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Preference Mapping of Longissimus Dorsi Beef Steaks for Northern Irish Consumers 355.00

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Abstract—Internal and external preference mapping of longissimus dorsi beef steaks was conducted for Northern Irish consumers to obtain a better understanding of consumers' preferences of beef and the relation of these preferences with eating quality attributes measured by sensory and instrumental techniques. Sensory profiling was conducted for 14 different beef treatment, from which the 7 most different in term of sensory attributes were selected to be used in consumer panels. Sarcomere lengths, Warner-Bratzler shear force (WBSF) and fatty acid profiles, were also conducted for the 7 treatments selected. The internal preference mapping showed that some texture (tenderness and stringy), flavour (sweet and sour) and appearance (open and oily) attributes seem important in the consumers' preferences. External preference mapping showed a relationship between some flavour attributes and total fat and polyunsaturated fatty acids and between WBSF and some texture attributes. Internal and external preference mapping thus permit a deeper understanding of consumer preferences of beef and its relationship with eating quality attributes.

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Index Terms— beef eating quality, consumers panel, flavour, preference mapping, sensory profiling, texture

I. INTRODUCTION

The eating quality attributes of beef that are commonly recognized as the most important for consumers are tenderness and flavour [1]. Tenderness has been traditionally considered more important than flavour in beef and has been the primary concern of retailers [2, 3]. However, recent sensory research on beef has found a higher correlation between flavour liking and consumers overall acceptability [4, 5], giving a much more complicated view about the consumer preferences of beef. These beef eating quality attributes can be influenced by pre and post slaughter factors, such as muscle structure and its chemical composition, ante-mortem stress, as well as post-mortem conditions and storage [6]. Amongst the pre-slaughter factors the age of animal and diet are some of the most important factors that can influence tenderness [7] and flavour [8]. In particular, the diet can change the fatty acid composition of the meat, with an important impact on the nutritional characteristics of the meat and also on flavour [9]. On the other hand, ageing, electrical stimulation of the carcasses [10], tenderstretching [11] and chilling rate [12] are post-slaughter factors that could influence the beef eating quality attributes. Understanding which of the sensory attributes drive consumer preferences is critical for the meat industry. The data obtained from sensory analysis (consumer and profiling) or instrumental analysis, is normally analyzed though univariate analysis, which has the implicit assumption that all the subjects exhibit the same behaviour. Therefore these methods give incomplete information about consumers' preferences. Preference mapping has been developed as a multidimensional technique, to relate the preference of each consumer to a set of analytical variables (sensory or instrumental) [13]. Preference mapping has been applied to the investigation of consumers' preferences of processed meat [14, 15], but has rarely been applied in fresh meat [16]. This paper presents research that identifies, through internal preference mapping, the beef eating quality attributes driving the preference of consumers in Northern Ireland and, through external preference mapping, the relation of these attributes to some instrumental analyses.

II. MATERIALS AND METHODS

2.1. Animals and sampling

Fourteen groups of cattle (n=28) were selected with the intention of achieving a wide range of eating quality attributes. The aim was to obtain sufficient meat from two animals from each treatment for profiling and consumer panels and instrumental measurements; this meat need to be well matched in terms of eating quality. Given the small number of animals, it was not the intention to compare the effects of treatments. The pre-slaughter factors which varied were age, breed, sex and diet and the post-slaughter factors were ageing time and electrical stimulation. The animals were slaughtered on four different days at a Northern Irish abattoir. The carcasses were boned out 48 hours after slaughter and samples for sarcomere length were taken at this time. The longissimus dorsi was removed, vacuum packed and aged for the time assigned to each group.

