sessions took place over a 4 week period prior to sample testing. During this phase, hams from a variety of manufacturers corresponding to maximum and minimum intensities that might be found for each attribute (1, very low, to 9, very high) were presented to panellists. To test the panel reproducibility, one additional ham was presented at each session. It was the replicate of the second sample of the set and was served as the last of the session. The panel sessions were held at mid-morning, about 3 hours after breakfast. Slices (1.5 mm thick) of the ham portions containing *Biceps*

femoris (BF), *Semimembranosus* (SM) and *Semitendinosus* (ST) muscles were obtained with a slicing machine about 1 hour before tasting, in order to allow slices to reach room temperature (22ºC). They were served on plates to panellists, which were told to taste narrow slice sections including both SM and BF muscles.

A profile of twenty-five sensory attributes of dry-cured ham grouped in appearance, odour, texture, flavour and acceptability was assessed. Attributes were rated on a structured scale of 1 to 9 (1, very low, to 9, very high). About 50 ml of water at room temperature and 20 g of unsalted bread were provided between successive hams. All sessions were done at 22ºC in a sensory panel room equipped with white fluorescent lighting (Philips TLD 86, 5600 ºK, 800 lux). Four hams from different manufacturers were successively evaluated in each of two sessions. The sample order was randomised within sessions. Each ham was evaluated just once by each panellist.

Design of consumers' sensory valuation

A sample of 213 consumers participated in the sensory assessment of ham. The tasting took place in Zaragoza (Spain), at the end of 2004, in a special room available in the two hypermarkets of the collaborative retailer's chain. Tables were facing in the same direction, in order to avoid communication between the participants. The participants were mainly women (67% *vs* 33% of men); and young and middle age (40% were aged between 36 and 50 years old; and 38% between 51 and 65). Interestingly, all of them declared to be highly involved with ham, as 64% usually consume ham several days in the week, and 26% daily.

Sessions of 45 minutes were organized, in the morning (between 10 am and 1 pm) and the afternoon (between 4 and 8pm) from Monday till Saturday, and along two consecutive weeks in November-December 2004. Each consumer participated in two sessions, in two different weeks, and in each of them, evaluated five cured ham samples in both information conditions, blind and identified, with a break between them of 15 minutes. No more than 12 consumers participated simultaneously. In both sessions, samples were presented monadically, following a complete block design balanced for order effect. The global appreciation was measured on a unstructured continuous scale (0-100 mm) with hedonic references ranging from "I do not like it at all" to "I like it very much". Marks on the scales were converted into scores from 0 to 10. The tasting room kept a temperature of 22º and was provided with white fluorescent lighting. Samples had been kept at environmental conditions for at least half an hour before the tasting, and small slices 1.5 mm thick containing *Biceps femoris*, *Semimembranosus* and *Semitendinosus* muscles were obtained with a slicing machine and were served on plastic plates to participants. Water and toasted bread were available and recommended in order to clean the palate after each plate. In the blind information condition, a three digit code was written on the reverse of the plate. In the identified tasting, the slides projector was used to present the label of each sample, highlighting the brand, origin and the presence or absence of quality certification.

Statistical analysis

Firstly, a descriptive analysis of results was done (means and standard deviations of ratings). Comparisons of means between both groups of individuals, consumers and trained assessors, were made through the Mann-Whitney test. This is a non-parametric test (distribution-free) suitable to compare two independent groups of sampled data.

Secondly, Principal Component Analysis (PCA) was applied to both sets of data in order to investigate the influence of sensory attributes on consumers' and trained panel's sensory preferences. PCA is a multivariate method whose purpose is to summarize most of the original information in a minimum number of factors for prediction purpose (Hair *et al*., 1998) and permits to represent graphically both, the ham samples and attributes. This statistical method has been broadly used in the literature with satisfactory results. As an illustration, Young *et al*. (2005) used PCA on trained assessors' sensory valuations of peanuts with different production origins, demonstrating that production origins determine distinctive flavour profiles; whereas Rousset and Martin (1998) separated 6 types of cured hams samples on their sensory properties, as perceived by trained assessors.

