JOURNAL OF PROTEOMICS XX (2013) XXX–XXX

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Review

Biomarker discovery and applications for foods and beverages: Proteomics to nanoproteomics ☆

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ARTICLE INFO

Article history:
Received 4 January 2013
Accepted 1 April 2013

Keywords:
Beverage
Biomarker
Food
Nanoproteomics
Nanotechnology
Translational proteomics

ABSTRACT

Foods and beverages have been at the heart of our society for centuries, sustaining humankind — health, life, and the pleasures that go with it. The more we grow and develop as a civilization, the more we feel the need to know about the food we eat and beverages we drink. Moreover, with an ever increasing demand for food due to the growing human population food security remains a major concern. Food safety is another growing concern as the consumers prefer varied foods and beverages that are not only traded nationally but also globally. The 21st century science and technology is at a new high, especially in the field of biological sciences. The availability of genome sequences and associated high-throughput sensitive technologies means that foods are being analyzed at various levels. For example and in particular, high-throughput omics approaches are being applied to develop suitable biomarkers for foods and beverages and their applications in addressing quality, technology, authenticity, and safety issues. Proteomics are one of those technologies that are increasingly being utilized to profile expressed proteins in different foods and beverages. Acquired knowledge and protein information have now been translated to address safety of foods and beverages. Very recently, the power of proteomic technology has been integrated with another highly sensitive and miniaturized technology called nanotechnology, yielding a new term nanoproteomics. Nanoproteomics offer a real-time multiplexed analysis performed in a miniaturized assay, with low-sample consumption and high sensitivity. To name a few, nanomaterials – quantum dots, gold nanoparticles, carbon nanotubes, and

Abbreviations: CFU, colony forming unit; CLA, conjugated linoleic acid; CPLL, combinatorial peptide ligand library; DLDI, direct laser desorption ionization mass spectroscopy; GEPIs, genetically engineered proteins for inorganics; HPLC, high-performance liquid chromatography; MALDI-MS, matrix-assisted laser desorption/ionization-time-of-flight mass spectrometry; MS/MS, tandem mass spectrometry; PBMCs, peripheral blood mononuclear cells; PCA, principal component analysis; PR, polyphenol rich; ROS, reactive oxygen species; SAW, surface acoustic wave; SERS, surface enhanced Raman spectroscopy; SPR, surface plasmon resonance; 2-DGE, two-dimensional gel electrophoresis; QCM, quartz crystal microbalance

☆ This article is part of a Special Issue entitled: Translational plant proteomics.

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1874-3919/$ – see front matter © 2013 Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.jprot.2013.04.014

nanowires – have demonstrated potential to overcome the challenges of sensitivity faced by proteomics for biomarker detection, discovery, and application. In this review, we will discuss the importance of biomarker discovery and applications for foods and beverages, the contribution of proteomic technology in this process, and a shift towards nanoproteomics to suitably address associated issues.
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Contents

1. Introduction

The combination of various omics technologies, system biology, applied to specific nutrients or other dietary factors will greatly facilitate the discovery of new biomarkers. A recent discipline that has emerged applying the advanced omics technologies to human health and well-being is 'foodomics' [1]. The field is directed towards preventing future diseases through adequate food intakes, nutraceuticals, and functional foods [2]. Indeed, foodomics is a multi-faceted approach that tackles the biological complexity of the sample under investigation from several perspectives: from the genome (nutrigenomics) to the transcriptome (nutritranscriptomics), proteome (nutriproteomics), and metabolome (nutraceuticals), followed by introduction of a mathematical and statistical modeling in order to interpret biological phenomena in light of high-throughput results (nutranteractomics) [3] (Fig. 1).

Nutrigenomics builds the scientific foundation for understanding the variability in diet preferences, nutritional requirements, and responses to a certain diet among different humans and human populations. It may become the future tools for consumer assessment motivated by personalized nutritional counseling for health maintenance and disease prevention. Nutriproteomics plays a central role in nutrigenomics, which attempts to holistically understand how a genome may differentially be expressed as a response to one diet to another. From a molecular perspective, nutritional proteomics allow to discover and quantify biomarkers and bioactives with proteins being the key actors in virtually all biological processes in the human body. Finally, metabolomics represents one founding pillar of foodomics [4,5] since metabolism is often considered to be 'one-step closer to the phenotype' in comparison to the other omics, in that protein expression is not necessarily tied to enzymatic activity, owing to the tuning effect of posttranslational modifications (PTMs) and, above all, phosphorylation [6]. Clearly, holistic and integrative approaches are therefore primordial.

Food-derived proteins and peptides provide much more than basic macronutrients and building blocks for protein turnover. Bioactive proteins and peptides are a large and significant class of nutraceuticals that can be isolated, purified, and characterized

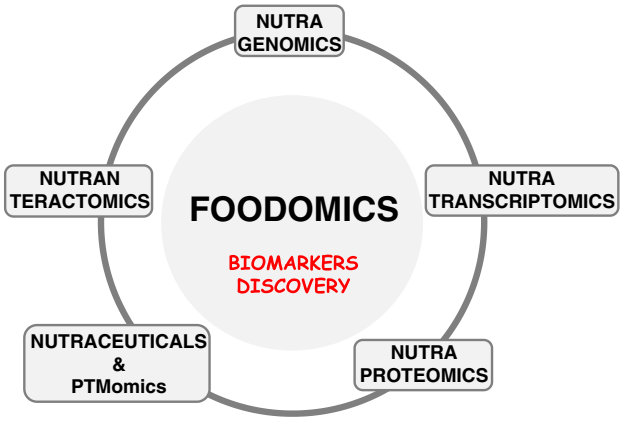

Fig. 1 – The clash of the "foodomics" — a system-oriented biology.

Please cite this article as: Agrawal GK, et al, Biomarker discovery and applications for foods and beverages: Proteomics to nanoproteomics, J Prot (2013), http://dx.doi.org/10.1016/j.jprot.2013.04.014