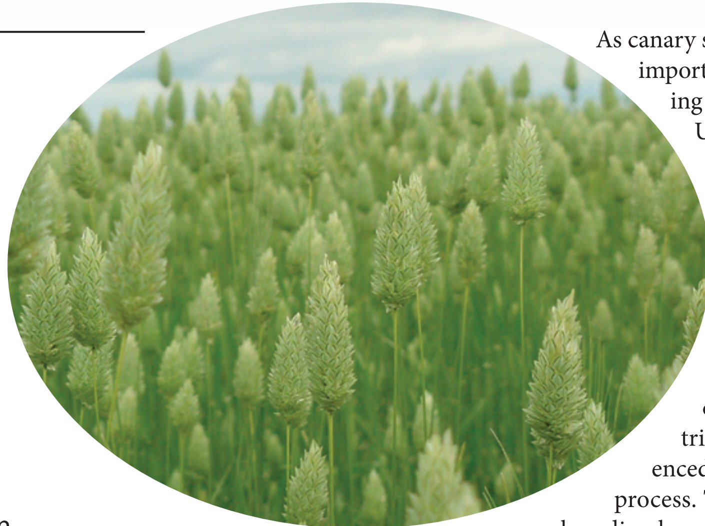
Glabrous Canary Seed: A Novel Food Ingredient

C. A. Patterson[1]
The Pathfinders & Research Management Ltd
Saskatoon, SK, Canada

L. Malcolmson,[2] C. Lukie,[3] and G. Young[4]
Canadian International Grains Institute
Winnipeg, MB, Canada

P. Hucl[5]
Crop Development Centre, University of Saskatchewan
Saskatoon, SK, Canada

E. Abdel-Aal[6]
Guelph Research and Development Centre, Agriculture and Agri-Food Canada
Guelph, ON, Canada



Annual glabrous canary seed is a new whole grain cereal that received novel food approval from Health Canada (11) and generally recognized as safe (GRAS) status (26) from the U.S. Food and Drug Administration (FDA) in 2015. Also known as annual canarygrass, canary seed (*Phalaris canariensis* L.) has gained commercial importance as a specialty grain crop for Canadian producers. Globally, Canada is the world's largest producer of hairy (pubescent) and hairless (glabrous) annual canary seeds. Although it is primarily used as a feed for pets and wild birds, there are opportunities to introduce glabrous canary seed grain to the food industry as a novel, nutritious food ingredient.

Investigations conducted in the 1970s first identified annual canary seed as a potential grain crop in North America (22–24). As canary seed production became more important in western Canada, a breeding program was established at the University of Saskatchewan (Saskatoon, SK, Canada) in the 1990s to eliminate hull pubescence (hairy characteristic) and brown seed color in canary seed. The small silicified hairs (trichomes) or spicules covering the hull surface of commercial pubescent canary seed cultivars contribute to skin irritations experienced by farmers during the harvest process. Two decades later, successful breeding has resulted in a portfolio of five glabrous (hairless hull) varieties of canary seed that are easier to harvest and, with regulatory approval, are now available for use in food applications. Four brown seed varieties (CDC Maria, CDC Togo, CDC Bastia, and CDC Calvi) and one yellow seed variety (CDC Cibo) are registered for commercial production (Fig. 1). Glabrous brown and yellow canary seed varieties with higher yields are also in the development pipeline.

Historical references suggest that canary seed may have originated in the Canary Islands, with some indications that canary seed was used as a food source as far back as the late 1500s, particularly in countries bordering the Mediterranean Sea. Spanish explorers may have introduced the grain to South America and Mexico (13,21,27,29). Pubescent (hairy) canary seed (*P. canariensis*) appears to have been introduced to North America in the mid to late 1800s (27), with the Canadian Ministry of Agriculture growing annual canary seed at its Indian Head Experimental Farm in Saskatchewan in the 1890s (20). Pubescent canary seed was grown commercially as a grain crop in the northern Great Plains in the Red River Valley of North Dakota and Minnesota starting after World War II, whereas commercial production of pubescent canary seed in Canada began in the 1960s in Manitoba and 1970s in Saskatchewan. Commercial production of hairless (glabrous) varieties began in Saskatchewan in the late 1990s.