Uni- and bi-variate analysis were carried out with SPSS 14.0, while XLSTAT-Pro was used in PCA, and GAUSS 8.0 to represent the joint positioning of brands and attributes on the same map.

Results and discussion

In Table 1 the mean and standard deviation of the ratings assigned by both, consumers and trained assessors, to each of the eight samples are presented. In the case of trained assessors, this is the average score assigned to the attribute "overall acceptability". The trained panel's scale of 1 to 9 has been converted into a scale of 0 to 10 to compare the ratings assigned by consumers and trained assessors. The Mann-Whitney comparison test has been applied to the variables transformed into this common scale.

In terms of overall acceptability, a first difference across groups of assessors is that the trained panel apparently is more demanding, as they assign lower scores to every ham sample than consumers, except for the Spanish ham without certification (S07) and Teruel ham with DO (S16). Secondly, trained assessors also assign a higher score for Teruel ham with DO than Teruel ham without DO, while consumers assign similar scores; and, finally, trained assessors score the distributor's brand noticeably lower than consumers, placing this brand closer to F15 Auvergne ham, which is the least valued by consumers.

According to the Mann-Whitney test, however, only average scores on Teruel ham with DO (S16), the distributor's brand (S20) and Aveyron ham (F16) are accepted to come from different populations, and therefore, average scores are statistically different across groups of assessors at 5% (1% in the case of S20) level of significance.

Sensory profile

Figure 1 shows the first two components obtained by PCA when applied to the average scores on the array of sensory attributes in Table 2 valuated by trained assessors. These two factors account for 52.66% of the total variation, where 29.14% corresponds to the first dimension and 23.52% to the second one.

The first principal component separates the samples according to the country of origin, which in turn appears to be correlated with some appearance, texture and odour attributes. Thus, French hams received high loadings of colour of the SM muscle, colour of the BF, subcutaneous fat, sheen (appearance attributes), pastiness, adhesiveness, hardness, fibrousness (texture attributes), rancid flavour, acorn flavour and pungency (flavour attributes). Whereas Spanish hams got high scores of crumbliness, softness, acorn odour, acceptabilility and flavour, according to this dimension.

The second component separates Auvergne ham (F15) from the other two French samples, and the distributor's brand (S20) from the remaining Spanish samples. F15 is characterised by high levels of crust, saltiness and rancid odour, and low levels of sweetness. S20, on the other hand, is better characterised by high scores of mould odour, colour homogeneity, crust, saltiness and rancid odour, and low scores of flavour, marbling, fat colour and sweetness on this dimension.

According to this figure, crumbliness, softness (texture attributes), sweetness, flavour (flavour attributes), aroma and acorn odour (odour attributes) are the main attributes that drive trained assessors acceptability in a positive direction. Whereas, subcutaneous fat, colour of the BF, crust (appearance attributes), pastiness and adhesiveness (texture attributes) are negatively correlated with trained assessors acceptability.

Consumers' acceptability

Figure 2 shows the first two components obtained by PCA applied to consumers' ratings. In the same map, the positioning of the correlation of sensory attributes (as rated by trained assessors) with the two components are plotted. This is a two-factors solution which accounts for 45.89% of the total variation, where 29.30% corresponds to the first dimension and 16.59% to the second one.

