PhD DISSERTATION PROJECTS

**Rapid analytical assessment of aroma and visual quality on food products of animal origin**

Mara Antonia Gagliano (maraantonia.gagliano@unibo.it)

Dept. of Agricultural and Food Sciences, *Alma Mater Studiorum* - Università di Bologna, Cesena, Italy

Tutor: Prof. Enrico Valli; co-tutors: Dr. Francesca Soglia, Prof. Francesca Patrignani

This PhD research project aims to characterize food products of animal origin (namely poultry and beef meat, dairy products and honey) and assess their quality by sensory and instrumental analytical approaches. More specifically, the main activities will be focused on the evaluation of the aromatic profile and visual aspects by developing and applying rapid, non-destructive and user-friendly analytical techniques, with the final goal to investigate the effect of the farming system, as well as the contribution of the origin, on the quality traits of food products of animal origin.

Valutazione rapida analitica dell'aroma e della qualità visiva dei prodotti alimentari di origine animale

Questo progetto di ricerca di dottorato si propone di caratterizzare alimenti di origine animale (carni avicole e bovine, prodotti lattiero-caseari e miele) mediante analisi di tipo sensoriale e strumentale. In particolare, la valutazione del profilo aromatico e della qualità visiva, mediante la messa a punto ed applicazione di determinazioni analitiche rapide, non distruttive e di facile impiego, rappresenteranno il focus principale del progetto di dottorato, con l'obiettivo finale di indagare l'effetto del sistema di allevamento, nonché l'origine, sui tratti qualitativi e microbiologici dei prodotti alimentari di origine animale.

# **1. State-of-the-Art**

Generally, descriptive sensory tests for food quality evaluation are conducted by trained panels with expert assessors. Although this approach is among the most commonly used it shows various disadvantages, such as being time-consuming and expensive (Chiofalo *et al*., 2017). In this regard, in recent years, human sense perception has been combined with “artificial senses”-based instruments, which have been applied in the food industry for e.g., quality control, freshness and maturity monitoring, shelf-life study and authenticity evaluations. Such equipment may show many advantages, such as being rapid, efficient, low cost and non-destructive, as well as more and more environmentally sustainable (Ali *et al*., 2020). Novel artificial sensing devices, such as e-noses and e-tongues based on hybrid or electronic sensors, are being investigated. The electronic nose usually comprises nonselective sensors that interact with volatile molecules; upon interaction, a signal, constituting a sort of fingerprint of the smells, is produced and used to identify the odour through comparison with a reference library of previously obtained measurements of known samples (Calvini *et al*., 2022). The electronic nose has been used to assess the quality of meat products (Munekata *et al*., 2023), verify the authenticity of Parmigiano-Reggiano (Chiofalo *et al*., 2017), and identify the botanical origin and evaluate the quality of honey (Huang *et al*., 2015). In addition to sensors-based e-nose, other analytical techniques are used for the determination of volatile organic compounds (VOCs), such as solid-phase microextraction with gas chromatography coupled with mass spectrometry (SPME-GC-MS), also associated with multivariate statistical analysis (Calvini *et al*., 2022) or flash gas chromatography (Wang *et al.,* 2022). Another rapid non-destructive instrument is the computer vision system (CVS) (also called as “electronic eye”), which consists of an illumination device, a camera, and a computer with a high-resolution monitor. CVS applications are mainly used for those food products for which appearance is among the main key quality attributes evaluated by consumers (Chiofalo *et al*., 2017). In fact, CVSs can be effectively used for classifying food products into specific grades, detecting visual defects and estimating properties such as colour, shape, size, surface defects and contamination; examples on food products of animal origin are the estimation of fat content in poultry products (Chmiel *et al*., 2011), the prediction of colour grade in beef meat (Sun *et al.*, 2011) and the characterization of several types of honey with different botanical origin (Shafiee *et al*., 2014). Especially, it is relevant to ascertain the eventual effects of farming systems and origin on the main quality traits and composition of meat and dairy products (El-Deek *et al*., 2016). Given the above, the application of instrumental analysis also to corroborate the results obtained by sensory analysis may be of particular interest. In this framework, the research activities of this PhD project will be focused on investigating the effect of the farming system, as well as the contribution of the origin, on the quality traits of different food products of animal origin. To achieve this goal, rapid analytical techniques to evaluate the aroma and the visual quality of such food products will be developed and implemented. In addition, the findings obtained by these methods will be combined with those obtained by conventional instrumental approaches, as well as both descriptive and affective sensory tests, and microbiological analyses. This PhD thesis is part of Alma Idea 2022 project INARIM and European project H2020 INTAQT (INnovative Tools for Assessment and Authentication of chicken meat, beef and dairy products’ QualiTies).

# **2. PhD Thesis Objectives and Milestones**

The aim of this PhD project is to assess the quality of different food products of animal origin (namely poultry and beef meat, dairy products, and honey), with a focus on the evaluation of the aromatic profile and visual aspects, through the development and subsequent application of rapid, non-destructive and easy-to-use analytical approaches to investigate the effect of the farming system, as well as the contribution of the botanical origin. Also, some microbiological aspects will be considered. In addition, since these do not require the use of reagents or solvents, they can be considered environmentally and operator health friendly, thus representing a sustainability advantage over other conventional analytical approaches. The project implementation will require the future following activities reported in the Gantt diagram below (Table 1).