The growth and development of annual canary seed is quite similar to that of wheat (*Triticum aestivum* L.) and oats (*Avena sativa* L.). It can be grown as either a spring-sown crop in regions with severe winter climates or as a winter-sown crop in milder Mediterranean climates (1). Canary seed produces small, elliptical grains with lengths and widths of approximately 4.0–5.1 and 1.5–2.0 mm, respectively (6). The glabrous grain weighs approximately 7 mg, with an average test weight of 70 kg/hL (14). Abdel-Aal et al. (3) have shown that the microstructure (bran, starchy endosperm, and germ) of glabrous canary seed is similar to that of wheat, oats, barley, and rice.

[1] Corresponding author. The Pathfinders & Research Management Ltd, 1124 Colony St, Saskatoon, SK, Canada S7N 0S5. Tel: +1.306.242.1306; Fax: +1.306.242.1307; E-mail: capatterson@thepathfinders.ca

[2] LM FoodTech Solutions, East St. Paul, MB, Canada R2E 1B3. Tel: +1.204.661.9696; E-mail: malcolmsonlinda@gmail.com

[3] Swan's Brewpub, 1601 Store St, Victoria, BC, Canada V8W 1N6. E-mail: chrislukie@gmail.com

[4] Canadian International Grains Institute, 1000-303 Main St, Winnipeg, MB, Canada R3C 3G7. Tel: +1.204.84.1063; E-mail: gyoung@cigi.ca

[5] Department of Plant Sciences, University of Saskatchewan, Rm 3C84 Agriculture Bldg, 51 Campus Dr, Saskatoon, SK, Canada S7N 5A8. Tel: +1.306.966.8667; E-mail: pierre.hucl@usask.ca

[6] Guelph Research and Development Centre, Science and Technology Branch, Agriculture and Agri-Food Canada, 93 Stone Rd W, Guelph, ON, Canada N1G 5C9. Tel: +1.226.217.8079; Fax: +1.226.217.8181; E-mail: elsayed.abdelaal@agr.gc.ca

https://doi.org/10.1094/ CFW-63-5-0194

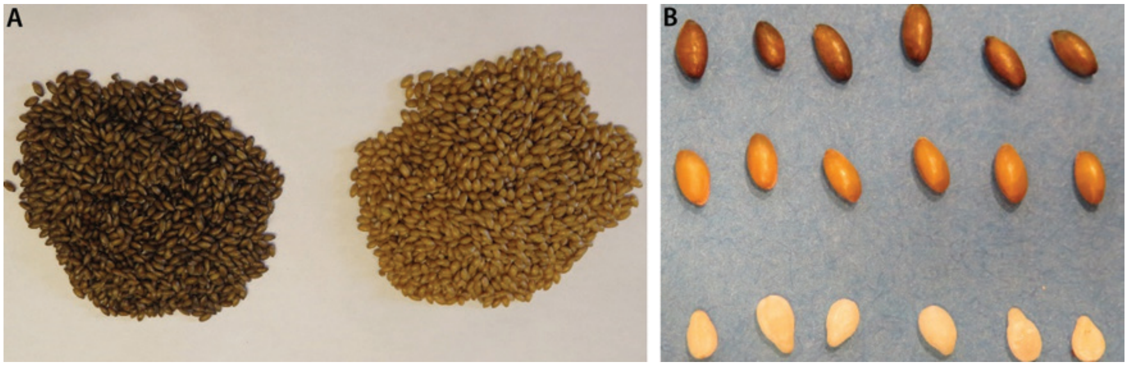


Fig. 1. A, Brown (left: CDC Maria) and yellow (right: CDC Cibo) canary seed groats. **B,** Comparison of brown (top) and yellow (center) canary seed groats and commercial sesame seeds (bottom).

Nutrient Composition

Glabrous canary seed is a highly nutritious cereal grain that contains, on a dry weight basis, 19.3–23.1% protein (higher than other common cereal grains), 55% starch, 5–7% crude fat, 6–8% dietary fiber, and 2–3% total ash in the whole grain (3). No significant difference in nutrient composition between yellow- and brown-colored grain varieties is evident (8).

Similar to other cereal grains, the proteins in canary seed are deficient in lysine; however, compared with other common cereals canary seed contains higher levels of tryptophan, phenylalanine, and cysteine (3). The major proteins found in canary seed are prolamins, which make up approximately 45.5% of the total protein, along with albumins and globulins, both of which are found at levels below those found in wheat (13.1% versus 23.6%) (1,6).

