

Objective

Formulation and manufacturing process are key parameters in the sensory stability and quality (taste, odor, color, texture...) of processed cheese.

In this study, an Electronic Nose, an Electronic Tongue and an Electronic Eye were used to analyze various batches of processed cheese. The objectives were to evaluate and characterize the sensory differences induced by the process variability.



Materials & Methods

Samples

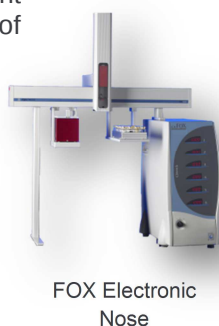
The samples consist of processed cheese that includes a mixture of Cheddar cheeses and some ingredients such as milk, milk proteins, preservative and colorant that contribute to the specific organoleptic properties of the product. They have an orange, yellowish color and a mild flavor.

Twelve batches of a same processed cheese were tested.

E-Sensing Instruments

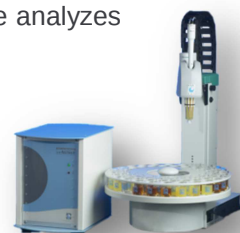
Tests on odor, taste and vision attributes were conducted respectively with FOX electronic nose, ASTREE electronic tongue and IRIS electronic eye (Alpha MOS, France).

The FOX instrument analyzes the headspace of the samples. It includes eighteen Metal Oxide Sensors that react to volatile compounds (change of electrical resistance) and measure the global odor fingerprint of products. It is further equipped with a HS100 autosampler (CTC Analytics, Switzerland) to automate sample incubation and injection.



FOX Electronic 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.

FOX electronic nose parameters	
Sample mass	4g in a 20 mL
Incubation temperature*	20 – 37 or 60°C
Incubation time	20min
Carrier gas	Synthetic dry air
Injected volume	2.5mL
Injection speed	2.5mL/s
Acquisition time	120 s
ASTREE electronic tongue parameters	
Sample preparation	25 g of cheddar in 100mL of water at 55°C. Mixing of the solutions for 20s. Removal of the lipid layer before the analysis
Sample volume	25 mL
Acquisition time	120 s
IRIS electronic eye parameters	
4 slices of the same batch analyzed simultaneously	

Table 1: Analytical parameters of the instruments

*For odor analysis, three headspace methods were tested to simulate different tasting conditions (20°C/37°C/60°C).

Odor analysis

The increase of sample incubation temperature accentuates the odor differences that can be observed between the various batches since more volatile compounds are released under an increasing temperature. In the odor map (Principal Components Analysis) shown at Fig. 1, batches 204 and 726 appear to be quite different from other samples; batches 658, 245 and 472 are also distinct; then the remaining batches present similar odor profiles.

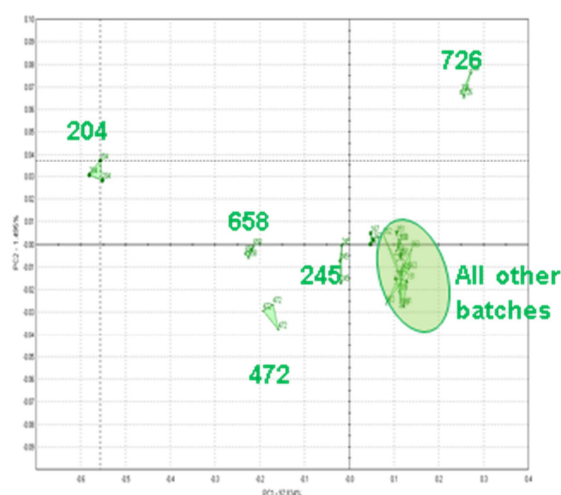


Figure 1. Cheddar slices odor map (Principal Components Analysis) at 60°C using FOX Electronic Nose

Taste Analysis

Based on ASTREE measurements, cheddar cheese solutions are discriminated following a taste direction along the x-axis on a Principal Components Analysis model (Fig. 2).

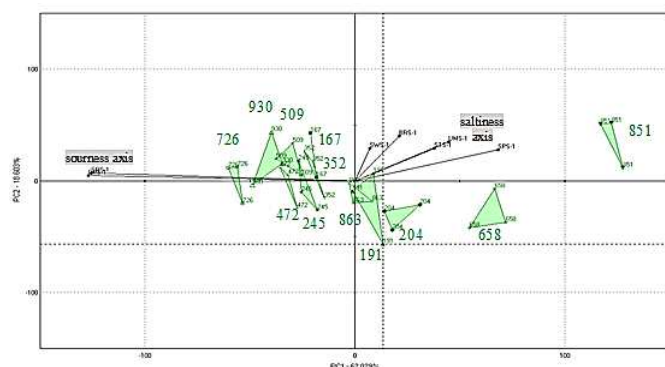


Figure 2. Taste map (Principal Components Analysis) of all cheese solutions obtained with ASTREE e-tongue

The sensor set used for this study on ASTREE electronic tongue, combined with integrated software functionality allows to rank the samples based on taste attributes. Samples are scored on a 0 to 12 scale.

Among the main taste attributes, sourness and saltiness are predominant in processed cheese taste.