2.2. Sensory profiling panels

The panellists were trained using a four step training model [17] during ten hours (five sessions of two hours each). The training method included the identification of attribute descriptors in the beef samples, recognition of standards for aroma, training in use of the line scale and feedback of panellist performance [18]. The sensory profiling panel identified 48 descriptors for appearance, aroma, flavour, texture and aftertaste. During profiling panels, the panellists assessed in triplicate the longissimus dorsi grilled steaks of the 14 treatments. The data obtained was analyzed by analysis of variance (ANOVA) and principal components analysis (PCA) with the aim to select the 7 most different beef treatments. The sensory profiling data was managed using the sensory analysis software FIZZ Network by Biosystemes (Dijon France) and the statistical analyses were conducted using the software GenStat 11th edition by VSN International (Hemel Hempstead, UK).

2.3. Consumer panels

The 7 treatments selected from the sensory profiling, were presented to consumer panels (n=120) to determine scores for the liking of aroma, flavour, tenderness, juiciness and overall liking in a scale between 0 and 100. The consumers were from sports clubs, charity groups and parents associations and all of them were over 15 years old. The consumer preference data was managed using the software FIZZ Form by Biosystemes.

2.4. Instrumental measurements

Instrumental measurements were conducted for the seven treatments selected for consumer panels. Sarcomere length was measured 48 hours after slaughter through a laser diffraction technique [19]. All other measurements were conducted at the same stage of ageing as the sensory panels. Warner-Bratzler shear force (WBSF) was measured using a texture analyzer Instron model 3366 fitted to a PC with the software Bluehill2 version 2.5,(High Wycombe, UK) [20]. Fatty acid profiles were determined from the lean tissue using a lipid isolation method (methanol and sulfuric acid); the samples were prepared from the fat extracted according to the British standard method (British standard institute BS 684-2.34) and were analysed by a Gas Chromatograph Varian-Chrompack CP-3800 (Walton on Thames, UK).

2.5. Data analysis

Internal preference mapping was conducted using the overall liking of the consumer data for all consumers who had fully completed the assessment and the 18 attributes which showed differences between the seven groups with a statistical probability of $P<0.2$, obtained from the sensory profiling. External preference mapping, using a vector model, was conducted using the same sensory profiling data (18 attributes), the consumer preference data and the instrumental data. Euclidean cluster analysis with Ward's agglomeration method was also conducted for a better understanding of the consumer distribution. Correlations were also conducted for the attributes from the sensory profiling and instrumental data. The statistical analyses were conducted using XLStat version 2009.3.01 by Addinson (New York, USA) for cluster analysis and correlation and the software GenStat 11th edition by VSN, was used for the PCA, internal and external preference mapping.

