Canonical correlation for characterize relation between sensory panel and electronic nose, using different bovine muscles

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Abstract

In recent years, consumers have demanded meat products that are safe, nutritious, convenient, rich in variety, attractive and innovative. Meat quality depends on organoleptic properties, such as color, texture, odors, flavor and juiciness. To characterize different muscles, odor and flavor parameters were determined. Muscle effects were observed for electronic nose and a sensory panel. Measurements of meat quality traits are traditionally determinate by sensory panel evaluation, which is complicated due to the interaction of physical and sensory processes. Sensory evaluations are labor intensive, time consuming and expensive. Volatile compounds released from foods are closely related to their aroma and can be determined to monitor their quality and safety. During cooking, thermally induced reactions occur resulting in the characteristic aroma of meat. Different artificial electronic nose devices have developed to discriminate complex vapor mixtures containing many different types of volatile organic compounds. These devices comprise several sensor types including metal oxide, semi conductive polymer, conductive electroactive polymers, optical, surface acoustics waves, and electrochemical gas sensors. The aim of the present research was to characterize the relation between, sensory panel and electronic nose in different bovine muscles. Each panel member evaluated two random cubes of each steak in a booth supplied with green light (ISO 8589, 1988). Panel members were provided with an evaluation form, salt free crackers and distilled water to rinse the palate. The description and the intensity off-flavors on a 9-point scale (0= none, 1=extremely slight off-flavor to 8= intense off-flavor). An electronic nose system α-PROMETHEUS (Alpha MOS, Toulouse, France) was used. The sensor array system (α -FOX 4000, France) contains eighteen metal oxide sensors: six LY ((LY2/AA, LY2/G, LY2/gCT, LY2/gCTI, LY2/Gh, LY2/LG); seven P (P10/1, P10/2, P30/1, P30/2, P40/1, P40/2, PA2) and five T (T30/1, T40/2, T40/1, TA2, T70/2)). Principal components analysis was applied on data to describe the relation between variables and their influence among muscles using the statistical software InfoStat. The relation between electronic nose data and aroma and beef flavor were also evaluated by Canonical Correlation procedure. One Canonical correlation could be sufficient to describe the relation between sensory panel and electronic noise.

Keywords: electronic nose, sensory panel, principal component, canonical correlation.

1. Introduction

The demand of meat consumption has increased, because the preferences of meat consumers are associated to their high nutritional value and sensory characteristics, primarily tenderness, juiciness, and flavour.

Meat quality depends on organoleptic properties, such as color, texture, flavor and juiciness, which are related to zoo technical characteristics such as breed, age and sex (Joo et al., 2013), anatomical characteristics such as type of muscle (Robinson et al., 2012) characteristics of handling and feeding (Montaño et al., 2014; Montanholi et al., 2013).