Canary seed crude fat contains about 85% unsaturated fatty acids, of which approximately 32% is monounsaturated and 55% is polyunsaturated. Like other cereals, the predominant fatty acids in glabrous brown and yellow canary seeds are palmitic (11%), oleic (29%), and linoleic (55%). Dehulled canary seeds (also known as groats) contain about 2% linolenic acid.

Canary seed groats contain 56.9–64.4% starch, which is composed of small uniform polygonal granules with A-type starch crystals (2,5). Compared with wheat starch, yellow and brown canary seed starches had higher gelatinization transition temperatures, a broader gelatinization range, and a higher swelling power and water solubility index (15). Differences have been shown between canary seed starches derived from brown and yellow seed varieties, with yellow seed varieties having higher pseudoplasticity and thixotropy properties compared with starch derived from brown seed varieties (17).

Canary seed groats contain lower levels of dietary fiber compared with most common cereals (6–8% versus 13–21% in wheat and 11–25% in oats) (25). Canary seed fiber is primarily composed of insoluble fiber, with <1% of the total fiber being soluble (3).

From a micronutrient perspective, canary seed contains the B vitamins thiamine and riboflavin at levels comparable to other cereals, but its niacin levels are lower than those found in wheat and barley. Total folate content in canary seed is higher than in wheat, barley, and oats. The predominant phenolic acids in glabrous canary seed are ferulic, caffeic, sinapic, and ρ-coumaric (4,19). Glabrous brown and yellow canary seed groats exhibit the same flavonoid profiles and are rich in flavonoid glycosides (18).

Canary seed is gluten-free (7) and can be safely consumed by individuals with celiac disease provided it is produced using methods to avoid cross-contamination with a gluten source (11). Celiac disease or gluten-sensitive enteropathy is a condition triggered by the consumption of cereal grains (e.g., wheat, barley, and rye) that contain gluten (gliadin or glutenin) proteins. The immune system of a person with celiac disease reacts to gluten in the diet, causing inflammatory damage to the inner lining of the small bowel. However, due to a possible cross-reactivity between canary seed proteins and wheat proteins responsible for allergic reactions, canary seed may not be suitable for individuals who are allergic to wheat (12). Wheat-allergic individuals are individuals who have an IgE-mediated allergic reaction to a wheat protein (e.g., albumin, globulin, gliadin, or glutenin). Thus, canary seed could pose a concern for individuals with wheat allergies, as opposed to individuals with celiac disease, because a gluten-free label claim can imply that a product is wheat-free. The cross-reactivity issue between wheat and canary seed proteins continues to be investigated by the Canaryseed Development Commission of Saskatchewan.

Use of Canary Seed Flour and Groats in Foods

Because glabrous canary seed is a novel whole grain cereal, prototype food products were developed to show the potential applications of canary seed ingredients in a variety of products. The results were used to determine proposed maximum usage levels for these novel foods and GRAS dossiers (Table I).

Canary seed groats can be used as whole groats or milled into a whole grain flour that is well suited for the bakery, cereal, pasta, snack, and convenience bar markets. Whole groats can also be used as a low-fat substitute for sesame seeds in bread and snack foods or in combination with other seeds as toppings or ingredients. Whole grain canary seed flour can be used to replace or complement other ingredients (e.g., wheat flour, rolled oats, or sesame seeds) in food formulations. The whole grain flour could also be sold as a stand-alone flour product in the retail market.

For the development of prototype food products, brown CDC Maria and yellow CDC Cibo canary seeds were milled into flours by first dehulling the seeds using an abrasive cone-type dehuller followed by air aspiration. The dehulled groats were then milled into flour using a hammer mill. Whole grain flours were analyzed for color, protein, ash, moisture, total starch, and dietary fiber (Table II). Roasted canary seed groats were prepared by spreading 2 kg of seeds in a single layer on a baking sheet and roasting at 325°F for 33 min. The details of how canary seed flours were incorporated into baked product, pasta, and snack product formulations are described in the following sections. Products were assessed for their sensory characteristics and overall acceptability by experienced panelists.

Pan Bread. Canary seed flour was substituted for 25% of the wheat flour in a standard commercial no-time bread formulation (quantities expressed in baker's percentage): 75% wheat flour, 25% canary seed flour, 4% yeast (fresh), 4% sugar, 2% salt, 2% canola oil, 2% dough conditioner (S500 Red, Puratos), and 62% water. The use of canary seed flour required minimal ingredient and processing changes to produce a quality pan bread. The addition of canary seed flour did result in a reduction in water absorption and an increase in final proofing time compared with the 100% wheat flour control dough. However, all other baking steps (mixing, dough rounding, and baking) remained the same as for the 100% wheat flour dough. Loaf volume (especially for the yellow canary seed flour), crumb texture, and structure were maintained (Fig. 2). The addition of canary seed flour did result in a change in crumb color, but the crumb color for both breads was considered acceptable. There was minimal effect on the flavor of the bread with the addition of canary seed flour.

