Pet Food Industry: E-nose and E-tongue Technology for Quality Control

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***Abstract* — The objective of this idea is to set up an electronic nose (e-nose) and tongue (e-tongue) as rapid quality control and research & development tools for the pet food industry. The final goal is to integrate e-nose and e-tongue with other sensing and imaging devices to 1) ensure high pet food standards in terms of nutritional properties, palatability and acceptability; 2) set up an instrumental protocol with good correlation to animal sensory properties in order to replace animal preference test, chemical and texture analysis.**

Keywords-pet food; palatability; electronic nose; electronic tongue.

I. INTRODUCTION

The pet food industry offers a wide range of products to satisfy pet's and owner's requirements. In pet food production, the development of new products must take into account both nutritional and palatability aspects. Pet food palatability is related to the pet food sensory properties, such as aroma, flavour, texture shape, and particle size [1]. Pet food formulation is one of the factors affecting its aromatic profile that is strictly associated with palatability and acceptability. Sensorial analysis of pet foods may be conducted by using several hedonic and analytical methods (Fig. 1) [2].

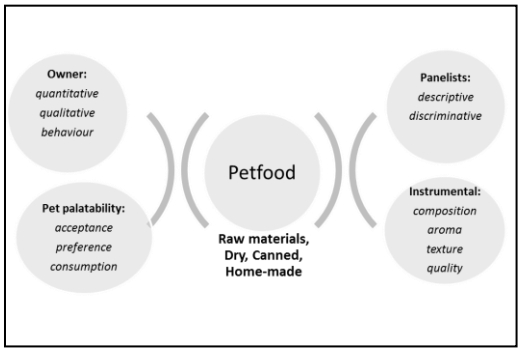

Figure 1. Pet food sensory analysis research methods.

Although taste and olfactory perceptions are not completely similar, dogs and cats use both taste and smell in food detection and selection [1][3]. Besides ingredient composition, pet food palatability may be affected by the use of palatability enhancers and food processing. Microbial growth, oxidation, and the presence of undesirable compounds and contaminants represent risk factors responsible of changes in aroma, flavours, and loss of palatability [4]. At the industry level, adoption of a rapid, low-cost, high-throughput and on-line analytical approach is needed at all stages of pet food production and processing in order to guarantee and standardize the quality of the production.

The objective of this idea is to set up an integrated e-nose and e-tongue technology as a rapid quality control and research & development tool for the pet food industry. To develop the idea, a step by step procedure must be designed: knowledge of e-nose and e-tongue characteristics and applications in the pet food industry, proper selection of an appropriate e-nose and e-tongue system for the specific application, and analysis of the pet food industry requirements.

II. THE ELECTRONIC NOSE AND ELECTRONIC TONGUE

The electronic nose (e-nose) is an instrument which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern recognition system, capable of recognizing simple or complex volatile organic compounds' (VOCs) patterns associated to a product odour. Researches have correlated VOCs to the sensory properties of a product; therefore, VOCs' profiles can be used for sensory characterisation and palatability evaluation of pet food [4]. The electronic tongue (e-tongue) has been developed in the last decade to evaluate the taste of liquid media. The common principle of the different e-tongue technologies is the application of an array of non-specific chemical sensors with high cross-sensitivity. To analyse results, similar pattern recognition techniques are needed for both the e-nose and e-tongue.

In literature, the applications of the e-nose and e-tongue in pet food analysis are very scarce. This could be attributed to the need to tune either the hardware and/or software to a specific application, or because data are kept confidentially by the product developers. E-nose associated or not with e-tongue has been used in studies for the standardization of a product development process, and in the quality control of the finished product [5]-[9]. In a study carried out in our department on commercial dry complete and dietetic dog and cat pet food, the e-nose was able to discriminate samples, although not completely, according to the species (dog *vs* cat), to the pet food formula (complete and balanced *vs* dietetic). Interestingly, e-nose was able to discriminate complete pet food for puppies or adult dogs (Fig. 2) [9].

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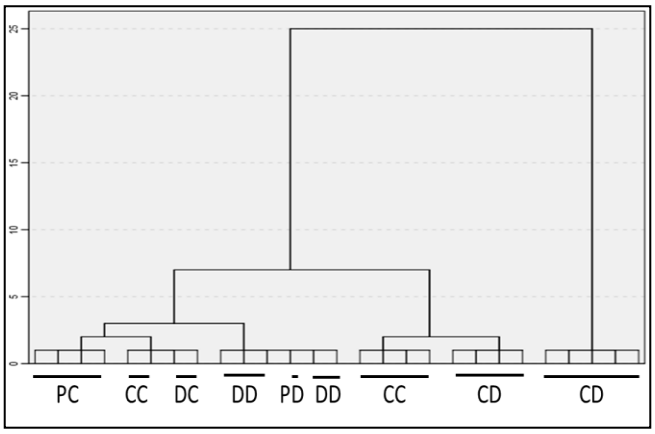

Figure 2. E-nose for dry pet food analysis (PC: puppy complete; DD: dog complete; CC: cat complete; PD: puppy dietetic; DD: dog dietetic CD: cat dietetic) (adapted from [9]).

