Journal of Functional Foods xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Functional Foods

journal homepage: www.elsevier.com/locate/jff

Total polyphenol content, carotenoid, tocopherol and fatty acid composition of commonly consumed Canadian pulses and their contribution to antioxidant activity

Emily M.T. Padhi, Ronghua Liu, Marta Hernandez, Rong Tsao, D. Dan Ramdath *

Guelph Research and Development Centre, Agriculture and Agri-Food Canada, Guelph, Ontario N1G 5C9, Canada

ARTICLE INFO

Article history:
Received 10 August 2016
Received in revised form 30 September 2016
Accepted 7 November 2016
Available online xxxx

Keywords:
Antioxidants
Bioactive
Carotenoids
Polyphenol
Pulse legumes
Tocopherols

ABSTRACT

To quantitate bioactive compounds in cooked cultivars of commercially available Canadian pulses, 14 peas, lentils, beans, and chickpeas were analyzed for total polyphenol content (TPC), antioxidant activity (DPPH, FRAP and ORAC) and fatty acid, carotenoid and tocopherol content. On a dry weight (DW) basis, cooked pulses contained (mean ± SD) 1.65 ± 0.10–8.39 ± 0.03% lipids; 22.5 ± 0.6–170.5 ± 2.0 μg/g total tocopherols, primarily γ-tocopherols (80–96%); 4.21 ± 0.40–20.26 ± 2.43 μg/g total carotenoids with lutein being the primary carotenoid (78–87%) then zeaxanthin (6–17%). TPC ranged from 1.16 ± 0.07 to 7.45 ± 0.69 mg gallic acid equivalents/g DW. TPC was significantly correlated with DPPH ($r = 0.688$, $p = 0.006$), FRAP ($r = 0.881$, $p < 0.001$) and ORAC ($r = 0.859$, $p < 0.001$). Antioxidant activity was related to tocopherol ($r = 0.665$, $p = 0.009$) but not carotenoid content ($r = 0.541$, $p = 0.132$). These results support the continued use of Canadian pulses for functional foods with health benefits.

Contents

Abbreviations: AAE, ascorbic acid equivalents; AAPH, 2,2′-azobis-(2-amidinopropane) dihydrochloride; BB, black turtle bean; CB, cranberry bean; CC, Consul chickpea; DPPH, 2,2-diphenyl-1-picrylhydrazyl; DW, dry weight; FAME, fatty acid methyl esters; FC, Frontier chickpea; FRAP, ferric reducing antioxidant power; GAE, gallic acid equivalents; HCl, hydrochloric acid; KB, dark red kidney bean; LC, Leader chickpea; LGL, large green lentil; MeOH, methanol; NB, navy bean; ORAC, oxygen radical absorption capacity; PTFE, polytetrafluorethylene; PVDF, polyvinylidene fluoride; SGL, split green lentil; SGP, split green pea; SRL, split red lentil; SYP, split yellow pea; TCC, total carotenoid content; TCI, total carotenoid index; TE, trolox equivalents; TPC, total polyphenol content; WYP, whole yellow pea; ZC, Cozy chickpea.

* Corresponding author.
E-mail address: dan.ramdath@agr.gc.ca (D.D. Ramdath).

http://dx.doi.org/10.1016/j.jff.2016.11.006
1756-4646/

1. Introduction

Pulses are the dried seeds of *Leguminosae* plants and are a staple in the human diet, valued for their high starch, protein and fibre content, in addition to an array of micronutrients (Tharanathan & Mahadevamma, 2003). Pulses are also a useful source of bioactive polyphenols, carotenoids and tocopherols, which may provide additional health benefits through their antioxidant activity (Rochfort & Panozzo, 2007). Elevated levels of reactive oxygen species have been implicated in the etiology and progression of cardiovascular diseases (CVD) inflammation and diabetes. It appears that oxidative stress induces cellular damage leading to endothelial dysfunction and a progressive deterioration of vascular health (Bielli, Scioli, Mazzaglia, Doldo, & Orlandi, 2015). Epidemiological evidence associates higher intakes of dietary antioxidants with lower rates of CVD (Tresserra-Rimbau et al., 2014), while increased serum antioxidant capacity is associated with greater glycemic control (Zemestani, Rafraf, & Ashgari-Jafarabadi, 2016), reduced blood pressure values (Rodrigo, Prat, Passaiacqua, Araya, & Bächler, 2008) and an improved blood lipid profile (Li, Zhang, Liu, Sun, & Xia, 2015). Further, there is evidence to suggest that phenolic compounds, being nucleophilic, can inhibit lipid peroxidation through their ability to scavenge free radicals and prevent free radical damage (Forman, Davies, & Ursini, 2014). This protective effect of polyphenol antioxidants is supported by mechanistic evidence which shows that certain food-derived components can prevent oxidative injury and cell apoptosis by donating electrons to unstable free radical molecules, thereby neutralizing their harmful activity (Rahal et al., 2014). Thus, regular consumption of commercially available pulses might provide valuable sources of antioxidants in addition to their unique fibre and protein contributions to human diets.

