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Phenolic Compositions and Antioxidant Activities of Newly Developed Day-neutral Strawberry Lines

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Abstract

The polyphenolic profiles and concentrations of 8 advanced day-neutral strawberry lines and cultivars were determined by high performance liquid chromatography (HPLC), total phenolic content (TPC) using the Folin-Ciocalteu method, and antioxidant capacity (AC) the ferric reducing/antioxidant power (FRAP). HPLC analysis identified and quantified several groups of phenolic compounds such as anthocyanins, flavonols, hydroxycinnamic, ellagic, and benzoic acids. Anthocyanins were the most predominant group accounting for 75.33% of the total phenolics. Large variations were observed between all strawberry lines, regarding phenolic compounds. FIN005-7 had the highest TPC and AC, and FIN005-55 had the lowest. The means of TPC and AC in strawberry lines were 848.0 and 1210.8 $\mu g \cdot g^{-1}$, respectively. Total phenolic content of the different lines correlated well with the antioxidant capacity ($r = 0.63$, $p < 0.01$). These results highlight the contribution of genetic background to total phenolic content, and emphasize their potential use in selecting lines as parents in future breeding program, in order to produce new lines having high antioxidant capacity.

Introduction

Strawberry (*Fragaria×ananassa* Duch), one of the most commonly consumed berries with unique, highly desirable taste and flavour, has been shown to be a rich source of phenolic compounds having antioxidant and antiproliferative activities (Wang *et al*., 1996; Halvorsen *et al*., 2002; Sun *et al*., 2002; Guo *et al*., 2003; Meyers *et al*., 2003). The polyphenolic compounds has important roles in plant defence mechanisms and external stresses (Feucht *et al*., 1992; Wang *et al*., 1994; Mayr *et al*., 1996; Di Venere *et al*., 1998). They also affect the quality, colour and taste of fruits, as well as their by-products like juice and fruit slices (Robards *et al*., 1999; Van der Sluis *et al*., 2002; Bushway *et al*., 2002). Karadeniz *et al*. (2005) and Lamien-Meda *et al*. (2008) reported that there is a high and significant correlation between total phenolic content and antioxidant activities. Fresh strawberries are unlike other fresh products, rapid cooling may only extend shelf-life for a few days. Senescence induced by oxidative stress causes physiological deterioration whereas endogenous antioxidant systems slow this process down. Hébert and Willemot (1997) investigated the possible relationship between antioxidant potential and fruit shelf-life of seven strawberry cultivars, and suggested that antioxidant potential of the tissues has an incidence on fruit quality and shelf-life. Hébert *et al.* (2002) suggested that the proanthocyanidin content can be used as an indicator of grey mold resistance in order to screen strawberry selections and cultivars for improved shelf-life and quality.

The objectives of the present work were to study and quantify individual phenolic compounds of selected advanced strawberry lines and to quantify their TPC and AC compared to known cultivars.

Materials and Methods

Eight advanced day-neutral strawberry lines and cultivars were collected randomly from three replicates established in Agriculture and Agri-Food Canada experimental farm, located at l'Acadie, Quebec. Ten grams of fresh-frozen fruits were used to determine the total phenolic content (TPC) and antioxydant capacity (AC). Folin-Ciocalteu method, FRAP and HPLC assays were used as described previously (Benzie and Strain, 1996; Tsao and Yang, 2003a; Tsao *et al*., 2003b).

Results and Discussion

Significant differences were observed among the tested strawberry genotypes (Table 1). Based on the Folin-Ciocalteu method and FRAP assay, FIN005-7, a new advanced line, contained the highest TPC (982.3 $\mu g \cdot g^{-1}$) and AC (1344.0 $\mu g \cdot g^{-1}$). Conversely, FIN005-55 contained the lowest (631.8 and 985.7 $\mu g \cdot g^{-1}$, respectively). The means of TPC and AC in strawberry lines were 848.0 and 1210.8 $\mu g \cdot g^{-1}$, respectively.

