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Editorial

Legumes and Cereals: Physicochemical Characterization, Technical Innovation and Nutritional Challenges

El-Sayed M. Abdel-Aal

Guelph Research and Development Centre, Agriculture and Agri-Food Canada, 93 Stone Road West, Guelph, ON N1G 5C9, Canada; elsayed.abdelaal@agr.gc.ca; Tel.: +1-(519)-362-1673; Fax: +1-(226)-217-8181

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Legume dry seeds (pulses) and cereal kernels or caryopses (grains) are staple foods worldwide and the primary supply of energy, protein, and fiber in our diet. In addition, they are good sources of micronutrients such as vitamins and minerals and health-promoting components including polyphenols, carotenoids, and others. Interestingly, pulses and cereals complement one another when combined in diets with regard to protein quality [1] and health-enhancing attributes [2] due to their synergistic effects of limiting amino acids and flavonoids, respectively. They are also good crops for a sustainable food production system and a healthy planet due to their complementary characteristics when they are sown together in a crop rotation system [3]. In other words, they jointly improve soil structure, fertility, and microorganisms, resulting in better crop yields. Furthermore, grains and pulses can be processed into a variety of convenient and nutritious food products to fulfill consumers' needs and growing market demands, especially for affordable, healthy, and culturally appropriate foods. Surely, these attributes make cereals and legumes key components of strategies that aim at improving food security and the health of the environment.

The first volume of this Special Issue (SI) was a great success and gained the attention and interest of tens of thousands of people. Special thanks go to the contributors and staff for their excellent work and high-quality research. Volume I of this SI is composed of 13 distinctive manuscripts, including 9 research papers and 4 review articles. It covers a broad spectrum of the latest research areas that are of interest to academia and the food industry alike. They include plant proteins in terms of their techno-functionality, protein quality, and applications; starch properties of different beans in relation to their functionality; healthy snacks made from blends of pseudocereal and pulse flours to meet nutritional requirements; special grains such as purple wheat, quinoa, and Nordic crops as alternatives to soybean; gluten-free ingredients and foods; and lastly, in vitro bioavailability of bioactive compounds from muffins and breads made from cereal flour blends.

Currently, there is a lot of interest in plant proteins due to their competitive advantages when compared to animal proteins, as their production has lower greenhouse gas emissions than animal-based foods [4] and lower costs and energy requirements [5]. Furthermore, plant proteins may have additional positive properties for human health over animal proteins in increasing satiety and reducing the risk factors for cardiovascular disease [6]. The SI featured three articles on various aspects of plant proteins. Penaranda and others [7] investigated pea protein enriched with lucerne, spinach, and chlorella in a texturized or powder form to determine its potential as a meat analogue in veggie burgers. In general, texturization enhances the quality and sensory properties of veggie burgers with pea protein enriched with chlorella, producing a final product similar to traditional meat burgers. In another study, the nutritional and techno-functional properties of faba bean protein isolates were evaluated [8]. The two protein isolates prepared from faba beans exhibit close protein content (71.4–72.6%) but they are significantly different in digestibility, solubility, and foam stability. A review article by Noseworthy and others [6] argued for the quality assessment methods of plant proteins and the health benefits of pulses.

The three most common methods employed in the assessment of protein quality are the protein efficiency ratio (PER), the protein digestibility-corrected amino acid score (PDCAAS), and the digestible indispensable amino acid score (DIAAS). Each method has its own advantages and disadvantages; PER is commonly used in Canada, and PDCAAS is needed in the USA for a successful protein content claim. The three methods are based on animal assays.

In addition to protein, pulses are also rich in starch. The structure and composition of starches and their thermal and functional properties are commonly used in identifying their utilizations and end uses. In this SI, two studies investigated the properties of starch fractions prepared from faba bean [8] and adzuki bean [9]. Both starches are good sources of resistant starch (RS), subject to the type of seed, bean variety, and method of preparation. In the study by Zhang et al. [9], adzuki bean varieties were categorized into three classes I, II, and III based on a cluster analysis of 24 quality parameters. The varieties that belong to class I have lower slowly digested starch (SDS) and higher rapidly digested starch (RDS), making them not suitable for the dietary requirements of diabetics,; those in class II are appropriate as gelling agents and/or stabilizers; while class III varieties are good at making bean pastes.

