# ANHTI02 – Instrumental Sensory Benchmarking

## Application to Sausages

### Objective

Competitive benchmarking, which consists of comparing one's products or processes to the leaders' ones, is a technique commonly employed by companies. This type of studies allows to position one's products in the market versus competitors and to give indications in order to improve, re-engineer or re-formulate products.
In this study, an Electronic Nose, an Electronic Tongue and an Electronic Eye were used to analyze and compare several brands of sausages. The objective was to get detailed sensory information about target competitive products with an aim to re-formulate an existing recipe by retro-engineering technique.

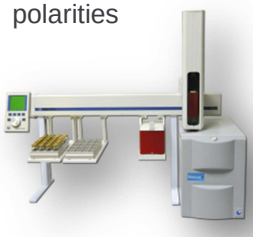
### Materials & Methods

#### Samples

Six batches of the company product were compared to two competitive brands of sausages.

#### E-Sensing Instruments

Tests on odor, taste and visual attributes were conducted respectively with HERACLES electronic nose, ASTREE electronic tongue and IRIS electronic eye (Alpha MOS, France).
The HERACLES is based on the technology of ultra fast chromatography, with two metal columns of different polarities (RXT-5 and RXT-1701, length = 10m, diameter = 180µm, Restek) in parallel and coupled to 2 Flame Ionization Detectors (FID). Two chromatograms are obtained simultaneously, allowing a sharper identification of the chemical compounds.



HERACLES
Electronic Nose

The integrated solid adsorbent trap thermo-regulated by Peltier cooler (0-260°C) achieves an efficient pre-concentration of light volatiles and shows a great sensitivity (in the pg range).
The electronic nose is coupled to an autosampler (HS 100, CTC Analytics) to automate sampling and injection. The analysis was conducted with headspace injection mode.
The HERACLES e-nose was additionally equipped with AroChembase module (Alpha MOS, France). It consists of a library of chemical compounds with name, formula, CAS number, molecular weight, Kovats retention Index, sensory attributes and related bibliography. It allows pre-screening the chemical compounds and giving sensory features by directly clicking on the chromatograms' peaks generated by HERACLES e-nose.

The ASTREE electronic tongue analyzes organic and inorganic compounds dissolved in liquids that are responsible for taste. The detection principle is based on a potentiometric measurement with seven ChemFET (Chemical modified Field Effect Transistor) sensors.

ASTREE
Electronic Tongue

Through a CCD camera, the IRIS analyzer achieves a detailed visual assessment of both color and shape parameters of the overall products or selected portions of these products.


IRIS Electronic Eye

Data acquisition and data processing was achieved with AlphaSoft software (Alpha MOS, France) for the three instruments.

The analytical parameters optimized for this analysis are described in table 1.

| HERACLES electronic nose parameters | |
|---|---|
| Sample mass | 40g of a blended sausage in a 100 mL vial |
| Headspace generation | 20 min at 50°C |
| Injected volume | 5 mL |
| Trap temperature | 40°C / 240°C (desorption) |
| Columns program | 40°C (2s) to 280°C (18s) by 3°C/s |
| FID temperature | 290°C |
| **ASTREE electronic tongue parameters** | |
| Sample preparation | 50g of sausage mixed with 250mL of deionised water. Decantation of the suspension. Filtering of the clear phase for analysis |
| Sample volume | 25 mL |
| Acquisition time | 120 s |
| **IRIS electronic eye parameters** | |
| 3 or 4 sausages of the same batch analyzed simultaneously | |

Table 1: Analytical parameters of the instruments

## Odor analysis

The comparison of the chromatograms obtained with HERACLES e-nose shows some significant differences between the flavor profiles of the three brands of sausages (Figure 1). Some volatile compounds are present only in one type of sausage. These volatile profiles variations are mostly linked to differences in flavors and spices contained in the different sausages, which explains the significant differences noticed upon tasting the products.