HPLC analysis identified and quantified five groups of phenolic compounds such as anthocyanins, flavonols, hydroxycinnamic, ellagic, and benzoic acids.

Among the five groups, anthocyanins were the most predominant group accounting for 75.33% of the total phenolics. FIN005-50 had the highest level, followed by SJN0328-2 and FIN005-7 with 435.3 and 394.3 $\mu g \cdot g^{-1}$, respectively. The lowest level was found in FIN0132-11 with 312.9 $\mu g \cdot g^{-1}$.

Hydroxycinnamic acids were the second most abundant group, accounting for 9.57% of the total phenolics among all genotypes. The highest content was observed in SJN0328-2 and SJN026-58, while FIN0132-11 had the lowest concentration.

Flavonols followed, depending on the genotypes, they varied from 21.6 to 85.3 $\mu g \cdot g^{-1}$.

Benzoic and ellagic acids constituted the lowest portion of the total phenolics, accounting for 4.83 and 2.09% of their composition, respectively. The highest benzoic acid content was observed in SJN0328-2, while FIN0132-11 had the lowest. Ellagic acid content varied from 7.8 to 14.1 $\mu g \cdot g^{-1}$ within all tested genotypes. The highest ellagic acid content was observed in SJN026-58, while FIN005-55 had the lowest.

Total phenolics, based on the sum of the five groups analyzed by HPLC, ranged from 370.5 to 657.9 $\mu g \cdot g^{-1}$. The mean of the total phenolics was 522.3 $\mu g \cdot g^{-1}$, with SJN0328-2 and FIN0132-11 having the highest and the lowest total phenolic concentrations, respectively. TPC of the different lines correlated well with AC ($r = 0.63$). This means that the higher TPC in fruits resulted in higher AC. A high and significant correlation was also observed between total anthocyanins and total phenolics ($r = 0.88$), while no significant difference was found between total anthocyanins and total phenolic content.

Results and Discussion (Cont'd)

Table 1. Total phenolic content (TPC) and antioxidant capacity (AC) of eight advanced day-neutral strawberry lines and cultivars.

Genotype	Total phenolic content[a] (µg GAE/g)	Antioxidant capacity[b] (µg AAE/g)
FIN005-55	631.8 b	985.7 c
FIN005-7	982.3 a	1344.0 a
FIN005-50	846.6 a	1170.7 b
FIN0016-115	967.3 a	1254.7 ab
SJN026-58	872.9 a	1278.3 ab
Seascape	856.5 a	1197.0 ab
FIN0132-11	800.5 ab	1164.0 b
SJN0328-2	825.8 a	1292.3 ab
Mean DN	848.0	1210.8
LSD $_{0.05}$	192.8	160.8

Values are means of three replicates for AC and duplicate for TPC.

a Total phenolic content (TPC) expressed as µg gallic acid equivalent (GAE) per gram fresh-frozen weight.

b Antioxidant capacity (FRAP assay): expressed as µg ascorbic acid equivalent (AAE) per gram fresh-frozen weight.

LSD 0.05: Least significant difference at 0.05 level.

From the above mentioned, our results show a significant variation in the antioxidant capacity, the total phenolics and the phenolic compounds, between and among the day-neutral strawberry genotypes. The major differences may be mainly due to their genetic profile but may also be due to flowering and fruiting times and/or environmental factors. High variability of antioxidant activity among the different genotypes clearly shows the potential value of certain new cultivars and advanced lines, and, their possible use in breeding programs to develop new strawberry cultivars having higher amounts of antioxidant compounds. Data analysis also showed a high significant correlation between TPC and AC in this study.

Although anthocyanins accounted for 75.33% of the total phenolics, in this study, there was no correlation between anthocyanins and total antioxidant activity, as in previous reports (Meyers et al., 2003; Khanizadeh et al., 2008). This result is probably due to other unquantified phenolics, vitamins or synergism among these compounds and/or major phenolics affecting the expected correlation between phenolics and antioxidant activities. Further research on strawberry is needed to evaluate the effect of storage and processing on the phenolic composition of these genotypes.

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