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AUTHENTICATION AND PREFERENCE MAPPING OF HAM

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ABSTRACT

Effective connection between the food industry and consumer demands are specific needs of consumers whitch were monitored in this study by using a preferential mapping method. Preference mapping is based on Principal Component Analysis (PCA), which is performed on preferences ratings given for each product and preferences of each consumer through an online questionnaire. Key features for the consumer choice were colour, odour, consistency, total flavour and overall appearance. We verified the composition and mapped the preferences of 10 hams purchased in Slovakia. In view of the persistence of identified cases of food counterfeiting and meat fraud, intensive monitoring and scrutiny is required through effective and accurate analytical methods, which are crucial for maintaining consumer confidence and ensuring compliance with local legislation and labeling. The reference approach for identifying animal species in food is the PCR method, which is however limited to several animal species, meat types. The use of microarray technology enables the identification of a wider range of animal species and greater user comfort, especially the speed of obtaining the results. It allows 24 animal species to be identified in one analysis in 8 samples at a time. Detection was performed using Chipron LCD Aarray Kit Meat 5.0. In all analyzed samples, components of animal origin were identified in accordance on the packaging of the products. The Meat 5.0 LCD chip, which was used for analysis, has detected the presence of other animal species.

Keywords: ham; consumer preference; sensory; PCA; DNA; animal species

INTRODUCTION

Consumer perception of food quality is different and strongly dependent on personal preferences such as level of experience, cultural influences, demographic and physiological characteristics, product perception and quality expectations. It may be affected by several factors, e.g. brand origin, price, nutritional information and traditional technological processes **(Supeková, 2008)**.

In the overall quality of the meat, taste plays a major role, and therefore the presence of sensory defects and/or lack of typical taste significantly reduces its quality, causing financial losses for the dairy industry **(Engel et al., 2001)**. The evaluation of sensory attributes makes it possible to define the taste profile and consumer preferences for dairy products with innovative properties. Meat sensory profile analysis allows to identify specific attributes that could be preferential properties and evaluate the impact of health information on consumer preferences, expectations and choices **(Santillo and Albenzio, 2015)**. Large data sets are becoming increasingly common and often difficult to interpret. Principal Component Analysis (PCA) is a technique to reduce the size of such data sets, thereby increasing interpretability but at the same time information loss is minimized **(Jolliffe and Cadima, 2016)**.

Preferential mapping is a set of statistical methods aimed to detecting consumer preferences of the products being compared using sensory profiles. This method is used in the food industry to develop new products, especially according to consumer requirements **(Meullenet et al., 2007)**. Preferential mapping is carried out by trained evaluators to better understand consumer acceptability of products. Product placement on the market determines their usability **(MacFie, 2007)**. It is also a key management tool that is often used to optimize products by combining consumer and sensory data **(Greenhoff and MacFie, 1994)**. Consumer segmentation strategies aim to identify sectors of the population of consumers with different criteria of preferences **(Carbonell et al., 2007)**. Using a preferential map, it is possible to describe consumer preferences for a set of competing products from the sensory profiles of these products, based on a trained panel of evaluators. Preferential mapping refers to a group of multivariate statistical techniques that provide a comprehensive overview of both external and internal mapping. External preference mapping is based on multidimensional product display based on their

sensory profile or a set of other external data, such as instrumental analysis using electronic tongue, nose and eye. This result is usually obtained through Principal Component Analysis (PCA). However, with this technique, it is possible to reduce each consumer's hedonic assessment to a set of descriptive attributes **(Cadena et al., 2012)**. External mapping approaches are limited by the fact that the sensory space (i.e., multidimensional representation) is obtained only from external data without the preference of attributes based on their importance to consumers **(Meullenet et al., 2007)**. Internal preference mapping brings a multidimensional depiction of products and consumers. This representation is obtained by means of a PCA data matrix with products such as rows and consumers as columns. For that consumer, the data is based on from the hedonic score **(Greenhoff, MacFie, 1994)**.

Meat and meat products have a profound impact on human nutrition and hence on consumer health. Meat is a rich source of protein, containing all essential amino acids is a good source of iron, phosphorus, zinc, selenium, riboflavin, niacin, vitamin B6, vitamin B12, choline and others. Red meats such as beef, pork and mutton contain many essential nutrients essential for healthy growth and development in children. Red meat is one of the best sources of iron and zinc that is well absorbed in the body. Meat is also used as part of many foods and meat products **(Mansoor et al., 2015)**. Given the high commercial value, meat has attracted the attention of counterfeiters for centuries **(Barai et al., 1992)**. Identifying the origin of meat and meat products is an important issue for the prevention and detection of fraud that could have economic, ethical and health implications **(Bertolini et al., 2015)**. Currently, there are several methods capable of recognizing chicken, pork and beef, which are among the most consumed meats in the world. Various analytical techniques have been proposed that identify these meats either alone or in mixtures **(Hsieh, 2006; Günssen et al. 2006)**.

