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Prospects of Nanoproteomics for Plant-Based Foods

RAVI SHUKLA[1,2], GANESH KUMAR AGRAWAL[3], and RANDEEP RAKWAL[4]

[1]Biotechnology Research Laboratory, School of Science, Rmit University, Melbourne Vic, Australia.
[2]Center for Advanced Materials & Industrial Chemistry, Rmit University, Melbourne Vic, Australia.
[3]Global Research Arch for Developing Education (Grade) Academy Pvt. Ltd., Birgunj, Nepal.
[4]Faculty of Health and Sport Sciences, University of Tsukuba, Tennodai, Tsukuba, Ibaraki, Japan.

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Plant-Based Food and Food Security

Food contributes substantially to the physical wellbeing of mankind and plays a pivotal role in the global economy. Food choices from plants have dominated ever since we evolved, and plant-based foods and beverages have been a critical contributor to the health, life, and happiness of our society. However, our rapidly growing population necessitates ensuring food security for every human being on the planet. Food security in its strict sense implies the availability of a sufficient amount of quality food to every individual to meet his or her dietary needs and to lead an active healthy life. There has been an increased focus in recent years on assurance of food quality and safety encompassing scrutiny of food for its composition, traceability, adulteration, and contamination. In fact, food safety and security have become a founding principle for two of the sustainable development goals (SDG) for the 2030 global agenda of the United Nations Department of Economic and Social Affairs. Therefore, the mandate of food security and safety necessitates that the quantity and quality of plant-based, healthy food be improved and rigorously analysed. The traditional methods to address food quality mainly rely on appearance, freshness, source, sanitation, microbial counts, and biochemical parameters for the composition (lipid, carbohydrate, protein, or vitamin content), etc. Recently, traceability in food production and distribution has gained considerable importance drawing significant public attention and awareness due to the accidental or deliberate food adulteration malpractices, and the controversies related to genetically modified (GM) crops in foods.

CONTACT Ravi Shukla ravi.shukla@rmit.edu.au Biotechnology Research Laboratory, School of Science, Rmit University, Melbourne Vic, Australia.

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THE '-*OMICS*' PERSPECTIVE TOWARD FOOD

There is no doubt that the science of plant-based foods is highly multidisciplinary in nature and strives for the amalgamation of advanced '-*OMICS*' technologies with the traditional knowledge in the areas of plant breeding, bio-physicochemical nature of foods, and the principles of food storage and processing. The advanced '-*OMICS*' technologies hold great promise to address the issues related to food security and safety by increasing not only our understanding of food at the level of the gene, protein, and metabolite but also by providing evidence of its accuracy by analysis with '-*OMICS*' tools. The post-human genome sequencing era has fuelled multiple plant genome sequencing projects and the number of sequenced crop genomes is progressively increasing.[1] However, with the observation that a major part of the genome is non-functional and noncoding (>90 %), the post-genomic era has realized that the sequenced genome is not enough to understand complex biological processes at systems level. For example, proteins are the most diverse group of macromolecules due to their massive structural and functional roles in the biological world. Considering post-translational modifications may contribute to potentially several forms of proteins from a single gene a typical food sample may contain multiple different protein forms. Therefore, rather than sequencing the entire genome of plants, the endeavour of sequencing only the regions of the genome that produce protein products (coding regions or transcriptome) and combining this knowledge with advanced proteomic tools, is a smarter approach from the food perspective. This approach focuses on the biochemical and synthetic pathways and has advantage over whole genome sequencing as only the genes that produce proteins are studied to understand mechanisms of various biological processes and are vital for the construction of robust evolutionary relationships through sequence comparison studies.

Prote*omics*, the science of identification, quantification, and characterization of proteins, offers unprecedented applications in food safety (screening of adulterants, food, and food-derived pathogens) and the production process of plant-based food and beverages (wine, beer, and transgenic plants). There is a wealth of prote*omics* data already generated through multiple plant-based studies that have created a solid background knowledge about the biochemical nature, quality, and traceability of plant-based foods. For example, maize and rice protein networks are included in Pathway Studio, and significant work is ongoing to extend the applicability of proteomic approaches already practiced in biomedicine to food-related studies.[2] Moreover, prote*omics* platforms allow the transformation of scientific knowledge into novel food biomarkers and bioactive discovery.[3]

The '-*Omics*' Integration To '-Nano' For Food

To better understand and exploit plant proteomes and their new biomarkers, new tools need to be developed in combination with other technologies. Therefore, the introduction of nanotechnology principles and tools to conventional prote*omics* has resulted in the recent progress of nanoprote*omics*, overcoming some of the limitations of existing proteomic techniques. For instance, conventional prote*omics*-based techniques for biomarker analysis such as microarrays require the labelling of proteins. The advanced high-end mass spectroscopy and chromatographic separations techniques are resource intensive, time-consuming, and require complex data analysis. Moreover, they suffer from issues related to the huge dynamic range of biomarkers present in the complex food samples and there is always a possibility of false identifications. The employment of Nanoprote*omics* in food technologies has the potential to offer solutions through improved sensitivity and selectivity for high-throughput analysis of samples.[4] Additionally, these are rapid and allow low-cost integration of technologies to develop miniaturized platforms for proteomic research.[5] Notably, the miniaturized nanoprote*omics* platforms offer real-time analytics with high sensitivity, selectivity, and low-cost detection of rare proteins/ biomarkers in food through multiplexing and high-throughput analysis. However, in developing nanoprote*omics* approaches, the end application and amiability to tailor nanotechnology tools are imperative. In summary, Nanoprote*omics* in plant-based foods is currently in the development phase and warrants optimizations for its wider commercial applicability. A common goal for nanotechnology applications in plant-based foods and beverages is toward making them safe for human consumption through quantitative, and in some cases qualitative food analysis. Hence, the nanoprote*omics* approaches in plant-based food and beverages should focus on developing devices that enrich samples or concentrate the target analyte, as the use of fewer sample amounts ultimately reduces the overall sensitivity of nanoprote*omics* devices.

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