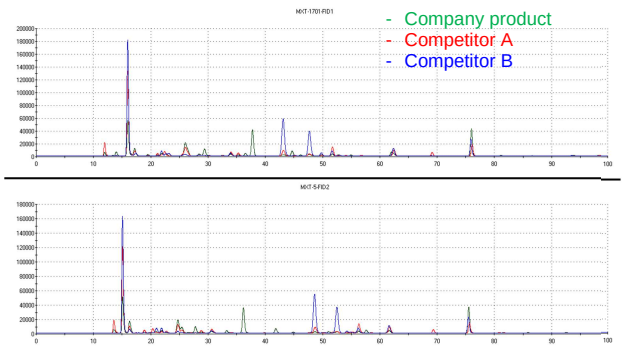



Figure 1. Superimposed chromatograms of the 3 brands of sausages, obtained with HERACLES e-nose

An odor map based on Principal Components Analysis (PCA) was generated based on all volatile compounds detected in the headspace of sausages (Figure 2).

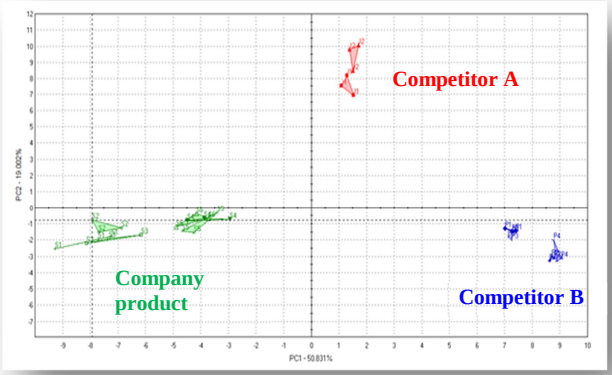



Figure 2: odor map of sausages based on Principal Components Analysis (PCA)

The 3 brands of sausages show very different odor profiles.
The company product batches show less reproducibility (samples more scattered) than the competitive products (competitive product A is the most reproducible).

The nature of the most discriminant volatile compounds involved in sausages flavor was investigated using their Kovats index and the AroChemBase database (Table 2). An important difference of flavor composition was observed between the company's sausages and the other brands. The presence of terpenes such as pinene, phellandrene, anethole and fenchone indicates that aromatic herbs or spices were added in the competitive products, either at higher concentration or of different qualities.

The most probable spice that corresponds to this different volatile profile observed in competitive products is fennel (Figure 3).

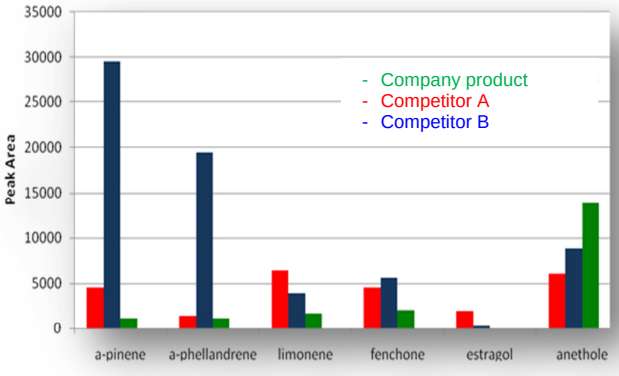



Figure 3. Concentration of various volatile compounds typical of fennel in the 3 brands of sausages