III. RESULTS AND DISCUSSION

In the internal preference map for overall liking the first two PCs explain 46% of variation, 24% for the first principal component and 22% for the second (Figure 1). The preference map shows a good distribution of the seven selected treatments, with a wide spread of preferences for individual consumers. Cluster analysis groups separated the preference data into three clusters of 38 (CG1), 49 (CG2), and 28 (CG3) consumers. The preferences of three cluster groups seem to be concentrated on the upper/ left side of the graph, which is associated with attributes such as tenderness and sweet flavour. In contrast, chewy, rubbery texture and bitter, livery and sour flavours seem to be in opposite direction to the consumers' preferences. Examination of the three cluster groups individually indicates that CG1 gave high scores for overall liking for all treatments, with treatments 11 and 8 (T11 and T8) scoring highest, indicating a preference for the attributes, "tenderness" and "sweet flavour". The overall liking scores of CG2 were generally lower than for CG1, with T1 and T13 scoring highest and T15 and T11 receiving low scores, suggesting a preference for "open appearance" and a dislike for "fatty flavour", "fatty aftertaste", and "livery aftertaste". Finally, CG3 were strongly discriminatory, scoring T11 highly and disliking T4 and T13. This suggested that these people liked "sweet flavour" and "juicy texture" disliked "bitter flavour" and "sour flavour". For the external preference mapping, the first and the second principal components (PC1 and PC2) account for 69% of the total variation (Figure 2). PC1 (45% of the variation) seems to be mainly explained by the texture attributes while the flavour attributes are distributed mainly in PC2 (24%). Again, CG1, CG2 and CG3 are associated with the preferred traits of tenderness and sweet flavour. Preliminary instrumental measurements show the expected associations (Figure 2). WBSF is related to attributes such as "connective tissue appearance" and with "rubbery", "stringy" and "chewy" texture and was also positioned in opposite direction from the descriptor "tenderness" and from the overall liking of the three consumer cluster groups. However, analysis of the correlation between WBSF and these traits showed that it was only correlated ($P<0.1$) with stringy texture ($R2 = 0.45$). Sarcomere length seems to be positioned opposite to WBSF, but it is not close to any texture attribute. This may be due to the fact that this measure was determined soon after slaughter rather than after ageing and measures only one contributory factor to tenderness. Total fat is correlated ($P<0.05$) with the attributes, "fatty flavour" ($R2 = 0.72$) and "fatty aftertaste" ($R2 = 0.8$), and also appears very close to these attributes in the preference map. Total unsaturated, monounsaturated fats and total saturated fat are also associated, as these are correlated with total fat. Polyunsaturated fatty acids (PUFA) appear to be related to "oily appearance", "sour flavour" and "sour aftertaste" with a positive correlation ($P<0.05$) with "sour flavour" ($R2 = 0.78$) and "sour aftertaste" ($R2 = 0.77$) and a negative correlation with "sweet flavour" ($R2 = 0.59$). Amongst the PUFAs, the total n-6 fatty acids is correlated positively with "sour flavour" ($R2 = 0.68$) and negatively to "sweet flavour" ($R2 = 0.6$). Finally the ratio n-6/n-3 was correlated positively ($R2 = 0.66$) with "bitter flavour". While a causative relationship has not been established, it is possible that higher levels of n-6 fatty acids, often associated with concentrate feeds, could be associated with increased oxidation of the lipids [21]. Analysis of volatiles compounds conducted for this experiment will help to clarify this possible association (data not available yet). These results are in accord with those reported for ham and lamb consumers. In an internal preference mapping study conducted by Pham [22] for dry-cured ham, the preferences of several consumer cluster groups, appeared to be closely related to "sweet" flavour and the dislikes of consumers appeared to be related to "chewiness", "fibrousnesses" and "hardness" of texture. Also, in external preference mapping conducted for Japanese and New Zealand lamb consumers [16], the preferences of both consumer groups were related to "sweet" flavour while "sour" flavour appeared in opposite direction. Even though these studies have been conducted on different meat products, it is interesting to note the similarity of the consumers' preferences between these studies and the present study conducted on beef steaks. It seems that these two flavour attributes, sweet and sour, have an important influence on the consumers' preference of meat products.

IV. CONCLUSION

Several texture and flavour attributes seem important in the consumers' preferences and dislikes for beef steaks. Internal preference mapping shows that attributes such as sweet flavour, tenderness, juicy and open appearance are related to the liking of beef steaks, while chewy, stringy texture, cardboard, sour aftertaste and connective tissue, oily appearance, are related with consumers' dislikes. External preference mapping showed the existence of relationships between some flavour attributes with PUFAs and total fat, and between WBSF and texture attributes. The identification of attributes affecting consumer acceptability of beef and the relationship of these attributes with pre and post slaughter factors, could permit to the meat industry to develop quality brands, identify new markets and reduce consumer complaints.