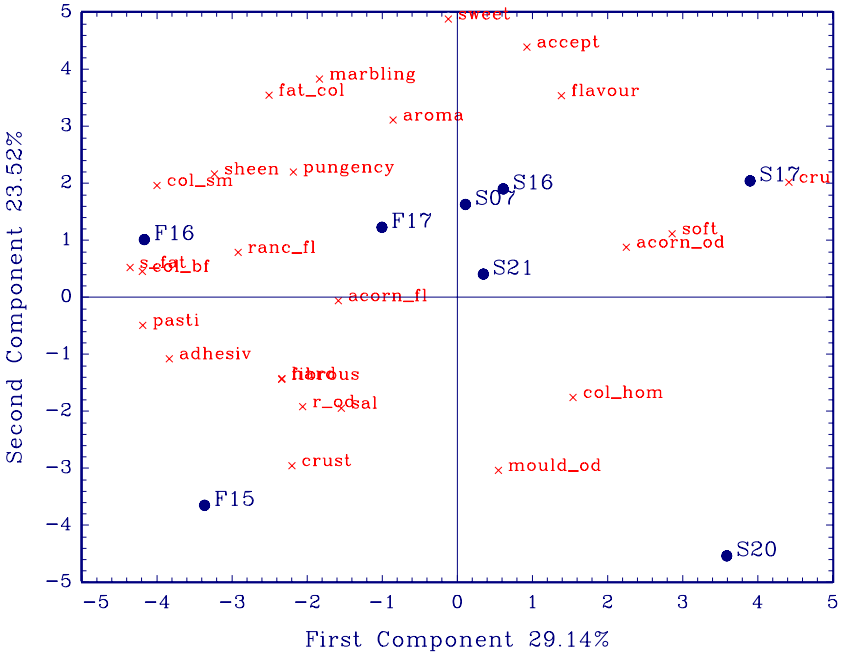

Fig. 1. Principal Component Analysis on assessors' ratings of sensory attributes.

Table 2. Description of sensory attributes

Categories of attributes	Attributes	Short name	Definition
Appearance	Crust	crust	Hardness and darkness of the outer part
	Colour BF	col_bf	Cured colour intensity of BF muscle
	Colour SM	col_sm	Cured colour intens. of SM muscle
	Colour homogeneity	col_hom	Colour homogeneity among muscle zones
	Subcutaneous fat	s_fat	Amount of subcutaneous fat
	Fat colour	fat_col	Colour intensity of subcut. fat
	Marbling	marb	Intramuscular fat infiltration
	Sheen	sheen	Light reflection due to melting fat
Odour	Aroma	aroma	Cured ham aroma intensity
	Rancid odour	r_od	Rancid odour intensity
	Acorn odour	acorn_od	Nut (acorn) odour intensity
	Mould odour	mould_od	Mould odour intensity
Texture	Hardness	hard	Mechanic resistance to mastication
	Softness	soft	Soft and palatable texture in mouth
	Crumbliness	cru	Ability to disintegrate in mastication
	Fibrousness	fibrous	Fibre-like (oriented) hardness
	Pastiness	pasti	Paste-like texture
	Adhesiveness	adhesive	Sticky to teeth and mouth
Flavour	Flavour	flavour	Cured ham flavour intensity
	Saltiness	sal	Salty taste intensity
	Rancid flavour	ranc_fl	Rancid flavour intensity
	Acorn flavour	acorn_fl	Nut (acorn) flavour intensity
	Pungency	pungency	Acrid perception intensity
	Sweetness	sweet	Sweet taste intensity
Acceptability	Acceptability	accept	Overall pleasantness intensity