| K MXT-5 | K MXT-1701 | Possible matches | Odor | Competitor B | Competitor A | Company product |
|---|---|---|---|---|---|---|
| 385 | 387 | butane | - | | x | |
| 441 | 559 | ethanol | alcohol | x | x | x |
| 490 | 593 | acetone | fruity | | x | x |
| 584 | 689 | butan-2,3-dione | pineapple / buttery | | x | x |
| 599 | 681 | butan-2-one | cheese | x | | |
| 612 | 695 | ethyl acetate | fruity | x | | |
| 612 | 702 | 2-butanol | alcohol | x | | |
| 663 | 741 | 3-methyl butanal | green | | x | x |
| 698 | 744 | pentanal / 2,3-pentanedione | green / buttery | | | x |
| 733 | 845 | 3-methyl butanol | cheese | | x | x |
| 800 | 893 | hexanal | green / rancid | | | x |
| 867 | 979 | 1-hexanol | fruity | | | x |
| 948 | 959 | a-pinene | herbal | x | x | |
| 995 | 1017 | a-phellandrene / b-pinene | spice / terpeny | x | x | |
| 1042 | 1070 | limonene | woody / orange | x | x | |
| 1112 | 1215 | fenchone | anisic | x | x | |
| 1132 | 1215 | Limonene oxide | floral | x | x | |
| 1213 | 1311 | estragol (methyl chavicol) | anisic | | x | |
| 1306 | 1421 | anethole | anisic | x | x | x |

Table 2. Possible volatile compounds responsible for sausages' flavor

The volatile composition of a spice of natural origin can vary with the variety and origin. Three fennels of different origins were analyzed with HERACLES e-nose (Figure 4).

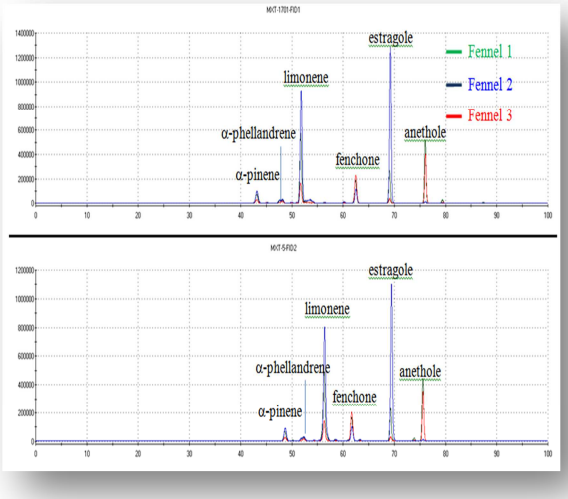



Figure 4. Chromatograms of 3 fennels of different origins

Among the 3 fennels investigated, one has a volatile profile closer to competitive product B, but globally all fennels show different proportions of the major compounds compared to the sausage odor profiles.

## Taste analysis

Based on ASTREE measurements, it can be observed that the 3 brands of sausages show very different taste profiles (Figure 5).
Product A is less reproducible than the 2 others in terms of taste.

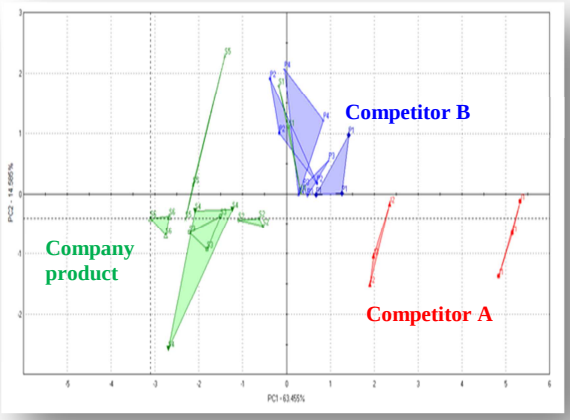



Figure 5. Taste map (Principal Components Analysis) of the 3 brands of sausages obtained with ASTREE e-tongue

The sensor set used for this study on ASTREE electronic tongue, combined with integrated software functionality allows to rank the samples according to taste attributes. Samples are scored on a 0 to 12 intensity scale.
The important and relevant taste attributes involved in sausages evaluation are sourness, saltiness, umami and sweetness.