Pulses and non-gluten cereal grains are the primary ingredients in gluten-free foods for people with celiac disease or gluten intolerance. The SI has five studies that have investigated the effect of various ingredients and treatments on the quality of gluten-free foods. A study has found that treatment of white and brown teff flours with microwave radiation improves their rheological, thermal, and techno-functional properties, subject to the moisture content of the teff flour. The study results suggest that the treated teff flour holds potential for making improved gluten-free foods in terms of nutritional properties and product quality [10]. Tsatsaragkou and others [11] studied the fermentation kinetics of gluten-free dough made from rice flour replaced with 15% of carob seed flour fractions: fraction A (315–500 μ) rich in fiber, fraction B (250–315 μ) rich in protein, fraction C (125–250 μ) rich in germ proteins, and fraction D (whole seed ultra-fine flour powder). A composite kinetic model based on the Gompertz equation is developed to predict optimized dough expansion for flour blends and the role of water and carob flour in gluten-free dough development and bread loaf volume. Fraction B produces a high dough volume and a soft crumb bread with an open crumb grain. Another study has looked into the potential of black, red, or white glutinous rice in making gluten-free bread based on the measurement of their pasting properties [12]. The study has shown that bread characteristics are strongly correlated with the pasting properties of flours. Additionally, fine flour has better baking performance than semi-coarse flour, and glutinous flour could be a good ingredient in making gluten-free bread. Furthermore, the pigmented black and red rice flours may be limited by the flavor and taste of bread products. Gluten-free cracker-type snacks made from blends of chickpea flour and quinoa at ratios of 10, 20, 30, 40, and 50% with and without inulin have been assessed [13]. Gluten-free snacks possess balanced essential amino acids and low energy, and snacks made from chickpea (50%) and quinoa (50%) with inulin could be a nutritious snack choice for children. The fifth study evaluated the nutritional properties of fifteen commercial gluten-free pastas made from cereals, pseudocereals, and pulses alone or in blends based on their composition of amino acids and protein chemical score [14]. The study also assessed thermal damage that occurred during the pasta-making process on the basis of the content of furosine, maltulose, hydroxymethylfurfural, and glucosylisomaltol in pasta samples. These compounds are used as markers for thermal damage due to the Maillard reaction. It has been concluded that a combination of different ingredients can help formulate pasta products with a high protein chemical score. Additionally, the formation of furosine and maltulose markers can be higher in formulated pastas than in pastas made from 100% semolina. It is preferable to use both markers (maltulose and furosine) together to assess the intensity and effects of heat treatment. The advanced phase markers of the Maillard reaction, e.g., the formation of hydroxymethylfurfural and glucosylisomaltol, have been found at negligible or undetectable levels in pasta products.

Pulses, cereals, and pseudocereals are good sources of bioactive compounds such as polyphenols and carotenoids. The role of carotenoids and polyphenols in promoting human health and preventing chronic diseases is largely dependent on their bioavailability. In a study, muffins and breads made from hairless canary seed, wheat, and corn blends were subjected to a gastrointestinal digestion system combined with a Caco-2 model to assess the bioaccessibility and cellular uptake of lutein, zeaxathin, and ferulic acid [15]. The study has found that the residual enzymes in the intestinal digests of samples result in damaging the Caco-2 monolayer; thus, those enzymes and other damaging compounds must be removed from digesta samples in order to assess in vitro bioavailability. The removal of residual digestive enzymes by a clean-up treatment reduces the concentration of lutein, zeaxanthin, and ferulic acid. The bioaccessibility of lutein from muffins is fairly high, at 81–94%; however, the cellular uptake is low (7–9%), with zeaxanthin exhibiting lower bioaccessibility and cellular uptake than lutein. Ferulic acid from muffins exhibits a wide range of bioaccessibility (53–229%) due to the release of some bound ferulic acid fraction during the digestion process, but it has very low cellular uptake (0.5–1.8%). Breads made from wheat/hairless canary seed possess higher lutein bioaccessibility (47–80%) than the control bread (42%), with an apical cellular uptake ranging from 4.3 to 9.2%. Similar to muffins, the bioaccessibility of zeaxanthin from bread is lower than that of lutein, while ferulic acid has a fairly high bioaccessibility (81–103%) and low cellular uptake (0.2%). The study suggests that hairless canary seed/corn muffins and wheat/hairless canary seed breads could boost the daily consumption of lutein, zeaxanthin, and ferulic acid, but only a small portion could be absorbed in the small intestine.