**A1) Bibliographic research:** research in the literature on the image analysis, the assessment of aromatic profile of food products of animal origin, as well as sensory analysis.

**A2) Aroma and visual analysis of food products of animal origin:** HS-Flash GC, SPME-GC-MS and electronic eye to characterize food products (dairy and meat products, and honey).

**A3) Sensory evaluation of food products of animal origin:** descriptive analysis(e.g., QDA®, Flash Profile, etc.) of cheese, milk and meat, as well as consumer tests on cheese and meat.

**A4) Microbiological analysis of food products of animal origin:**microbiological analysis on food products of animal origin, including cheese.

**A5) Statistical analysis:** univariate and multivariate analysis. Joint statistical analyses of the results obtained from sensory, microbiological tests and instrumental analysis.

**A6) Writing** of the oral and/or poster communications, scientific papers and PhD final thesis.

***Table 1***Gantt diagram for the future activities of this PhD thesis project.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Activity Months | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| A1) | ***Bibliographic research***  |   |   |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
| A2) | ***Aroma and visual analysis***  |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |   |  |   |   |   |  |  |  |  |
|  | 1) Set up of the analytical methods |   |   |   |  |  |  |  |   |   |  |  |  |  |   |   |  |  |  |   |   |  |  |  |  |
|  | 2) Methods application on food products |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |   |  |   |   |   |  |  |  |  |
| A3) | ***Sensory evaluation on food products*** |   |  |   |   |   |   |  |   |   |   |   |   |  |   |  |  |  |  |   |   |   |   |   |  |
|  | 1) Descriptive analysis  |   |  |   |   |   |  |  |   |   |   |   |  |  |   |  |  |  |  |   |   |   |   |  |  |
|  | 2) Consumer test  |   |  |   |  |  |   |  |   |   |  |  |   |  |   |  |  |  |  |   |   |  |  |   |  |
| A4) | ***Microbiological analysis*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Statistical analysis*** |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
|  | 1) Data elaboration |   |  |   |  |  |   |   |   |   |  |  |   |   |   |  |  |  |  |   |   |  |  |   |   |
|  | 2) Univariate and multivariate approaches |   |  |   |  |  |  |  |   |   |  |  |  |  |   |  |  |  |  |   |   |  |  |  |  |
| A6) | ***Thesis and Paper Preparation*** |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |  |   |   |   |   |   |   |   |

# **3. Selected References**

Ali MM, Hashim N, Abd Aziz S, Lasekan O (2020) Principles and recent advances in electronic nose for quality inspection of agricultural and food products, *Trends Food Sci. Technol.* **99**: 1-10.

Calvini R, Pigani, L (2022) Toward the development of combined artificial sensing systems for food quality evaluation: A review on the application of data fusion of electronic noses, electronic tongues and electronic eyes, *Sensors***22**: 577.

Chmiel M, Slowinski M, Dasiewicz K, Florowski T (2016) Use of computer vision system (CVS) for detection of PSE pork meat obtained from m. semimembranosus, *LWT - Food Sci. Technol.* **65**: 532-536.

Di Rosa AR, Leone F, Cheli F, Chiofalo V (2017) Fusion of electronic nose, electronic tongue and computer vision for animal source food authentication and quality assessment–A review, *J. Food Eng.* **210**: 62-75.

El-Deek A, El-Sabrout K (2019) Behaviour and meat quality of chicken under different housing systems, *Worlds Poult Sci J.* **75**(1): 105-114.

Huang X, Xu H, Wu L, Dai H, Yao L, Han F (2016) A data fusion detection method for fish freshness based on computer vision and near-infrared spectroscopy, *Anal. Methods* **8**: 2929-2935.

Munekata PES, Finardi S, de Souza CK, Meinert C, Pateiro M, Hoffmann TG, Domínguez R, Bertoli SL, Kumar M, Lorenzo JM (2023) Applications of Electronic Nose, Electronic Eye and Electronic Tongue in Quality, Safety and Shelf Life of Meat and Meat Products: A Review, *Sensors* **23**: 672.

Shafiee S, Minaei S, Moghaddam-Charkari N, Barzegar M (2014) Honey characterization using computer vision system and artificial neural networks, *Food Chem.* **159**: 143-150.

Sun X, Chen K, Berg EP, Magolski, JD (2011) Predicting fresh beef colour gradesing machine vision imagine and support vector machine (SVM) analysis, *J. Animal Veterinary Adv.* **10**: 1504-1511.

Wang J, Chen L, Liu Y, Olajide TM, Jiang Y, Cao, W (2022) Identification of key aroma-active compounds in beef tallow varieties using flash GC electronic nose and GC× GC-TOF/MS, *Eur Food Res Technol*. **248**: 1733-1747.