Hygiene and proper labeling on the label of food products are very important aspects in particular for public health. Food safety covers all precautions for food supply and ensuring health and hygiene conditions for consumers **(Özpinar et al., 2013)**. Adulteration detection is a demanding industry in the food industry. Active development of additives, as well as novel foods that have undergone significant changes in the food matrix, increase the demands for accuracy and reliability of analytical methods based on the identification of sensory, anatomical, morphological and histological differences in the detection of counterfeiting **(Yosef, 2014)**. Testing techniques are becoming faster, more accurate, more sensitive, more user-friendly, capable of detecting more than one species in one reaction **(İlhak and Arslan, 2007)**. These tests are also available as commercial test kits, are suitable for routine analysis due to their ease of use, speed and relatively low cost, but limited use for highly processed foods **(Montowska et al., 2014)**.

Scientific hypothesis

Hypothesis 1: To map the preferences of consumers of hams produced in Slovakia using the preferential mapping method.

Hypothesis 2: Verified the composition of 10 hams.

Hypothesis 3: Determine whether there is a link between consumer preferences and the composition of the product.

MATERIAL AND METHODOLOGY

Preference mapping

Internal mapping

Samples were prepared from 10 hams produced in Slovakia. Samples were served on white ceramic plates, coded with three-digit random numbers and served at temperature of consumption 20 ±2 °C. The evaluation was carried out in a standardized sensory laboratory **(ISO 8589, 2007)** built in the Slovak University of Agriculture in Nitra on Department of Food Safety and Hygiene. 13 assesors participated in the analyzes, who evaluated 10 ham samples. They evaluated the following sensory qualities: colour, odour, consistency, total flavour and overall appearance, which they could assign 1 – 9 points (1 – very bad and 9 – very good).

External mapping

External mapping (consumer survey) was conducted through an electronic questionnaire in which 140 respondents were addressed, from whom a statement on the products was requested. Their task was to organize the individual products according to their personal preferences (from 1 – best to 9 – worst).

Species identification

Ten samples were purchased in various retail networks. The identified animal species were compared to the product composition of the manufacturer. In the first step of the analysis, we used Maxwell 16 DNA Purification kit (Promega, Wisconsin, USA) to achieve optimal DNA purity obtained from the purchased products. A PCR product was generated from the isolated DNA using the Aarray Kit Meat 5.0 (Chipron, Berlin, Germany), which was verified by gel electrophoresis followed by the protocol of the Chipron LCD manufacturer Aarray Kit Meat 5.0, allowing 24 species (cattle, sheep, equine, goat, camel, water buffalo, pork, kangaroo, hare, rabbit, reindeer, roe deer, red deer, fallow deer, springbok, canine, cat, chicken, turkey, goose, ostrich, mallard duck, muscovy duck and pheasant) to be identified. We used instrumentation, scanner and software (SlideReader V12) designed and recommended by the manufacturer for evaluation.

Statistic analysis

XLSTAT statistical software (2019.1.1, Addinsoft) was used to process data from both internal, external evaluation and authentication. PCA (Principal Component Analysis) was used for internal data from sensory analysis and AHC (Agglomerative Hierarchical Clustering) for external data (questionaire). Preferential map was created by combining these two outputs. ANOVA was used to determine if there was a statistically significant difference between the samples.

RESULTS AND DISCUSSION

Table 1 show summary evaluation of sensory analysis. From the PCA (Figure 1) we can observe that three groups of samples have been specified. Samples 2, 4, 8, 9, and 10 show obtained a higher rating from samples in colou, odour, consistency, total flavor and overall appearance.

Table 1 Summary evaluation of sensory analysis.