Roasted canary seed groats were also evaluated as a seed topping on the bread and as an ingredient in the dough (added at 20%). The appearance and texture of the roasted canary seed groats were comparable to other seeds and grain bits commonly used in breads or as bread toppings (Fig. 3). The flavor of the roasted canary seed groats was mild, especially compared with sesame seeds.

Tortillas. Canary seed flour was substituted for 35 and 50% of the wheat flour in a standard commercial tortilla formulation (quantities expressed in baker's percentage): 65 or 50% wheat flour, 35 or 50% canary seed flour, 10% canola oil, 2% baking powder, 1.5% salt, 0.5% sugar, 0.5% monoglycerides, 0.375% sodium stearoyl lactylate, 0.25% fumaric acid, 35 ppm L-cysteine hydrochloride, and 54% water. Slightly less water was required for the tortillas made with canary seed flour. The canary seed flour tortillas had a similar flavor, texture, and rollability compared with the control tortilla. The color of the tortillas made with yellow canary seed flour was more appealing than that of the tortillas made with brown canary seed flour (Fig. 4).

Snack Crackers. Yellow canary seed flour was substituted for 30% of the wheat flour in a standard commercial snack cracker formulation (quantities expressed in baker's percent-

Table I. Proposed maximum usage levels for glabrous canary seed in novel foods

Food Category	Food Products	Maximum Usage Level (%)
Baked goods and baking mixes	Bagels	25
	Biscuits	20
	Breads and rolls	25
	Cakes	20
	Cookies	50
	Corn breads, corn muffins, and tortillas	25
	Crackers	26
	Croissants and pastries	25
	Doughnuts	25
	Flours and brans (prepackaged)	100
	Muffins	20
	Pancakes and waffles	25
	Pies	10
Breakfast cereals	Instant and regular hot cereals	15
	Ready-to-eat breakfast cereals	15
Grain products and pastas	Energy, meal replacement, and fortified bars	25
	Granola and cereal bars	25
	Macaroni and noodle products	15
	Pasta, rice, and other grain products	15
Snack foods	Savory snacks	25
	Seed-based snacks	40

Table II. Nutrient content (g/100 g, dwb) and color of whole grain brown and yellow canary seed flours

	Brown Canary Seed (CDC Maria)	Yellow Canary Seed (CDC Cibo)
Protein (N × 5.7) (%)	22.5	19.9
Ash (%)	1.93	2.11
Total starch (%)	55.9	56.2
Moisture (%)	8.5	8.3
Total fiber (%)	6.7	7.1
Insoluble fiber (%)	5.6	5.9
Soluble fiber (%)	1.1	1.2
Color		
*L**	66.5	74.5
*a**	0.47	1.56
*b**	10.1	17.3

Fig. 2. Bread made with canary seed flour. Left to right: 100% wheat flour control; 25% yellow canary seed flour; 25% brown canary seed flour.

Fig. 3. Bread made with 25% yellow canary seed flour and topped with roasted yellow canary seed groats.

age): 60% wheat flour (9.8% protein), 30% canary seed flour, 15% roasted canary seed, 0.7% yeast (fresh), 9% shortening, 5.4% corn syrup, 1.4% salt, 0.4% baking soda, 0.4% acid powder, and 32% water. Processing of the crackers followed a straight-dough procedure with bulk fermentation of 4 hr. No changes in processing steps were required with the addition of canary seed flour and roasted canary seeds to the formulation. The crackers had an acceptable appearance (Fig. 5) and mild flavor. The texture was similar to multigrain or whole wheat crackers, with a slightly gritty mouthfeel that was acceptable.

Spaghetti. Canary seed flour was substituted for 25% of the durum wheat semolina in spaghetti. The spaghetti was processed using a pilot-scale pasta extruder and dryer following standard commercial processing conditions. The partial substitution of durum semolina with canary seed flour required minimal ingredient and processing changes. There was a slight increase in the amount of water required compared with the 100% durum semolina spaghetti control. No changes to the extrusion parameters or drying cycle conditions were needed. Figure 6 shows the color of dried spaghetti made with yellow and brown canary seed flours. Compared with the control spaghetti, the spaghetti made with canary seed flour had lower L^* values, higher a^* values, and negative b^* values.

