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Metabolomics to investigate the effects of treatments on food and of food consumption on health

Qiuyu Lan (email: Qiuyu.lan@unibo.it)
Dipartimento di Scienze e Tecnologie Agro-Alimentari, *Alma Mater Studiorum* - Università di Bologna
Tutor: Prof. Luca Laghi Co-tutor: Prof. Fausto Gardini

The study aims to investigate consequences of a wide spectrum of food transformation approaches and observe their effects on food metabolites profile for verifying the quality of food and, in turn, the possible consequences of food consumption on health.

State of the art

With the growing demand for healthy and convenient foods, innovative technologies could be applied in processing and storage, to produce high quality food, by replacing or integrating thermal treatments or traditional processing technologies. These are non-thermal physical technologies: pulsed light, dielectric barrier discharge (DBD), pulsed electric field (PEF), high hydrostatic pressures (HHP). The mentioned approaches could be applied to optimize microorganisms' profiles or to affect food composition. To investigate the overall effects of these approaches on the characteristics of food, it is possible to focus the attention on its metabolome, shading light on the metabolism of its cells and of its microorganisms.

Metabolomics, the study of the metabolome, could come handy also when considering a second key aspect of food treatments design, represented by the consequences of food consumption on human body. In fact, while it is accepted that the diet has a significant impact on a living creature health, the complete set of small molecule metabolites present in foods that make up the human diet and the role of food production systems in altering food metabolome are still largely unknown. Whether fresh or processed, just packaged, or nearing the expiration date, the foods we eat undergo continuous changes in chemical, biochemical, and physical characteristics. These changes in food metabolites directly affect food characteristics, what has implications on human health (Johanningsmeier, et al., 2016).

Proton high-resolution nuclear magnetic resonance (^{1}H-NMR) is one of the election analytical platforms for metabolomics investigation. This is because of easy sample preparation and reproducibility in the quantification of metabolites, inherent in the nature of NMR spectroscopy (Emwas, et al., 2019). As an example of the potentialities of ^{1}H-NMR, Elenilson *et al.* (2016) evaluated the effect of atmospheric cold plasma and ozone treatments in orange juice by ^{1}H-NMR and chemometric analysis. They found the ^{1}H-NMR was a valuable tool because the data were obtained quickly and provided comprehensive and quantitative information on the variation of the organic compounds of orange juice.

Interaction of food with human body upon eating could be affected by food structure, as it has been shown, for example, in the case of carnosine from cured meat along digestion (Marcolini, et al., 2015). To obtain valuable pieces of information on food structure, time-domain nuclear magnetic resonance (TD-NMR) has been found convenient, especially when the existence of structures leads to water compartmentalization. This has been largely employed, for example, to assess meat suitability for transformation (Baldi, et al., 2017).

PhD Thesis Objectives and Milestones

This PhD thesis project can be subdivided into the following activities according to the Gantt diagram given in Table 1:

A1) Literature review (A1.1) about latest researchers related to investigating the effects of stress conditions on the physiological response and metabolism of food-related microorganisms and experimental design (A1.2).

A2) Set up and apply specific NMR SOP (Standard operation procedures).

A3) Metabolomics-oriented experiments focusing on the consequences on food composition with treatments. I will read papers to select the most appropriate foods to investigate (A3.1), then investigate the changes of metabolites with treatments (A3.2).

A4) Metabolomics-oriented experiments focusing on the relationship between food composition and health. to assess the changes of metabolites during processing (A4.1) and the relationship between food composition and health (A4.2).

A5) Writing and publishing the doctoral thesis, posters, scientific articles, and oral presentations.

Activity	Months	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
A1)	Literature review and Experimental design																		
	1) preliminary studies in metabolomics																		
	2) experiment design																		
A2)	Set up and apply specific NMR SOP																		
A3)	Experiments focusing on the metabolites of food under treatments																		
	1) read papers to select the most appropriate foods to investigate																		
	2) assessments of the changes of metabolites with treatments																		
A4)	Experiments focusing on the metabolites and health																		
	1) assessments of the changes of metabolites during processing																		
	2) assesssments of the relationship between food composition and health																		
A5)	To write and publish the doctoral thesis																		

Selected References

Baldi G, Soglia F, Mazzoni M, et al. (2017) *Implications of white striping and spaghetti meat abnormalities on meat quality and histological features in broilers*. Animal, 12:164–173.

Emwas AH, Roy R, McKay RT, et al. (2019) *NMR Spectroscopy for Metabolomics Research*, Metabolites, 9:7123.

Johanningsmeier SD, Harris GK, Klevorn CM. (2016) *Metabolomic Technologies for Improving the Quality of Food: Practice and Promise*, Annual Review of Food Science and Technology, 7:413–438.

Marcolini, E, Babini, E, Bordoni, A, et al. (2015) *Bioaccessibility of the Bioactive Peptide Carnosine during in Vitro Digestion of Cured Beef Meat*. Journal of Agricultural and Food Chemistry, 63:4973–4978.