Samples	Sensory qualities									
	Color		Odour		Consistency		Total flavour		Overall appearance	
	Average	Variance	Average	Variance	Average	Variance	Average	Variance	Average	Variance
1	6.2	2.40	5.7	5.57	6.1	5.43	5.3	6.23	5.4	5.82
2	6.8	2.18	7.1	0.77	6.7	2.68	6.4	2.71	6	4.89
3	5.8	2.84	4.8	5.29	5.7	6.01	5.1	4.99	5.2	4.40
4	7.1	1.88	6.8	5.29	6.9	2.99	7.5	2.06	7.1	3.21
5	6.3	3.12	5.5	0.72	6.4	5.82	5.8	2.40	5.4	2.71
6	6.1	4.32	5.3	2.68	5.7	5.79	4.8	3.73	5.5	3.61
7	6.3	2.23	5.8	3.07	6.5	2.28	5.8	1.51	6	2.22
8	6.7	2.68	6.5	1.61	6.8	3.73	6.7	1.79	6.6	2.49
9	6.8	2.62	6.3	5.12	7.1	3.66	7	3.33	7.2	2.62
10	7.3	1.57	7	3.33	7	1.33	6.6	4.27	6.5	4.94

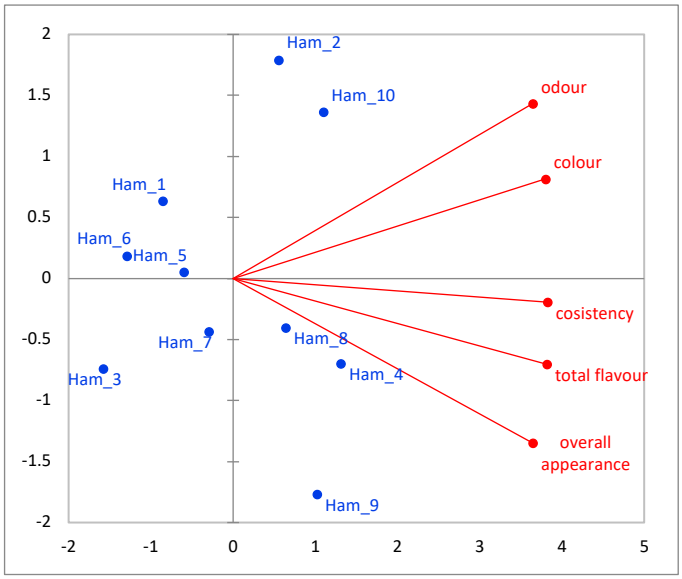

Figure 1 Evaluation using PCA.

The resulting processing of internal and external data is a map of preferences (Figure 2).

From the graphical representation of the results, we can conclude that sample 10 was placed in the highest consumer preference zone (80 – 100%) and samples 2, 4, 8 and 9 in the preference zone from 60 – 80% based on the characteristics of the surveyed products. Samples placed in the lowest consumer preference zone (0 – 40%) were 1, 3, 5, 6, 7 and recorded also lowest scores for overall appearance, odour, consistency, flavour and colour. The ANOVA test results show that there is a statistically significant difference between the samples (*p*-value = 0.033).

Our results are consistent with studies done abroad. These techniques have recently been applied to dulce de leche **(Gaze et al., 2015)**, ice cream **(Cadena, et al., 2012)**, apples **(Bonany et al., 2014)**, raspberries **(Villamor, et al., 2013)**, tomatoes **(Oltman, Yates and Drake, 2016)** and have shown that they provide a very good understanding of the attributes that lead to popularity among consumers.

DNA Microarray and Real Time PCR methods differentiate from each other in simultaneously detection of animal species in one reaction. The only common similarity between them is the step of DNA isolation. Microarray Analysis can enable us for detecting more than one species in one reaction only whereas Real Time PCR requires specially designed primers and probes needed to simultaneously amplify the specially selected regions of DNAs belonging to different species. This difference means longer time needed in the optimization step of primers and probes **(Myers et al., 2010)**. DNA Microarray can deliver the results faster and more sensitive using amplified DNA by conventional PCR technique **(Azuka et al., 2011)**. DNA Microarray makes possible the whole genome to be displayed on a chip and to express the interaction of thousands of genes with each other simultaneously **(Pereira, Carneiro and Amorim, 2008; Miller and Tang 2009)**.