The cooked spaghetti made with yellow canary seed flour had a color similar to the whole grain durum semolina spaghetti, which was more acceptable than the color of the spaghetti made with brown canary seed flour (Fig. 7). Minimal flavor differences were detected in the cooked canary seed spaghetti compared with the durum semolina spaghetti. Spaghetti made with canary seed flour had a firmer cooked texture and lower cooking losses than did the durum semolina spaghetti.

Muffins. Yellow canary seed flour was substituted for 35% of the whole wheat flour in a household-sized muffin recipe: 120 g of whole wheat flour, 65 g of canary seed flour, 90 g of rolled oats; 50 g of brown sugar, 50 g of unsweetened shredded coconut, 50 g of wheat germ, 2.5 g of cinnamon, 1.5 g of allspice, 5 g of baking powder, 5 g of baking soda, 2.5 g of salt, 50 g of canola oil, 360 g of buttermilk, 50 g of whole egg, 7.5 g of vanilla extract, 180 g of liquid honey, 50 g of chopped walnuts, and 100 g of raisins. The muffins made with canary seed flour required 9% less liquid compared with the 100% whole wheat flour control muffins. The muffins made with canary

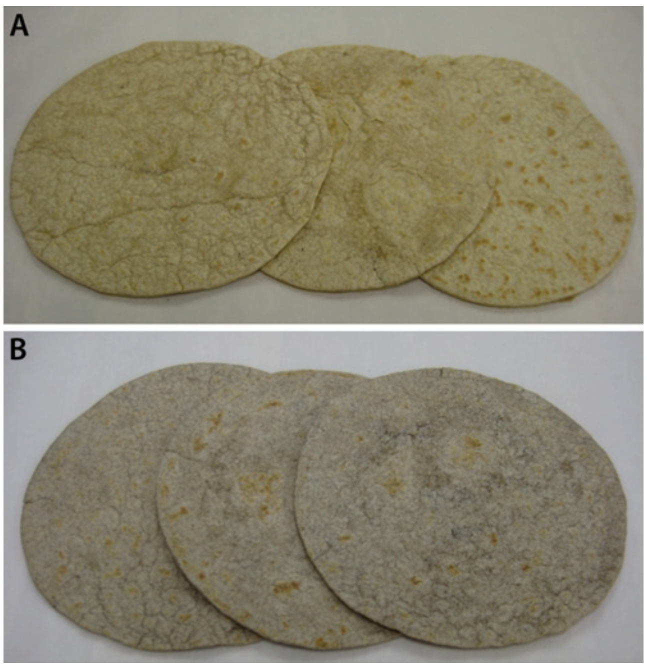


Fig. 4. Tortillas made with canary seed flour: **A,** 50% yellow canary seed flour; **B,** 50% brown canary seed flour.

Fig. 5. Snack crackers made with 30% yellow canary seed flour and topped with roasted yellow canary seed groats.

Fig. 6. Spaghetti made with 25% yellow canary seed flour (top) and 25% brown canary seed flour (bottom).

seed flour had acceptable appearance (Fig. 8), texture, and flavor.

Confections. Roasted canary seed groats were substituted for 100% of the sesame seeds in a sesame seed confection (snap) formulation (quantities expressed in percentage of total weight): 50% sugar, 40% canary seed, 5% honey, 7.5% water, and 0.1% lemon juice. The snaps were made by heating the sugar, honey, lemon juice, and water to 155°C before adding the roasted canary seed groats. The mixture was then spread on a pan, scored into individual serving sizes, and allowed to cool before breaking along the score lines. Roasted yellow canary seed groats produced a more visually appealing product than roasted brown canary seed groats (Fig. 9). Both products had good texture and a mild flavor.

Cereal and Fruit Bars. Roasted yellow canary seed groats were substituted for 100% of the sesame seeds in a cereal and fruit bar formulation (quantities expressed in percentage of total weight): 23% rolled oats, 5.5% roasted canary seed groats, 5.4% unsweetened shredded coconut, 3.6% wheat germ, 0.3% salt, 5% brown sugar, 9.4% slivered almonds, 0.2% cinnamon, 0.5% vanilla, 26.1% liquid honey, 10.4% chunky peanut butter, 11% dried cranberries, and 0.13% xanthan gum. The ingredients were mixed together, pressed into a pan, and cut into individual serving sizes. The bars had an appealing appearance (Fig. 10) and a very acceptable flavor and texture.

