Quantification, Benchmarking & Development
Application to Coffee & Caffeine

This application note presents results extracted from various studies requested by our customers.

Application Note

AT 05

Due to the stagnant growth of coffee consumption worldwide and the rapid increase in sales of beverages such as teas, infusions and milk-based beverages, coffee manufacturers need to differentiate their product lines with more original coffees. Developing new aroma and taste attributes of their coffees is playing an increasingly important role in finding new customers.

Even though traditional coffees continue to be appreciated, consumers are now asking for new varieties of gourmet coffees. They are looking for customized coffees to be used in making cappuccinos, lattes and mochas as well as a host of new flavors.

In order to successfully launch new coffees and to increase the overall consumption of coffee, developers of new coffee products need to compare them to competitive ones already on the market. But even more fundamental is their need to develop new products according to the consumer tastes.

Objective – Quantification, Benchmarking and Product Development

The following is an overview of three experiments conducted to evaluate the accuracy of the Alpha M.O.S. ASTREE Electronic Tongue in order to:

- compare instant coffees with others,
- quantify caffeine in instant coffees,
- measure the effect of milk and sugar on the bitterness of coffee.

Experimental Plan and System Conditions

System used for the study

The ASTREE Electronic Tongue uses an array of 7 sensors specifically designed for the food & beverage industry. These sensors perform global taste analyses similar to the human tongue's taste receptors.
The system also includes an auto-sampler and easy-to-use software for statistical data analysis.

Analytical Conditions

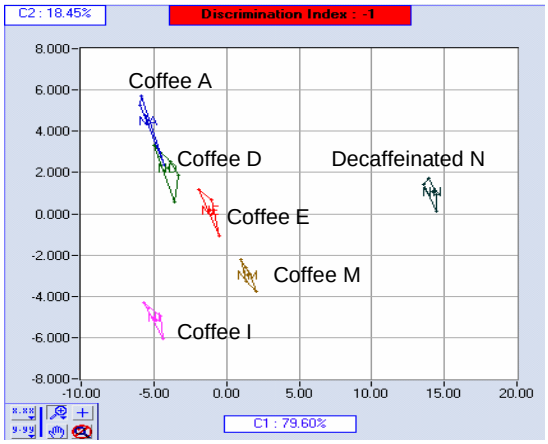
Sensor array N°1:	ZZ, BA, BB, CA, GA, HA, JB
Sample volume used	100 mL
Temperature	ambient
Time between analyses	180 sec
Acquisition time	120 sec
Rinsing Time	60 sec

Benchmarking

Objective:
Evaluate the ability of the ASTREE Electronic Tongue to compare various instant coffees.

Samples:
1.5g of each instant coffee was dissolved in 100 ml of cold distilled water. Six different regular instant coffees (A, D, E, I, M) and one decaffeinated variety (N) from various brands have been analyzed

Results:
The ASTREE Electronic Tongue is able to distinguish each instant coffee from each other even if instant coffee lacks aromatic volatile compounds causing a decrease in the overall flavor. The sample which was most differentiated was obviously the decaffeinated one.
The negative discrimination index (-1) is due to the overlapping of Coffee A and D, which are very close in character.



Principal Component Analysis (PCA)

As seen in the PCA graph, it is clear that the ASTREE Analyzer can easily compare coffees. The ASTREE provides a better understanding of competitive brands and makes it easier to optimize the taste of new coffees before product launching.

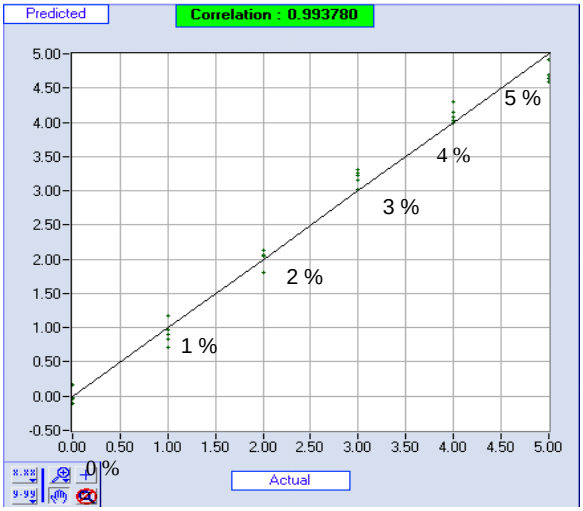
Quantification of caffeine

Objective:
To test the efficiency of the ASTREE Electronic tongue in quantifying the level of caffeine in various instant coffees and caffeine solutions.