To characterize different muscles, odor and flavor parameters were determined. Muscle effects were observed for electronic nose and a sensory panel. Measurements of meat quality traits are traditionally determinate by sensory panel evaluation, which is complicated due to the interaction of physical and sensory processes. Sensory evaluations are labor intensive, time consuming and expensive (Sun et al., 2013).. Volatile compounds released from foods are closely related to their aroma and can be determined to monitor their quality and safety. During cooking, thermally induced reactions occur resulting in the characteristic aroma of meat. Different artificial electronic nose devices have developed to discriminate complex vapor mixtures containing many different types of volatile organic compounds. These devices comprise several sensor types including metal oxide, semi conductive polymer, conductive electroactive polymers, optical, surface acoustics waves, and electrochemical gas sensors (Grigioni et al., 2012). The aim of the present research was to characterize the relation between, sensory panel and electronic nose in different bovine muscles. Animals used in this study were females 10–12 months old, with a hot carcass weight (HCW) of 236 kg, and entire males 13–15 months old, HCW of 364 kg and a carcass classification value of U3. They were slaughtered in a commercial abattoir and processed according to the rules. Carcasses were weighed and classified, and pH was measured 45 min post mortem in Bovine Muscle: Semitendinous (ST), Gluteus Mediums (GM) and Psoas Major (PM). Each panel member evaluated two random cubes of each steak in a booth supplied with green light (ISO 8589, 1988). Panel members were provided with an evaluation form, salt free crackers and distilled water to rinse the palate. The description and the intensity off-flavors on a 9-point scale (0= none, 1=extremely slight off-flavor to 8= intense off-flavor). An electronic nose system α-PROMETHEUS (Alpha MOS, Toulouse, France) was used. The sensor array system (α -FOX 4000, France) contains eighteen metal oxide sensors: six LY ((LY2/AA, LY2/G, LY2/gCT, LY2/gCTI, LY2/Gh, LY2/LG); seven P (P10/1, P10/2, P30/1, P30/2, P40/1, P40/2, PA2) and five T (T30/1, T40/2, T40/1, TA2, T70/2)). Principal components analysis was applied on data to describe the relation between variables and their influence among muscles using the statistical software InfoStat 2014. The relation between electronic nose data and aroma and beef flavor were also evaluated by Canonical Correlation procedure. One Canonical correlation could be sufficient to describe the relation between sensory panel and electronic noise.

2. Material & Method

Slaughter and sampling

The animals used in this study were females 10–12 months old, with a hot carcass weight (HCW) of 236 kg, and entire males 13–15 months old, 364 kg HCW and a carcass classification value of U3. They were slaughtered in a commercial abattoir and processed according to the rules. Carcasses were weighed and classified by an official of the PGI, and pH was measured 45 min post mortem in Bovine Muscle: Semitendinosus (ST), Gluteus Mediums (GM) and Psoas Major (PM). Twenty-four hours post mortem the loin muscles were removed and cut into sample steaks (2.5-cm thick). Each steak was divided into two halves, by means of a cut parallel to the sagittal plane surface. Samples were deep frozen (under -30 °C) and preserved at -25 °C until assessment.

Sensory Panel

Steaks (2.5-cm thick) were cooked, allowed to thaw for 24 h at 4 °C. After thawing, steaks were weighed and were placed on aluminum-folded strips and cooked to an endpoint temperature of 71.5 ± 0.5 °C on an electric grill (Philips, CABA, Argentina).

After cooking, each steak was trimmed of fat and connective tissue, and the muscle section was cut into 1 cm^3 cubes and immediately served to an eight-member trained sensory panel (AMSA, 1995; Cross et al., 1978).

Each panel member evaluated two random cubes of each steak in a booth supplied with green light (ISO 8589, 1988). Panel members were provided with an evaluation form, salt free crackers and distilled water to rinse the palate. The samples were evaluated using a nine-point non-structured linear scale for juiciness (1=extremely dry, 9=extremely juicy), initial and sustained tenderness (1=extremely tough, 9=extremely tender), beef flavor (1=extremely bland, 9=extremely intense), aroma (1=extremely weak, 9=extremely intense) and amount of connective tissue (1=very much, 9=none). Panel also asked to report the description and the intensity off-flavors on a 9-point scale (0= none, 1=extremely slight off-flavor to 8= intense off-flavor).

Electronic Nose

An electronic nose system α-PROMETHEUS (Alpha MOS, Toulouse, France) was used. The sensor array system (α -FOX 4000, France) contains eighteen metal oxide sensors: six LY ((LY2/AA, LY2/G, LY2/gCT, LY2/gCTI, LY2/Gh, LY2/LG); seven P (P10/1, P10/2, P30/1, P30/2, P40/1, P40/2, PA2) and five T (T30/1, T40/2, T40/1, TA2, T70/2)).
P and T are metal oxide sensors. They are based on tin dioxide SnO_2 (n-type semiconductor), the difference between them resides in the geometry of the sensors. The LY sensors are metal oxide ones based on chromium titanium oxide (p-type semiconductor) and on tungsten oxide (n-type semiconductor). In the presence of a reducing gas, there is absorption with an electronic exchange of gas towards the sensors: the conductance of the n-type increase while for the p-type the resistance will increase, due that n-type are based on tin dioxide SnO_2 and p-type are based on chromium titanium oxide.