The direct ranking of cheese samples obtained with ASTREE on saltiness and sourness scales showed that (table 3 and Fig. 4):

- Batch 851 has the highest sourness and saltiness levels compared to other batches
- Sourness is also important in batch 658, then 863 and 204
- Saltiness is homogeneous for all batches except batch 851.

Batch	Sourness score	Saltiness score
726	4	5
509	4	6
930	4	7
472	5	4
352	5	6
245	5	6
167	5	5
191	6	5
863	7	7
204	7	6
658	9	5
851	11	9

Table 3. Scores of sourness and saltiness of cheese batches determined with ASTREE electronic tongue

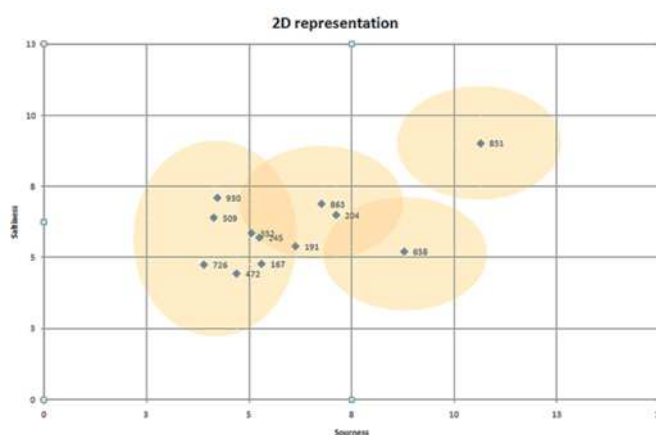


Figure 3. Taste graph of processed cheese solutions: Sourness intensity (x-axis) versus Saltiness intensity (y-axis) on Astree instrument

Visual analysis

A color characterization was performed with IRIS electronic eye, after calibrating the instrument with a certified color scale.

The color aspect is a non-negligible criterion in assessing the batch-to-batch variability since composition (cheddar mix, colorant, etc) and process may affect the color of the finished product.

The pictures taken with IRIS are decomposed in a 4096 color spectrum, with the surface of each significant color calculated in percentage (Fig. 4).

Various undertones of yellow and orange were observed.

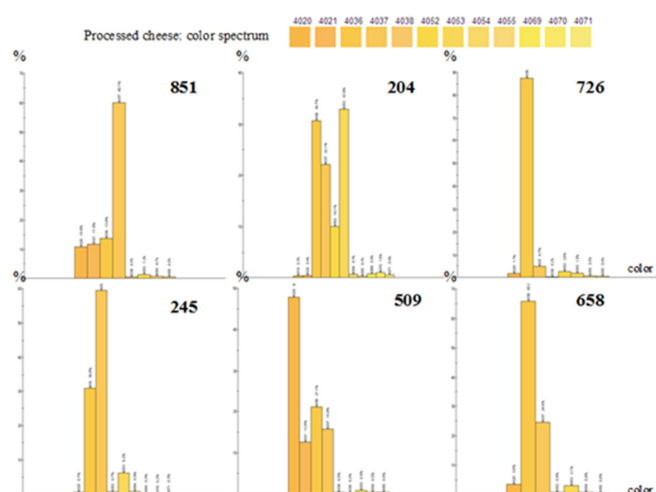


Figure 4. Color spectrum of 6 processed cheeses obtained with IRIS system

To rapidly and easily compare the global color of the cheese batches, the color parameters were computed on a Principal Components Analysis model (Fig. 5).

An important heterogeneity linked with orange color intensity was observed between the various samples. Two groups of batches could be distinguished based on their similarities: [191-658-726-863] and [167-245-472-851-930]. Batches 204, 352 and 509 showed different profiles.

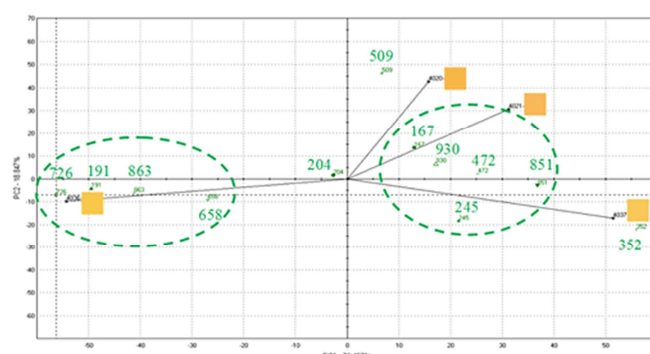


Figure 5. Principal Components Analysis (PCA) of processed cheeses based on IRIS color measurements

Combination of odor, taste and visual analyses

Upon building a Principal Components Analysis with the data of all instruments, four classes of cheese batches can be distinguished (Fig. 6). The differentiation of samples based on odor parameters is mainly observed on the x-axis, taste parameters on the y-axis, and visual parameters on both axes.

Batch 204 is far from all other samples. The important difference with other samples is mainly due to an odor difference (higher content in volatile compounds) highlighted by the electronic nose, but also to a predominant yellowish color compared to other samples. It contains a high proportion of volatile compounds and has also A second group of samples is composed of batches [191-863-658-245], close to batch 726 which constitutes a separate group. The last group includes batches [472-167-930-352-509-851].

The graph shows that odor is the main discriminant parameters of the various cheeses, whereas taste differences are weaker, except for batch 851 which has a taste significantly different. Color differences are also significant as seen in Fig. 5.