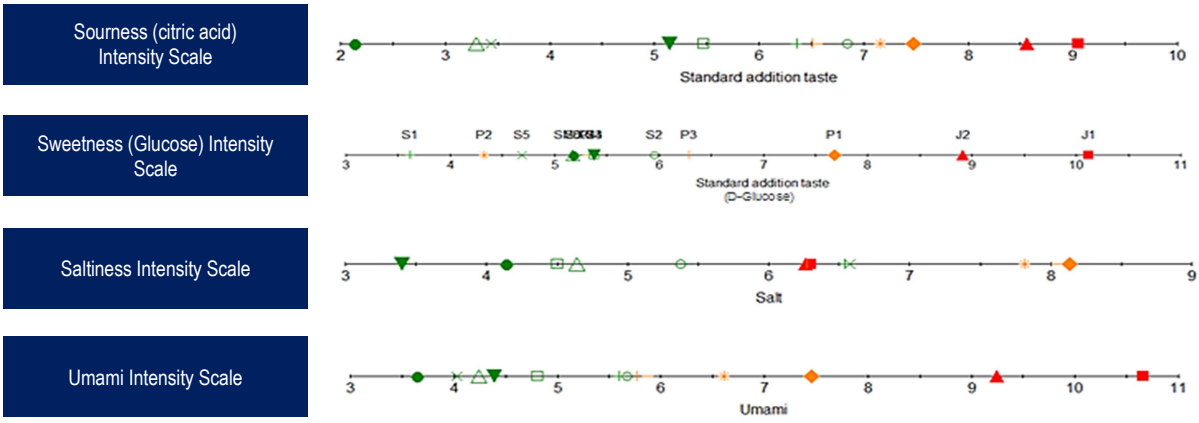
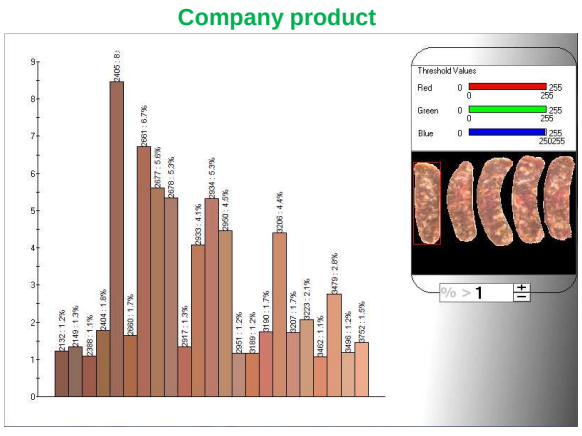



Figure 6. Ranking of sausages based on taste attributes, with ASTREE e-tongue

Compared to competitors' brands, the company products were found to be slightly less acidic, less sweet, less salty and less umami (Figure 6).

## Visual analysis

A visual characterization was performed with IRIS electronic eye, after calibrating the instrument with a certified color scale.
Indeed, the visual aspect, which is linked to the composition (fat content, colorant, spices...) is an important parameter for the sensory benchmarking of sausages since it influences the visual perception of consumers.
The analysis with IRIS instrument consists of taking a picture of the different samples. The pictures are then processed as a 4096 color spectrum, with the surface of each significant color calculated in percentage (Figure 7).
Various shades of brown to pink colors were observed, in different proportions according to the brand.