The major pulse crops grown and consumed globally include field peas, lentils, common beans and chickpeas, which represent over 70% of pulses consumed worldwide (FAO, 2015). Increased pulse consumption is associated with a reduced risk of several diet-related chronic diseases, including diabetes, metabolic syndrome, CVD, and cancer (Messina, 2014). Several clinical studies suggest that pulses reduce chronic disease risk by modulating serum lipids, and through hypoglycemic and anti-inflammatory mechanisms (Anderson et al., 2014; Pittaway, Ahuja, Robertson, & Ball, 2007; Winham, Hutchins, & Johnston, 2007). The action of several bioactive compounds in pulses, including polyphenols, resistant starch, and lipophilic antioxidants may also contribute to this protective effect (Rochfort & Panozzo, 2007), although the mechanisms are not fully understood. However, a majority of the population do not accrue these health benefits because pulses are currently underutilized as a food source in North America (Messina, 2014).

Increasing dietary intake of pulses represents an opportunity to improve population health, and the development of value-added products that highlight the functional properties of pulse foods may stimulate local consumption (Rochfort & Panozzo, 2007). To improve food development and formulation, more information is required about the bioactive constituents and antioxidant capacity of commercially available cooked pulses. Therefore, the objective of this study was to quantify polyphenolic compounds, carotenoids, and tocopherols in a selection of commercially available pulse varieties in Canada and relate these findings to antioxidant activity. Analyses were conducted on cooked pulse seeds to better approximate dietary intake of these bioactive compounds.

2. Methods and methods

2.1. Plant materials

Four pulse varieties that are commercially available in Canada were used for this study; they included field pea (*Pisum sativum*), lentil (*Lens culinaris*), bean (*Phaseolus vulgaris*) and chickpea (*Cicer arietinum*). Overall, 14 pulses were analyzed: 3 cultivars of pea (whole yellow pea, WYP; split yellow pea, SYP; split green pea, SGP); 3 cultivars of lentils (large green lentil, LGL; small green lentil, SGL; split red lentil, SRL); 4 cultivars of bean (dark red kidney bean, KB; navy bean, NB; cranberry bean, CB; black turtle bean, BB); and 4 cultivars of chickpea (Frontier chickpea [Kabuli], FC; Leader chickpea [Kabuli], LC; Consul chickpea [Desi], CC; Cozy chickpea [Desi], ZC). With the exception of lentil samples, which were rinsed and cooked immediately, all pulses were soaked overnight in excess deionized water and rinsed prior to cooking. All pulses (approx. 125 g, dry weight) were cooked in boiling deionized water (300–400 mL, 20–70 min.) with a partially open lid, until a sample of 5–6 seeds were easily crushed when depressed between two fingers. The cooking water was completely evaporated (i.e. no water discarded). Cooked samples were dried in a FreeZone® Plus 12 L Cascade freeze dry system (Labonco Corp., Kansas City, MO, USA), ground into fine powder using a M-20 Universal mill (IKA Works Inc., Wilmington, NC, USA), and filtered through a 250 μm (No. 60) sieve. Larger particles were ground in a MM 200 Mixer Mill (Retsch Ltd., Haan, Germany) for 2–3 min and then passed through the sieve. Ground samples were stored in Ziploc® plastic bags (Brantford, ON, Canada) that were wrapped in aluminum foil, and stored at −4 °C until use.

2.2. Chemicals and reagents

All standard reference materials including L-ascorbic acid, gallic acid, Folin-Ciocalteu's phenol reagent, fluorescein, 2,2-diphenyl-1-picrylhydrazyl (DPPH), Trolox, 2,2′-azobis-(2-amidinopropane) dihydrochloride (AAPH), tocopherol standards (α, γ, δ) and carotenoid standards (lutein, zeaxanthin) were purchased from Sigma-Aldrich Co. (St. Louis, MO, USA). Sodium acetate, ferric chloride

Please cite this article in press as: Padhi, E. M. T., et al. Total polyphenol content, carotenoid, tocopherol and fatty acid composition of commonly consumed Canadian pulses and their contribution to antioxidant activity. *Journal of Functional Foods* (2016), http://dx.doi.org/10.1016/j.jff.2016.11.006