Samples:
6 samples of instant coffees dissolved in water and 6 solutions of caffeine ranging in concentration from 0% to 5% were analyzed.

Instant coffees (1.5 g dissolved in 100 ml of cold distilled water)	Coffee A	
	Coffee D	
	Coffee E	
	Coffee I	
	Coffee M	
	Decaffeinated Coffee N	
Solutions of caffeine (in 100 ml of cold distilled water)	C = 0 %	0 mg
	C = 1 %	15 mg
	C = 2 %	30 mg
	C = 3 %	45 mg
	C = 4 %	60 mg
	C = 5 %	75 mg

Calibration Curve of Caffeine Solutions



Partial Least Square (PLS) of solutions of caffeine

Results:
As can be seen on the PLS graph, different solutions of caffeine are easily discriminated. A calibration curve has been obtained with very high correlation coefficient (99,37%).

It is clear that caffeine can be quantified with very accurate results and a mean RSD of 6%.

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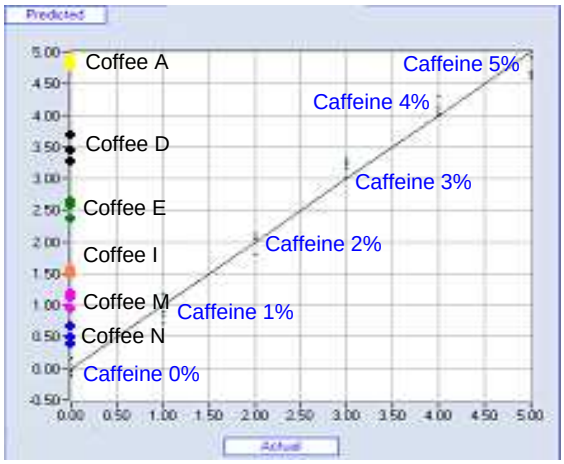
Prediction of Percentage of caffeine

The following graph shows the **projection** of various instant coffees on the calibration curve. **Predicted percentages** of caffeine are given in the following table.



Instant coffee	Mean of predicted values	SD	RSD %
A	4.808	0.22	4.6
D	3.578	0.17	4.9
E	2.578	0.11	4.2
I	1.682	0.11	6.6
M	1.106	0.09	8.4
N	0.502	0.11	22.0

SD: Standard Deviation
RSD: Residual Standard Deviation = SD/Mean *100

Results:

The ASTREE Electronic Tongue allows accurate quantification of the percentage of caffeine in a coffee. The standard deviation of predicted values is low (between 0.09 and 0.22) as is the RSD percentage (between 4.2% and 8.4%). The high RSD of decaffeinated coffee (22%) is due to the very low concentration of caffeine in Coffee N. It seems that this is the prediction limit of ASTREE.

ASTREE Electronic tongue is an excellent analytical instrument for rapid control of caffeine concentration in coffee. This is an excellent tool for coffee manufacturers as it gives them the ability to accurately quantify the percentage of caffeine in their products in order to compare them to competitive ones.

Coffee Taste and New Product Development

Objective

To evaluate the ability of the ASTREE Electronic Tongue to assess taste changes in Arabica or Caffeine-free coffee (Decaf) with the addition of milk and sugar.

In the following experiments, various samples are prepared:

- 100 ml of distilled water heated at 80°C and poured on coffee through a filter
- Addition of sugar / sucrose / aspartame to coffee
- Cooling samples to room temperature
- Addition of milk to coffee.

Discrimination of coffees

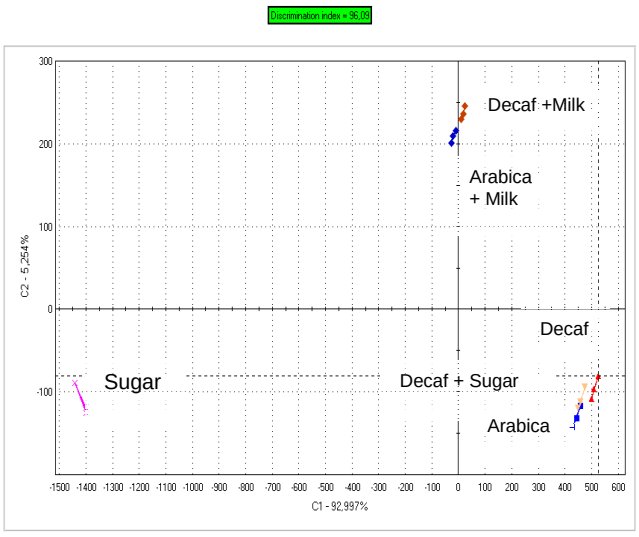
Samples:
6 mixtures have been tested

Names	Coffee	Sugar	Milk
Arabica	6 g coffee Arabica		
Arabica + Milk	6 g coffee Arabica		20mL
Decaf	6 g coffee Decaf		
Decaf + Milk	6 g coffee Decaf		20mL
Decaf + Sugar	6 g coffee Decaf	6g sugar	
Sugar		6g sugar	

Results:

The ASTREE System is able to discriminate all the samples. We note 3 groups:

- Pure sugar (on the left)
- Coffee + milk and Decaf + milk (on the top)
- Pure coffee, Decaf + sugar and Pure Decaf (on the bottom right).