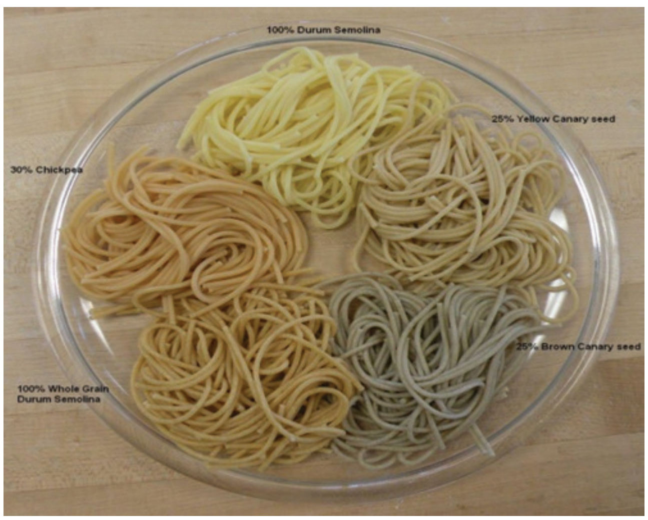


Fig. 7. Cooked spaghetti made with yellow and brown canary seed flour compared with spaghetti made with 100% durum semolina, 100% whole grain durum semolina, and 30% chickpea.

Fig. 8. Muffins made with 35% yellow canary seed flour.

Other Opportunities for Canary Seed Applications

Fractionation of canary seed has yielded protein-, starch-, and oil-rich fractions with unique characteristics (2). It has been suggested that canary seed starch may be well suited to applications in the cosmetic industry due to the small and uniform size of the starch granules compared with wheat starch (10). Furthermore, canary seed starch shows unique characteristics compared with wheat starch and may have potential for use in both food and nonfood applications (15–17). Likewise, protein isolated from canary seed groats may have potential as a supplementary or blending protein due to its high tryptophan content (6) and as a health promoter due to the antihypertensive properties of its peptides (9,28). More research on protein structure and functionality needs to be undertaken, particularly in light of the growing interest in plant-based proteins.

Conclusions

Glabrous canary seed provides a novel and nutritious alternative ingredient for use in the food industry, either as a complement to or as a substitute for common grains in food formulations. The examples of food products presented here demonstrate that dehulled glabrous brown and yellow canary seed (groats) can be processed into flour or roasted to produce a wide variety of bakery, pasta, and snack products with few required adjust-

Fig. 9. Confections (snaps) made with 100% roasted brown (left) and yellow (right) canary seed groats.

Fig. 10. Cereal and fruit bars made with 100% roasted yellow canary seed groats.

ments to product formulations and processing conditions. The flavor of canary seed flour and roasted canary seed groats is mild and does not detract from the flavor of the other ingredients in a formulation nor do canary seed flour and groats negatively affect product texture. Products made with yellow canary seed flour and roasted groats are more visually appealing than products made with brown canary seed flour and roasted groats.

Acknowledgments

Funding was provided by the Canaryseed Development Commission of Saskatchewan and the Agriculture Council of Saskatchewan through the Advancing Canadian Agriculture and Agri-Food Saskatchewan (ACAAFS) program. Funding for the ACAAFS program is provided by Agriculture and Agri-Food Canada.