An electronic nose system must satisfy reproducibility, long term stability, identification capability and model robustness. In order to monitor these requirements, standardized chemicals aqueous solutions were analyzed. The used solutions were propanol (Aldrich®) 0.1%v/v, acetone (Aldrich®) 0.1%v/v and isopropanol (Aldrich®) 0.05%v/v; being all solutions prepared with HPLC degree water. Measurements were performed over a period of one week, the lapse of time needed to evaluate all samples. In each time of analysis, a total of 10 standards (i.e. three replicates with 1 ml of each standard plus one vial containing 1 ml of propanol, the first vial is not considered in the analysis) were analyzed following a pre-established procedure.

The analysis was defined as follows: during the acquisition process, samples were kept a 90 °C for 40 min while shaking at 500 rpm to reach the equilibrium in the headspace. The device was continuously purged with dry air (synthetic air N35, Air Liquid) set at 150 ml/min. The acquisition time was set at 120 s and the delay time (time elapsed between subsequent analyses) was 18 min. These experimental conditions ensured that each step during the acquisition was enough to establish a correct baseline to collect volatile compounds and to allow the recovery up of sensors between sample analyses. The maximal amplitude for sensors response curve was considered for analysis.

3. Statistical analysis

Exploratory data analysis was carried out to investigate the variable variation and correlation.

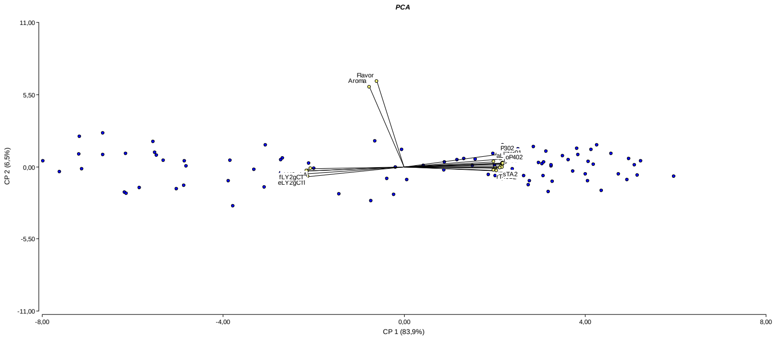
Principal Component Analysis (PCA) was applied to variable outcome from sensory panel and electronic nose, to reduce dimensions and to analyze the inherent structure of the data.

Canonical correlation analysis was applied for exploring the relationships between sensory panel variables and electronic nose variables.

4. Results

Principal Components Analysis was applied using the data obtained from sensory panel and electronic nose of ST, PM and GM. As it can be observed in Figure 1 two compounds were found accounting 90.4% of the total variation (PC1: 83.9%; PC2: 6.5%). The PC1 was related with variables measured by electronic nose and PC2 with sensory panel variables. The cophenetic correlation is 0,992

Figure 1.- Principal Component Biplot



The first canonical correlation, in Table 1, show R=0,65 and R^2=0,42 indicate that 42% of the data variability is explained by it. The hypothesis test based on the Lambda of Wilks with 36 degree of freedom, with a p-value <0,001 show that the first canonical correlation is different of zero, meanwhile the second is not.

Table 1 - Canonical Correlations

	L(1)	L(2)
R	0,65	0,52
R^2	0,42	0,27
Lambda	68,23	24,68
DF	36,00	17,00
p-value	9,4E-04	0,10

5. Conclusions

The two first principal component of variables measured by sensory panel and electronic nose explain the 90,4% of total variation contained in the data set.

One Canonical correlation could be sufficient to describe the relation between sensory panel and electronic nose.

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