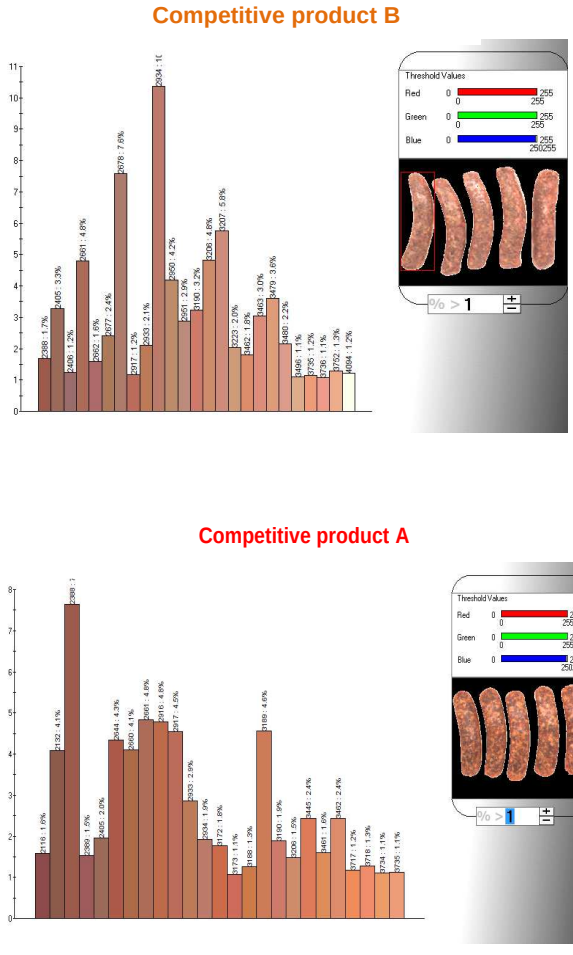




Figure 7. Color spectrum of the 3 brands of sausages obtained with IRIS system

To rapidly and easily compare the global visual aspect of the different sausages, the color and shape parameters measured with IRIS instrument were computed on a Principal Components Analysis model (Figure 8).

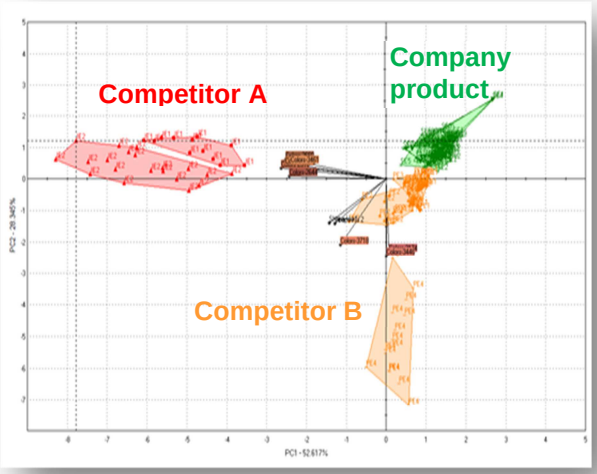



Figure 8. Principal Components Analysis model applied to color and shape parameters measured with IRIS on the sausages

The comparison of the visual profiles based on color and shape criteria shows a clear discrimination between the brands:

- The differentiation of the 3 brands is mostly correlated with brown colors intensity
- The company product is closer to competitor B, whereas competitor A is quite different
- Competitive product B is less reproducible than the others in terms of visual aspect since one batch is far from the others.

The same observations can be done on a Quality Control Card build up from a Statistical Quality Control (SQC) model with the company product taken as the reference quality (Figure 9).

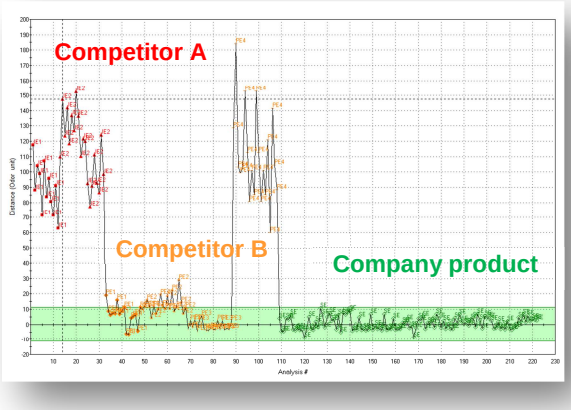



Figure 9. Visual Quality Control Card of sausages

Three batches of competitive product B are plotted inside the area of acceptable quality (green band) whereas the fourth batch is outside this area. The quality control card allows to rapidly decide whether the visual aspect of sausages is conform or not.

## Conclusion

This benchmarking study conducted on various brands of sausages with sensory analysis instruments (e-nose, e-tongue, e-eye) showed that the major differences were related to odor and flavor characteristics.

The taste of the sausages proved also to be well differentiated, especially on salty, sweet, umami and sour attributes.

Finally, the evaluation of the overall visual aspect highlighted significant differences in terms of colors and color distribution, as well as a high variability in the visual aspect of some products.