Special grains, such as colored or anthocyanin-pigmented wheat, have been developed for making functional foods and beverages due to their demonstrated health benefits. A review article in this SI provides insights into purple wheat food product development, its roles in human health, and processes for anthocyanin stabilization during processing [16]. Purple wheat can be processed into a wide range of staple foods, including bread, pasta, and cereal breakfasts, but considerable amounts of anthocyanins could be lost. The study suggests several approaches that can be employed to avoid or minimize anthocyanin loss, such as the use of the sour dough method along with short-time and low-temperature oven baking, the use of purple wheat bran, grits, or flakes in acidic foods such as yoghurt, and applying co-pigmentation of anthocyanins with non-color flavonoids and/or other molecular interactions with proteins or polysaccharides as part of processing through formulation and process optimization. Another review by Auer and others [17] evaluated three Nordic crops, faba bean, yellow peas, and oat, as alternatives to soybean based on their nutritional, functional, and sensory attributes. Despite the lower protein quality and the presence of anti-nutritional factors and off-flavor compounds in these crops, several methods, such as enzymatic treatment, fermentation, and fibrillation, can be applied to improve the nutritional value, sensory attributes, and functional properties, making them suitable for replacing soy in a broad range of food products. In addition, these protein sources can be mixed at certain ratios to balance the limiting amino acid composition, reduce antinutrients and off-flavor compounds, and improve overall digestibility through processing. The study has also shown that the functional properties of faba bean, pea, and oat are comparable to those of soy, making them usable for 3D printing, gelation, emulsification and extrusion. Their protein could also be employed in making meat-like fiber using 3D printing or protein nano-fibrillation technologies, which would complement the extrusion process to create plant-based meat analogues. In another study, quinoa seed components were examined based on their physicochemical, nutritional, and functional properties, as well as the use of innovative technologies such as sonication, high hydrostatic pressure, and atmospheric pressure cold plasma as a means to improve the techno-functionalities of quinoa seeds and subsequently the quality of quinoa-based products [18]. Quinoa seeds hold promise for several applications in the food industry, including bakery products, meat analogues, fermented beverages, plant milk, and edible films. Additionally, quinoa seed proteins and polysaccharides could have potential for designing delivery systems for bioactive compounds. Quinoa seed proteins contain a balanced amino acid profile similar to the milk protein casein, as well as highly digestible and biologically available proteins. Additionally, the polypeptides obtained after in vitro simulated gastric digestion exhibit potent antioxidant properties. Quinoa seed starch has unique properties as well, such as long chains of amylopectin configuration, more short chains of amylose, relatively low gelatinization temperature, soft gel, low retrogradation, and high enzyme accessibility. In general, the review highlights the potential benefits of incorporating quinoa into diets and the importance of developing innovative approaches to enhance the nutritional quality and functionality of quinoa products.

Overall, this SI volume I underscores the importance of pulses and cereals in several emerging food applications, such as plant proteins, nutritionally improved gluten-free foods, meat analogues, healthy snack foods, and others. In addition, it provides a valuable information resource on their nutrient composition and functional properties, especially since they are staple foods in many parts of the world. Additionally, novel processing treatments and technologies to improve their nutritional and functional attributes have been suggested. The current SI also unlocks the potential of special grains such as purple wheat, teff, and quinoa in making healthy ingredients and functional foods. Optimistically, this SI stimulates more research to expand the exploitation of legumes and cereals to feed a growing world population and fulfill consumers' demands around the globe. Volume II is now available, and hopefully authors will be inspired to make their valuable contributions to this important topic, "Legumes and Cereals", to secure enough foods worldwide.

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