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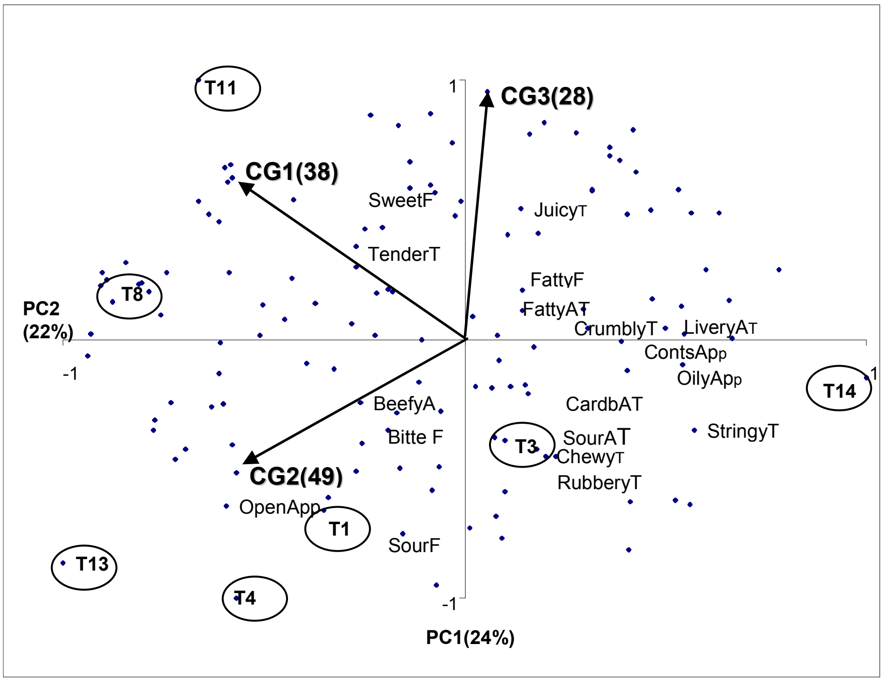
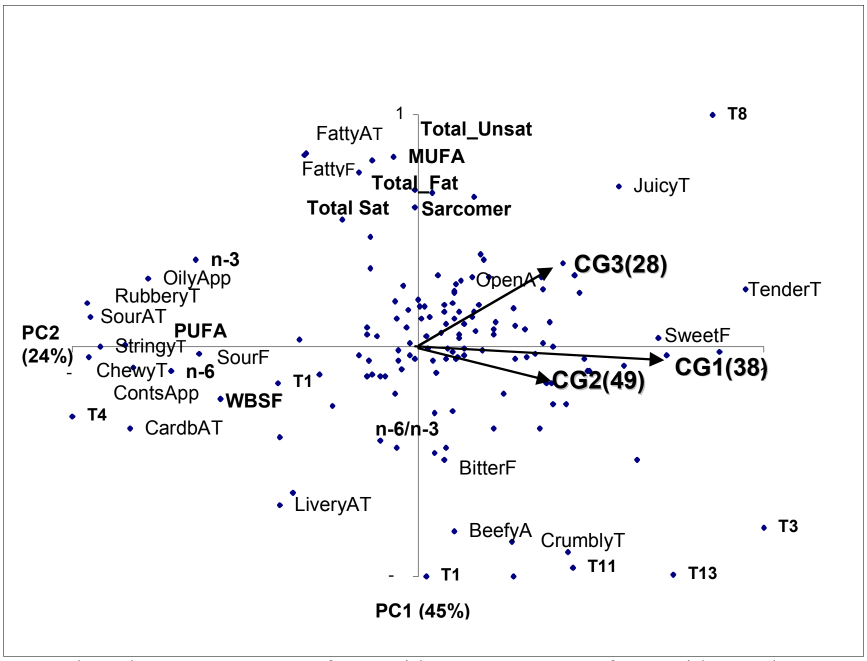
Figure 1. Internal preference mapping of *longissimus dorsi* grilled beef steaks for overall liking PC1/PC2 (46% of Variation)



● = consumers; ⟶ preference vector; T1, T3, T4, T8, T11, T13, T14 = treatments 1, 3, 4, 8, 11, 13, 14; CG1 to CG3 = cluster groups 1-3; A= aroma; App = appearance; T = texture; F = flavour; AT = aftertaste; ContsApp = connective tissue appearance; TenderT = Tenderness texture; CardboardAT = Cardboard aftertaste.

Figure 2. . External preference mapping of *longissimus dorsi* grilled beef steaks for overall liking PC1/PC2 (69% of Variation)



Sacomer = sarcomere length; n-3 = omega 3 fatty acid; n-6 = omega 6 fatty acid; TotalSat = total saturated fatty acids; Total_Unsat = total unsaturated fatty acids; MUFA = monounsaturated fatty acids; n-6/n-3 = ratio omega 6/omega3 fatty acids