References

1. Abdel-Aal, E.-S. M., and Hucl, P. Hairless canary seed: A potential food crop. Page 203 in: *Specialty Grains for Food and Feed*. E.-S. M. Abdel-Aal and P. Wood, eds. AACC International, St. Paul, MN, 2005.
2. Abdel-Al, E.-S. M., Hucl, P., Miller, S., Patterson, C. A., and Gray, D. Fractionation of hairless canary seed (*Phalaris canariensis*) into starch, protein and oil. J. Agric. Food Chem. 58:7046, 2010.
3. Abdel-Aal, E.-S. M., Hucl, P., Miller, S., Patterson, C. A., and Gray, D. Microstructure and nutrient composition of hairless canary seed and its potential as a blending flour for food use. Food Chem. 125: 410, 2011.
4. Abdel-Aal, E.-S. M., Hucl, P. J., Patterson, C. A., and Gray, D. Phytochemicals and heavy metals content of hairless canary seed: A variety developed for food use. LWT Food Sci. Technol. 44:904, 2011.
5. Abdel-Aal, E.-S. M., Hucl, P., and Sosulski, F. W. Characteristics of canary seed (*Phalaris canariensis* L.) starch. Starch 49:475, 1997.
6. Abdel-Aal, E.-S. M., Hucl, P. J., and Sosulski, F. W. Structural and compositional characteristics of canary seed (*Phalaris canariensis* L.). J. Agric. Food Chem. 45:3049, 1997.
7. Boye, J. I., Achouri, A., Raymone, N., Cleroux, C., Weber, D., Koerner, T. B., Hucl, P., and Patterson, C. A. Analysis of glabrous canary seeds by ELISA, mass spectrometry and western blotting for the absence of cross-reactivity with major plant food allergens. J. Agric. Food Chem. 61:6102, 2013.
8. Canaryseed Development Commission of Saskatchewan. Internal report benchmarking 10 varieties of yellow and brown canaryseed. CDCS, Saskatoon, SK, Canada, 2014.
9. Estrada-Salas, P. A., Montero-Morán, G. M., Martínez-Cuevas, P. P., González, C., and Barba de la Rosa, A. P. Characterization of antidiabetic and antihypertensive properties of canary seed (*Phalaris canariensis* L.) peptides. J. Agric. Food Chem. 62:427, 2014.
10. Goering, K. J., and Schuh, M. New starches. III. Properties of starch from *Phalaris canariensis*. Cereal Chem. 44:532, 1967.
11. Health Canada. Glabrous canary seed (*Phalaris canariensis* L.). Published on line at www.canada.ca/en/health-canada/services/food-nutrition/genetically-modified-foods-other-novel-foods/approved-products/glabrous-canary-seed-phalaris-canariensis.html. Health Canada, Ottawa, 2015.
12. Health Canada. Information for wheat-allergic individuals—Canary seed. Published on line at www.canada.ca/en/health-canada/services/food-nutrition/genetically-modified-foods-other-novel-foods/approved-products/information-wheat-allergic-individuals-canary-seed.html. Health Canada, Ottawa, 2016.
13. Hedrick, U. P., ed. Sturtevant's notes on edible plants. Page 487 in: *Report of the New York Agricultural Experiment Station for the Year 1919 (27th Annual Report, Volume 2, Part II)*. J. B. Lyon Company, State Printers, Albany, NY, 1919.
14. Hucl, P. Western Canada glabrous canary seed cooperative registration test. Internal document, Crop Development Centre, University of Saskatchewan. Prairie Grain Development Committee, www.pgdc.ca, 2009.
15. Irani, M., Abdel-Aal, E. S. M, Razavi, S. M. A., Hucl, P., and Patterson,

C. A. Thermal and functional properties of hairless canary seed (*Phalaris canariensis* L.) starch in comparison with wheat starch. Cereal Chem. 94:341, 2017.
16. Irani, M., Razavi, S. M. A., Abdel-Aal, E. S. M., Hucl, P., and Patterson, C. A. Dilute solution properties of canary seed (*Phalaris canariensis*) starch in comparison to wheat starch. Int. J. Biol. Macromol. 87:123, 2016.
17. Irani, M., Razavi, S. M. A., Abdel-Aal, E. S. M., and Taghizadeh, M. Influence of variety, concentration, and temperature on the steady shear flow behavior and thixotropy of canary seed (*Phalaris canariensis*) starch gels. Starch 68:1203, 2016.
18. Li, W., and Beta, T. An evaluation of carotenoid levels and composition of glabrous canary seed. Food Chem. 133:782, 2012.
19. Li, W., Qui, Y., Patterson, C. A., and Beta, T. The analysis of phenolic constituents in glabrous canary seed. Food Chem. 127:10, 2011.
20. MacKay, A. Experimental report for the North-West Territories. Page 291 in: *Experimental Farms Reports for 1891: Appendix to the Report of the Minister of Agriculture*. No. 7F. Available online at http://publications.gc.ca/collections/collection_2016/aac-aafc/A51-8-1891-eng.pdf. Canadiana Online Database. University of Saskatchewan. S. E. Dawson, Ottawa, 1892.
21. Prance, G., and Nesbitt, M. *The Cultural History of Plants*. Routledge, New York, page 44, 2005.
22. Robinson, R. G. Chemical composition and potential uses of annual canary seed. Agron. J. 70:797, 1978.
23. Robinson, R. G. Annual canarygrass: A potential food grain crop. Crops Soils Mag. 32:13, 1979.
24. Robinson, R. G. Registration of Keet annual canarygrass (*Phalaris canariensis*, cultivar). Crop Sci. 19:652, 1979.
25. Silva, L. P., and Ciocca, M. D. L. S. Total, insoluble and soluble dietary fiber values measured by enzymatic-gravimetric method in cereal grains. J. Food Compos. Anal. 18:113, 2005.
26. U.S. Food and Drug Administration. GRAS Notice No. 529: Seed of *Phalaris canariensis* L. (canary seed). FDA, Silver Spring, MD, 2015.
27. Usher, G. *A Dictionary of Plants Used by Man*. Constable and Company, London, page 451, 1974.
28. Valverde, M. E., Orona-Tamayo, D., Nieto-Rendon, B., and Paredes-Lopez, O. Antioxidant and antihypertensive potential of protein fractions from flour and milk substitutes from canary seeds (*Phalaris canarienis* L.). Plant Foods Hum. Nutr. (Dordr.) 72:20, 2016.
29. Ward, A. *The Grocer's Encyclopedia* or *The Encyclopedia of Foods and Beverages*. Available online at http://digital.lib.msu.edu/projects/cookbooks/books/grocersencyclopedia/ency.pdf. Baker & Taylor Company, New York, 1911.