In a study on commercial canned dog and cat pet food, similar results have been reported, with no complete discrimination obtained with e-nose analysis. A combination of e-nose and e-tongue determined a better discrimination between samples [7].

Although inconsistent results have been reported, e-nose and e-tongue may represent rapid and sensitive instrumental techniques for pet food evaluation. However, to represent an effective tool for a rapid quality control and research & development in the pet food industry, the analytical platform still needs several improvements, such as the definition of the best sensors' array, the development of data fusion analysis systems, and a better understanding of the industrial needs. The final aim of this idea is to develop an analytical sensory platform able to ensure high pet food standards in terms of nutritional properties, palatability and acceptability. The development of an instrumental protocol with good correlation to animal sensory properties could replace animal preference test, and chemical and texture analysis.

III. E-NOSE AND E-TONGUE IN AN INTEGRATED SYSTEM FOR PET FOOD EVALUATION

Domestic dogs and cats have different nutritional requirements and feeding behaviours, are sensitive to numerous palatability drivers, and differ in the food characteristics that they find desirable. Cats are strongly affected by the aroma of a food, and carefully smell a new food before tasting it. Dogs often prefer foods that are high in fat and include protein from animal sources. For both dogs and cats, the texture, size, and shape of food pieces are important aspects; scientists who study palatability refer to this as "mouth feel". Therefore, e-nose and e-tongue should be integrated in an instrumental platform to develop the full potential of an electronic sense analysis of pet food. Multi-sensor data fusion is an available technology capable of combining information from several sources in order to form a unified picture that can be used as a "finger print" of a product. A practical and general data fusion system model capable of handling data from various applications must be established on the basis of feature extraction. The final goal is to create a high-level fusion, namely decision-making fusion, able to analyse the features from each analytical system first, and then to associate these features to produce a fused result.

A. Set the e-nose and e-tongue for the specific application

A proper selection of an appropriate e-nose and e-tongue system for a particular application must involve an evaluation on a case-by-case basis. E-nose and e-tongue selection for a particular application must necessarily include: the assessment of the selectivity and the sensitivity range of individual sensor arrays for a particular target VOCs (i.e., related to the target organoleptic properties of the products), the number of unnecessary (redundancy) sensors with similar sensitivities, as well as sensor accuracy, reproducibility, response speed, recovery rate, robustness, and overall performance. Most of these steps are common points in a validation procedure. New ways to improve e-nose and e-tongue performance, through the use of better or more target-specific sensors, pattern-recognition algorithms, and data analysis methods will significantly amplify the range of applications of e-noses and e-tongue in the pet food industry.

B. An eye on the pet food industry requirements

According to The European Pet Food Industry Federation (FEDIAF), quality and safety, nutritional balance and palatability, variety and value for money, pet owner demands, and convenience are the important elements for pets and their owners. Feed material selection, processing, production techniques for canned or dry products, and final product quality and palatability control represent the critical processing points, which need and may take advantage from a real-time monitoring by the use of e-nose and/or e-tongue.

TABLE 1. PET FOOD INDUSTRY: E-NOSE AND E-TONGUE FOR RESEARCH & DEVELOPMENT.

Main topics	**Application areas**
Palatants	flavour profile of new palatants for pets and identifications of key aromas and taste attributes
Palatability	Replace animal preference test, chemical and texture analysis
Brand	Characterisation of a quality brand

Besides quality control, e-nose and e-tongue may be used for research & development purposes in the pet food. Regarding this point, several hot topics may be suggested (Table 1).

IV. CONCLUSION

The pet food industry may take advantage of an appropriate e-nose and e-tongue system as a powerful tool for both quality control and research & development purposes. Future work is needed on the materials' side (sensors' array), on the data analysis side (better modelling, development of data fusion analysis for the process control

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system for a continuous quality assurance), and on the industrial side (better understanding of the industrial needs related to quality control and monitoring of food processing). Moreover, to develop the full potential of an electronic sense analysis of pet food, e-nose and e-tongue could be integrated in an instrumental platform including electronic sensors for colour, texture, size, and shape evaluation. Once properly set, this platform could replace animal preference test, chemical and texture analysis to assess pet food palatability.

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