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DELEGATE MANUAL

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Application of an electronic tongue to detect gliadins in gluten-free foods

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Celiac disease is an autoimmune-mediated disorder triggered in genetically susceptible individuals by the ingestion of some gluten proteins, namely gliadins. To prevent inadvertent gluten consumption, the Commission Regulation (EC) Nº41/2009 will implement labelling foods as "gluten-free" or "low-gluten content"[1].

The feasibility of an all-solid-state potentiometric electronic tongue to detect the contamination of "gluten-free" foodstuffs with gliadins was evaluated. The device was constituted by 36 cross-sensibility lipo/polymeric membranes and its performance was assessed using food ethanolic extracts (Figure 1).

A semi-quantitative linear discriminant (LDA) model was established based on the signal patterns of 11 polymeric membranes. The model was able to distinguish between "Gluten-free" extracts (<10 ppm gliadins), "Low-Gluten content" extracts (20-50 ppm gliadins) and "Gluten-containing" extracts (>50 ppm gliadins), with sensibilities of 100% and 77% for the original grouped cases and "leaving one-out" cross-validation, respectively (Figure 2). The device sensitivity was towards 1-2 ppm.

The device was also applied to discriminate between "gluten-free" and "gluten-containing" foodstuffs (flours, baby milked flours, breads, cookies and breakfast cereals), being the label information checked by HPLC-DAD analysis. In this case, the LDA was based on the signals of only 4 polymeric membranes. The model allowed to classify correctly 89% and 84%, for the original grouped cases and "leaving one-out" cross-validation procedures, respectively, which is very satisfactory taking in account the higher complexity due to the food matrix effect. Furthermore, only one of the "Gluten-containing" foodstuffs (a bread sample) was misclassified by the model as "Gluten-free". This misclassification could be tentatively due to an additional difficulty in the gliadins extraction from bread, which is a more processed food matrix.

Finally, the work carried out showed that the E-tongue device could be used in practice as a fast and economic preliminary tool to evaluate, in a real time basis, the possible gluten contaminations of "Gluten-free" foodstuffs.

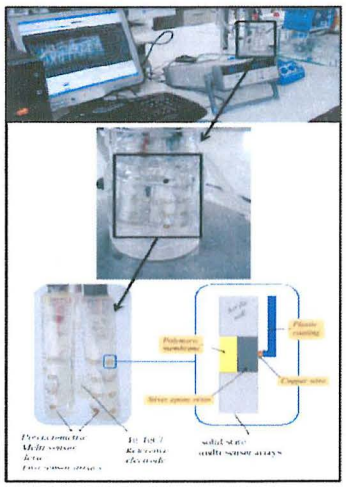

Fig. 1: Experimental set-up: electronic tongue

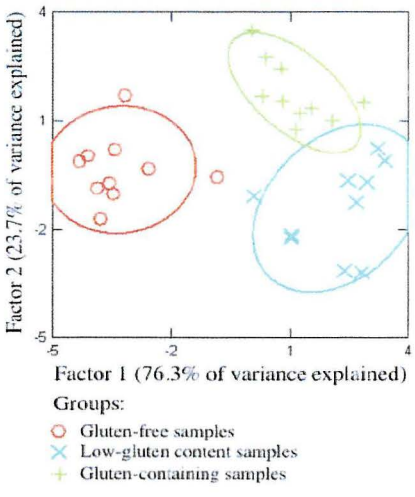

Fig. 2: Linear discriminant analysis classification based on the signal profiles recorded by the electronic tongue.

References

[1] Commission Regulation (EC) Nº41/2009 of 20 January 2009 concerning the composition and labelling of foodstuffs suitable for people intolerant to gluten, Official Journal of the European Union of 21.1.2009, L 16/3-L 16/5.

Keywords: Gliadins, Electronic Tongue, Linear discriminant analysis, Celiac disease

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OBJECTIVES

Foodstuffs analysed – To apply an all-solid-state potentiometric electronic tongue to detect the contamination of "gluten-free" foodstuffs with gliadins.