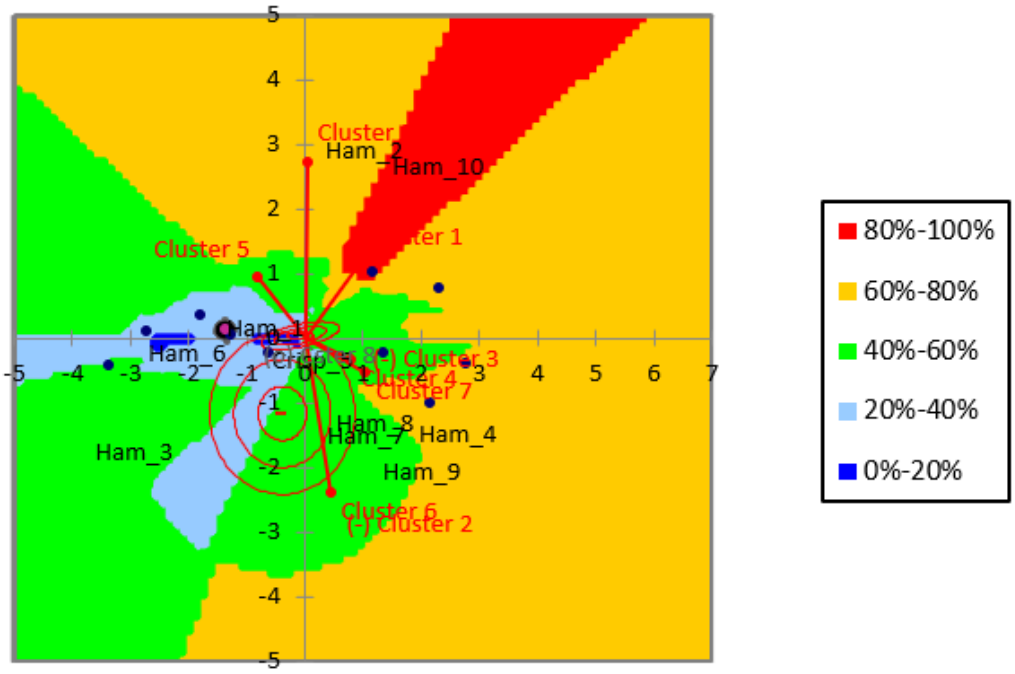

Figure 2 Preference mapping of hams.

Table 2 Composition of samples and species identification.

Sample	Fat (g)	Carbohydrates (g)	Protein (g)	Salt (g)	Meat content %	Cattle	Pork	Chicken	Turkey
1	9.0	1.0	20.0	2.75	96	-	X	-	-
2	2.0	1.0	20.0	2.5	96	-	X	-	-
3	3.0	1.0	20.0	2.5	96	-	X	-	-
4	4.1	<0.5	19.5	2.22	96	-	X	-	-
5	3.0	0.5	19.5	1.9	94	-	X	-	-
6	3.2	1.2	15.6	2.1	85	-	X	-	-
7	3.2	1.2	15.6	2.1	85	-	X	Y	Y
8	4.0	0.3	14.3	2.1	75	-	X	-	-
9	2.0	1.0	20.0	2.25	95	-	X	-	-
10	8.0	1.4	19.1	2.0	90	Y	X	-	-

Note: X – declared, Y – undeclared. - – not present

Table 2 shows the composition of the individual samples including the animal species identified in the samples. The analyzed sample set consisting of hams included samples with a declared single animal species on the product label. Based on the results obtained from ten samples, we collected three samples which contained DNA of another animal species. Eight products were in line with labeling and identified animal species.

Based on the EU recommendation **(European Commission, 2013)**, a detection threshold of 1% (w/w) was targeted. Our results are consistent with studies done abroad. In a study carried out in Turkey, 73 samples of meat and meat products sold in shops, markets and public bazaars located in different urban areas in Istanbul were analyzed. The study pointed to a number of disagreements with the label on the product label **(Özpinar et al., 2013)**. A study on meat processing revealed that the DNA fragment size was progressively degraded into smaller fragments with increase in duration of heating and temperature **(Şakalar et al., 2012)**. Species identification is important for legal authorities to detect undeclared ingredients in food products. When an undeclared species is detected, the next step is to discriminate between intentional substitution with cheaper meat or unintentional contamination during food preparation **(Cravero et al., 2019)**. DNA Microarray as a method has been widely preferred for understanding mechanisms, detection of foodborne microbial pathogens and food safety studies, nutreaceuticals and functional foods as well as following up the different expression levels of DNA in bacteria, yeasts, plants and human; genetic and mutation analyses; environmental studies; identification of antimicrobial genes, proteomics, protein-nucleic acids, protein-protein interactions, biochemical analysis of protein functions and drug development **(Bottero and Dalmasso, 2010; Kostrzynska and Bachand, 2006)**.

CONCLUSION

From the obtained results we can conclude that it is necessary to put emphasis on intensive control and management of technological steps in the production of meat products. In the analyzed samples, we captured 2 samples that did not conform to the label on the product label. DNA of other species was also detected in the samples. The presence of bovine and poultry DNA is explained by the fact that some manufacturers may have added bovine haemoglobin or poultry globin to improve product colour or it may be contamination. The results obtained are an incentive for further investigation and analysis.

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