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Food selection and processing: can we blend science with engineering to address Chronic Kidney Disease (CKD)?

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Abstract

Chronic Kidney Disease (CKD) alters the function and structure of the kidney irreversibly, over months or years. The rising incidence of CKD has become a leading global health problem and therefore a number of multi-field investigations are being carried on. In general, diabetes and high blood pressure (hypertension) are the most common causes of CKD. However, the importance of functional food selection and less consumption of ultra-processed food is at the forefront of the current research domain to manage CKD. To address this threat, experts suggest and recommend adopting a science-based dietary pattern, for instance, the Dietary Approaches to Stop Hypertension (DASH). Moreover, food bioactive compounds are non-nutrients that typically occur in small quantities in foods, and hence, the selection of proper food (source) and subsequent processing is of paramount importance to attenuate the magnitude of CKD. The role of food science in managing chronic diseases could be coupled with the advancement of food engineering to minimize the detrimental effect of food processing along with the delivery of target bioactive molecules. This potentially indicates bold ambitions to innovate holistic solutions to address CKD through a proper selection of food and processing parameters.

Keywords: Food bioactive; Food selection; Food processing and formulation; Foodomics; Chronic Kidney Disease (CKD).

Chronic Kidney Disease (CKD) is a progressive condition that deteriorates the function and structure of the kidney. The burden of CKD is substantially growing. Approximately 10% of the total global population at present die from it and by 2040 is predicted to be the fifth leading cause of death (Kalantar-Zadeh et al., 2021). Although diabetes and hypertension are the leading causes of CKD, an unhealthy diet (high in sugar, salt, and saturated fat) and ultra-processed food (synthetic emulsifiers, additives, and preservatives) are the Trojan horses to the burgeoning onset of this global challenge and other chronic diseases (Shahidi, 2020). The latest details of CKD's progression, effects, and management have been well-discussed (Cockwell and Fisher, 2020; Kalantar-Zadeh et al., 2021) and the Dietary Approaches to Stop Hypertension (DASH) diet is being recommended by several experts (e.g., Song et al., 2021) as a nutritional intervention for CKD patients. However, we believe that the multidimensional roles of food go even further than explained.

Consequently, in addition to the post-COVID-19 health aware-

ness, the concept of "Food as (a source of) Medicine" has gained boosted interest (Mafra et al., 2021); however, yet the advancement of food science and engineering has not been fully harnessed to retard CKD and the renotropic functions of bioactive compounds need to be explored further. At present, food processing industries are adopting mild processing (emerging) technologies, notably high pressure processing (HPP), that offer minimum processing, impregnation of target bioactives, and preservation of nutritional quality and sensory attributes, way better than products after conventional thermal processing (Balakrishna et al., 2020; Wazed and Farid, 2021; Wazed et al., 2020) with hypoallergenic attributes (Wazed and Farid, 2019) and improved storage stability (Wazed and Farid, 2022). Hence, the selection of functional, healthy, nutraceutical, geriatric, and renotropic food items and their processing is of paramount importance to ameliorate the impacts of CKD. In fact, food labels of processed items often do not provide adequate information on the exact amount of additives. Moreover, a food label provides mainly energy value and amounts of fat, protein, carbohydrate, sugars, salt, etc. A novel food label would be a more pragmatic and helpful tool for public health if it educates us the bioavailability/bioaccessibility in addition to nutrition content (Bovell-Benjamin, 2022). The bioavailability of the nutrients present in a food product indicates how nutritionally sound it is, which unfortunately is not present on the current food/nutrition labels. Ongoing research on customizing food technologies and combining several techniques (hurdle) would endeavor to develop clean-label formulated foods for special use.

For eating right, a kidney-friendly diet plan requires the selection of the right foods, lower or no intake of foods high in sodium, potassium, and phosphorus along with the careful choice of calorie values, fats, proteins, and fluids. Apart from the increasing evidence and subsequent establishment of a plant-based (fiber-rich) diet to attenuate the progression of CKD and other renal injuries (Carrero et al., 2020; Mafra et al., 2021), bioactive compounds from plants and foods are well-acknowledged through the booming research in this area. Bioactive ingredients (e.g., allicin, astaxanthin, berberine, fucoidan, genistein, emodin, rhein, curcumin, rutin, hyperoside, isoquercitrin, quercetin, saikosaponin D, astragaloside II, scutellarin, oleuropein, glycyrrhetinic acid, etc.) have shown proven action against CKD either through direct action or through synergistic behavior with the presence of other molecules (de Almeida Alvarenga, et al., 2018; Mafra et al., 2019; Marón et al., 2020; Zhao et al., 2021). Probiotic foods (fermented or fortified with beneficial microorganisms) alleviate oxidative stress in CKD patients (Borges et al., 2018). Moreover, herbal sources are promising in both research and manufacturing, and therefore, taken together, natural bioactives have enormous potential in drug formulation for renal health (Chen et al., 2021). This further necessitates the application of state-of-the-art technologies to extract and purify candidate bioactives; and to explore their pharmacokinetic behavior where food science and engineering may take a proud lead in embracing the latest innovations in drug delivery. Among current nanotechnological approaches, tailor-made nanoparticle systems and encapsulation of bioactives would enhance the pharmacological properties, targetability, and bioavailability of novel bioactives (drugs) for pragmatic solutions to the diagnosis and treatment of CKD and other kidney diseases (Mitchell et al., 2021). Moreover, optimized artificial intelligence (Islam et al., 2022) could be coupled with foodomics to streamline the benefits of food matrices to innovate holistic solutions in nephrology to ensure food for both people and the planet thus accommodating Industry 4.0 to achieve sustainability (Režek Jambrak et al., 2021).

Therefore, it is imperative to adopt a global and concerted approach through smart selection and bioprocessing of food materials to manage CKD and other renal problems. Thus, food science can meet engineering to develop a suite of technologies and management strategies (both conservative and preservative) to tackle the severity of CKD. We better shout out loud now for this multidisciplinary corridor for our better health.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

M.A.W conceived the idea and discussed with M.F & E.A.F.A. Draft writing, literature search, and primary editing: M.A.W; J.R; E.A.F.A & M.A.A. Overall supervision: M.F.

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