A) To differentiate three groups of a foodstuff with ≠ gliadin contents:
- "Gluten-free" extracts (<10ppm gliadins)
- "Low-Gluten content" extracts (20-50ppm gliadins)
- "Gluten-containing" extracts (>50ppm gliadins)

B) To differentiate two foodstuffs groups:
- "Gluten-free" extract of foodstuffs
- "Gluten-containing" extract of foodstuffs

Using LINEAR DISCRIMINANT ANALYSIS (LDA)

SAMPLES

15 commercially available foodstuffs:

Flours, baby milked flours, breads, cookies and breakfast cereals
- 8 labelled as "Gluten-containing"
- 7 as "Gluten-free"

GLIADINS EXTRACTS: using 70% ethanolic solution

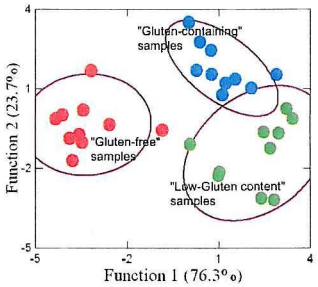
GLIADIN PROTEINS LEVELS: confirmed by HPLC

RESULTS

A) LDA classification model using the signal patterns of 11 polymeric membranes.

Original grouped cases
100% correct classification

"Leaving one-out" cross-validation procedure
77% correct classification

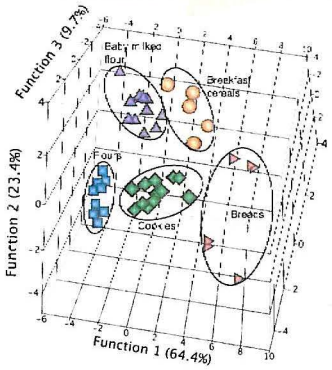


B) LDA model based on the signals of only 4 polymeric membranes.

Original grouped cases
89% correct classification

"Leaving one-out" cross-validation procedure
84% correct classification

LDA model, was able to successfully differentiate 5 different kinds of foodstuffs regardless their gluten level.



CONCLUSIONS

Very satisfactory classifications taking in account the high complexity due to the food matrix effect. The E-tongue device could be used in practice as a fast and economic preliminary tool to evaluate, in a real time basis, the possible gluten contaminations of "Gluten-free" foodstuffs.

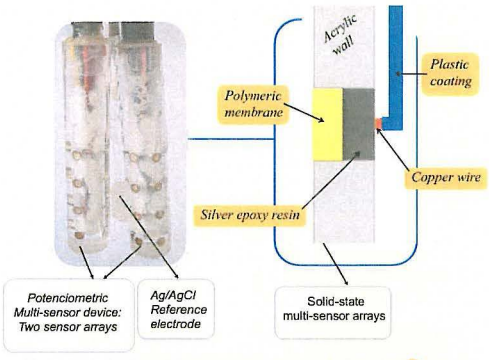
EQUIPMENT AND SENSORS

Multi-sensor system:
1- PC for data acquisition;
2- DataLogger Agilent;
3- E-tongue device in a double glass cell thermostatized;
4- Magnetic stirrer;
5- Thermostatic bath.

Additives and plasticizers used for polymeric membranes preparation

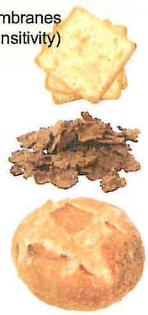
Membrane Additive substance	Plasticizer substance
[1] Octadecylamine	[A] Bis(2-ethylhexyl)phthalate
[2] Bis(2-ethylhexyl)phosphate	[B] Bis(1-butylpentyl) adipate
[3] Oleyl alcohol	[C] Tris(2-ethylhexyl)phosphate
[4] Methyltrioctylammonium chloride	[D] Dibutyl sebacate
[5] Tridodecylmethylammonium chloride	[E] 2-Nitrophenyl-octylether
[6] Oleic acid	[F] Dioctyl phenylphosphonate

Each membrane: 31.9-32.3% of PVC
64.7-65.2% of one of the plasticizers
2.8-3.2% of one of the membrane additives



E-tongue device: 36 lipo/polymeric membranes (non-specific, low selectivity and cross-sensitivity)

ELECTRONIC TONGUE
New methodology
Faster
Low cost
Quite reliable



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