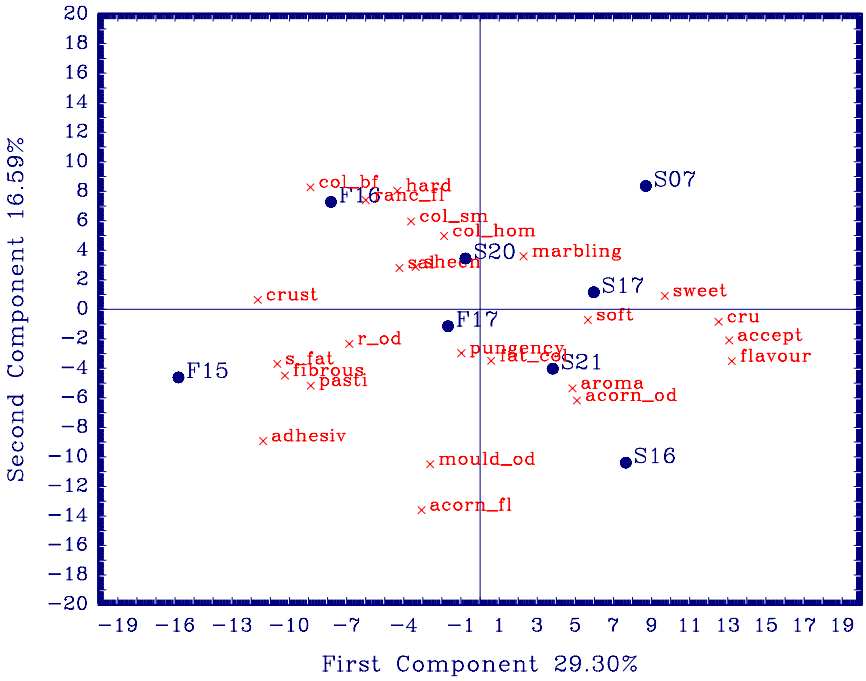

Fig. 2. Principal Component Analysis on consumers' ratings.

The first principal component is correlated with the country of origin, as in Fig. 1, with the exception of S20. French hams are characterized for their adhesiveness, pastiness, fibrousness, hardness and less crumbliness (according to their texture), crust, subcutaneous fat and the colour of the BF (according to their appearance). The second principal component separates samples which differ in their appearance, mainly colour Aveyron ham (F16), distributor's brand (S20), Teruel ham without DO (S17) and producer's brand without DO (S07) from the rest.

Colour of the BF muscle, colour of the SM muscle, colour homogeneity, crust, sheen and marbling have high positive loadings on this dimension, whereas the remaining samples are related to the texture attributes except hardness and also all the odour atributes.

According to this figure, crumbliness, softness (texture attributes), sweetness, flavour (flavour attributes), aroma and acorn odour (odour attributes) are the main attributes that drive consumers preferences in a positive direction. Whereas, crust, subcutaneous fat, colour of the BF, (appearance attributes), fibrousness, pastiness and adhesiveness (texture attribute) are negatively correlated with consumers acceptability.

Conclusions

The overall features of hams, from France and Spain, determine the cured ham sensory valuations. According to the PCA results, both Spanish consumers and trained assessors clearly discriminate between French and Spanish hams, which in turn differ in terms of appearance and texture attributes, and also in flavour attributes for the trained panel.

Spanish consumers place their samples' assessments similarly to trained panel regarding the different attributes, with special emphasis for the most appreciated hams and the French hams.

Besides, both consumers and trained panel mostly agree on the attributes that drive their overall acceptability. In a positive direction, these attributes are crumbliness and softness for texture, for odour these attributes are aroma and acorn odour, and for flavour, sweetness and flavour. Whereas, subcutaneous fat, colour of the BF, crust for appearance, pastiness and adhesiveness for texture are negatively correlated with trained panel and consumers acceptability. That is also the case for fibrousness and consumers acceptability.

In terms of acceptability there are many coincidences between consumers and the trained panel except for three hams, where the Mann-Whitney test shows significant differences, as trained panel assigns a much higher score to the PDO Teruel and lower scores to one Spanish and one French ham. Moreover, both prefer Spanish hams over French hams.

Finally, we need to emphasize that the aim of this study lies on the comparison between trained assessors and naïve consumers of sensory overall acceptability of homogeneous parts of the the same pieces of ham. A typification of cured ham's profiles based on extrinsic common attributes, such as region of origin, quality certified label, brand, is beyond the scope of this paper, which would requiere a significantly larger number of samples.

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