Carol Ann Patterson is president of Pathfinders Research & Management Ltd, an agri-food consulting business specializing in the evaluation of functional attributes and health benefits of ingredients derived from plant, animal, and microbial sources. She led the novel food and GRAS submission for regulatory approval of canary seed. Carol Ann has a Ph.D. degree in applied microbiology and food science from the University of Saskatchewan. Carol Ann is an AACCI member and can be reached at capatterson@thepathfinders.ca.

Linda Malcolmson was the manager of Special Crops, Oilseeds and Pulses, at the Canadian International Grains Institute (Cigi) in Winnipeg, MB, where she undertook market development and applied research on Canadian field crops. Prior to joining Cigi she was a professor at the University of Manitoba. She is now a consultant with LM FoodTech Solutions in Winnipeg. Linda obtained her Ph.D. degree from the University of Manitoba in Food and Nutritional Sciences. Linda is an AACCI member and can be reached at malcolmsonlinda@gmail.com.

Chris Lukie obtained his M.S. degree from the University of Manitoba in food science. He has worked with a number of bakeries and breweries and was a technical specialist in baking at the Canadian International Grains Institute in Winnipeg, MB, where he undertook research on food barley and canary seed. His passion for brewing led to further education with Siebel's in Chicago and Doemen's in Munich. Chris is now working as a brewmaster at Swan's Brewpub in Victoria, BC.

Gina Young is a technologist at the Canadian International Grains Institute in Winnipeg, MB, where she is responsible for undertaking applied research on pulses and special crops. She obtained her B.S. degree in human nutritional sciences from the University of Manitoba.

Pierre Hucl is currently a professor in the Crop Development Centre (CDC; Department of Plant Sciences, University of Saskatchewan). Pierre joined the CDC in 1990. Prior to 1990 he worked in the private sector as a spring wheat breeder for more than three years. His current duties encompass the breeding and genetics of spring wheat, alternative wheat, and canary seed. Pierre is the developer or codeveloper of more than 65 varieties of wheat, canary seed, dry bean, pea, and peanut. He is the author or coauthor of more than 170 refereed papers and more than 100 conference abstracts and presentations.

Elsayed Abdelaal (E-S. M. Abdel-Aal) was named an AACCI Fellow in 2017 and is the former chair of the AACCI Bioactive Compounds Technical Committee (2008–2016) and vice-chair of the AACCI Nutrition Division (2014–2016). He is a well-known expert in the area of grain chemistry and nutrition, in which he has made significant contributions, particularly in the development of purple wheat products, hairless canary seed as a novel food, barley as a low-glycemic food, and high-lutein wheat/corn foods. He is the associate director, RDT for the Guelph Research and Development Centre with Agriculture and Agri-Food Canada. He is also an adjunct professor at the Universities of Toronto and Guelph. He is a coeditor of the bestselling book *Specialty Grains for Food and Feed* published by AACCI. Elsayed is an AACCI member and can be reached at Elsayed.Abdelaal@agr.gc.ca.