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The Electronic Tongue can differentiate coffees even if they are mixed with sugar or milk.

Ranking According to Sweet Taste

Samples

Arabica has been compared to:

- 6 g Arabica + 6 g sugar
- 6 g Arabica + 0.08 g aspartame
- 6 g Arabica + 20 ml milk
- 6 g Arabica + 6 g sugar + 20 ml milk

Data treatment

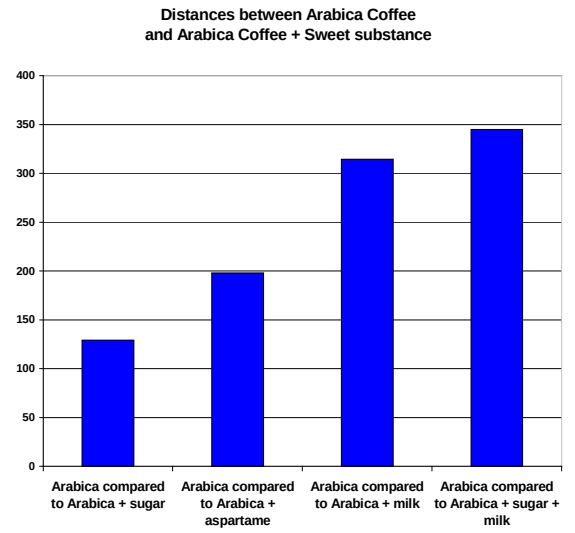
In order to be able to quantify the difference between coffee and coffee with sugar and/or milk, the software automatically computes euclidean distances between pure Arabica coffee and other samples. These distances are calculated thanks to the sensor raw data (potentiometric variation).

These euclidean distances are representative of difference between two samples.

Results

Arabica compared to **Arabica + sugar**	129.28
Arabica compared to **Arabica + aspartame**	198.08
Arabica compared to **Arabica + milk**	314.59
Arabica compared to **Arabica + sugar + milk**	345.05

Distances between pure Arabica coffee and Arabica coffee + sweet substance



The ASTREE Instrument ranks the coffee according to sweet taste. Thus, aspartame is sweeter than sugar since the difference between Arabica and Arabica with aspartame is larger (200) than with sugar (130). On the other hand, adding milk to coffee makes it sweeter than adding sugar or aspartame.

ASTREE permits the ranking of coffees according to their sweet taste.

Conclusion

Coffee manufacturers must anticipate competitive strategies and differentiate their offering with new and attractive coffees more closely allied to changing consumer tastes.

Alpha MOS instruments allow the benchmarking of various brands in terms of percentage of caffeine, the quantification of caffeine and the testing of coffee bitterness. The system is also effective in ranking coffees with milk, sugar or aspartame added and with different sugar concentrations. It therefore helps manufacturers speed up the development process.

The ASTREE system offers greater speed than traditional analytical techniques
thanks to its global analysis of products. The speed of analysis offers the
opportunity to test a larger number of coffees in a shorter time.

DASTEC S.R.L.
Representantes / Distribuidores Exclusivos
Buenos Aires, Argentina
Tel.: (54-11) 5352-2500
E-mail: info@dastecsrl.com.ar
Web: www.dastecsrl.com.ar

Alpha MOS France
20 avenue Didier Daurat
31400 Toulouse – France
Ph: +33 5 62 47 53 80
info@alpha-mos.com

Alpha MOS America
7502 Connelley Drive, Suite 110
Hanover, MD 21076-1705 – USA
Ph: (410) 553-9736
amusa@alpha-mos.com

Alpha MOS China
Suite 705A, Xin Da Tower
#322 Xian Xia Road
Shanghai, P. R. China, 200336
Ph: 86 (0) 21 6208 1655
asia@alpha-mos.com

Alpha MOS Japan
Jowa Takanawa Bld. Minato-ku 8F
1-5-4 Takanawa
Tokyo 108-0074 - Japan
Ph: +81-3-5475-3291
japan@alpha-mos.com

www.alpha-mos.com