Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

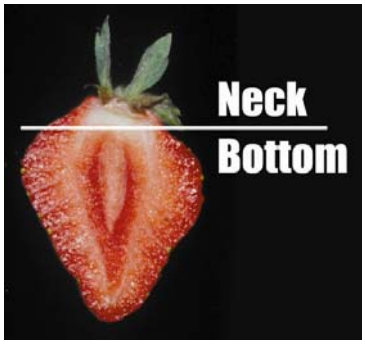
Distribution of phenolic and antioxidant capacity of strawberry fruit parts

Ying Wang[1,2], Djamila Rekika[1], Marie Thérèse Charles[1], Rong Tsao[3], Raymond Yang[3], Wenxuan Dong[2] and Shahrokh Khanizadeh[1,*]

[1] Horticultural Research and Development Centre, Agriculture and Agri-Food Canada, 430 Blvd. Gouin, St-Jean-Sur-Richelieu, QC, Canada, J3B 3E6; [2] College of Horticulture, Shenyang Agricultural University, 120 Road, Dongling Street Shenyang, Liaoning province, P. R. China, 110161; [3] Guelph Food Research Centre, Agriculture and Agri-Food Canada, Food 93 Stone Road West, Guelph, ON, Canada, N1G 5C9.

Abstract

Different fruit parts (neck vs rest) of the two selected strawberry lines 'Chambly' and 'LL0220-10' were evaluated for their total phenolic content (TPC), phenolics composition (PC) and total antioxidant capacity (TAC). TPC was evaluated using Folin-Ciocalteu (FC), PC using High Performance Liquid Chromatography (HPLC) and TAC using ferric reducing/antioxidant power (FRAP) assays. A significant interaction ($p<0.05$) was observed between the examined parts and the cultivars. Highest phenolics (sum of five groups) was found in the bottom fruit part of 'Chambly' compared to the neck while no difference was observed in the neck and the bottom fruit part of 'LL0220-10' line. Anthocyanins was the most predominant group and contributed to 83.53% of the phenolics. The data presented are the first step in establishing a correlation between fruit anatomy and chemical composition that could serve as a guide in breeding new strawberry lines with higher disease resistance.



Introduction

Strawberry *(Fragaria x ananasa* Deuch.*)* is an important cash crop in Canada. It is very nutritional but also delicate, perishable and have a very short post-harvest life which is partially due to gray mold caused by *B. cinerea*. Several cultural practices can help to minimize disease development including fungicide applications, temperature, controlled atmosphere, irrigation and moisture control in different growth stages and post-harvest, but primary in selecting the resistant cultivars (Hébert *et al*., 2002; Terry *et al.*, 2004). Authors have attributed variation in the inherent natural disease resistance of strawberry fruit to skin strength (Gooding, 1976), fruit tissue firmness (Barritt, 1980) and flower susceptibility (Bristow *et al*., 1986) as strawberries with raised neck, reflexed calyxes and greater flesh firmness seem to have a better resistance to gray mold (Olcott-Reid *et al*., 1995). Resistance of strawberries to gray mold was also associated to specific phenolics and to their antioxidant capacity. Strawberry cultivars with variation in phenolics content (Khanizadeh *et al.*, 2006) showed different shelf life and susceptibility to pathogen infections. High level of catechins found in immature strawberry fruits was associated with resistance to gray mold (Di Venere *et al*., 1998).

The objectives of this preliminary research were to establish if there is differences in PC composition of different fruit parts and furthermore to investigate if this composition have an affect on gray mold disease susceptibility.

Materials and Methods

Fruit samples from two selected strawberry lines 'Chambly' and 'LL0220-10', which both have deep red fruits with raised neck, elevated calyx, and uniform well-colored flesh, were collected from a completely randomized design in four replicates established in Agriculture and Agri-Food Canada experimental farm, located at l'Acadie, Quebec. The harvested fruits were separated into neck and bottom (Fig. 1). Previous methods used by Tsao et al (2003) and Wang et al (2002) were used to detect their TPC, PC and TAC.

Results

TPC and TAC determined by FC and FRAP, respectively, are shown in Table 1.

A significant variation was observed among the fruit parts of the two selected strawberry lines ('Chambly' and 'LL0220-10'). TPC ranged from 1093.11 µgGAE/g to 459.85 µgGAE/g. The highest TPC was found in the bottom fruit part of 'Chambly' (1093.11µgGAE/g) rather than in its neck (774.87µgGAE/g). The TPC of the neck and the bottom fruit part of 'LL0220-10' were both lower than that of 'Chambly', and no significant difference was found between them (585.09 µgGAE/g and 459.85µgGAE/g, respectively.). No significant difference was observed for TAC even though the TPC of these different fruit parts were different (Table 1). PC were divided into five groups. Our study revealed that anthocyanins was the most predominant phenolic accounting for 88.53% overall in all parts among the five groups, followed by total flavonols (7.89%), total hydroxycinnamic acids (3.66%), total benzoic acids (2.71%) and ellagic acids (2.22%).

The highest level of anthocyanins was found in the bottom fruit part of 'Chambly' (869.33µg g-1) followed by its neck (751.78µg/g), compared to the neck and the bottom fruit part of 'LL0220-10' (464.00µg/g and 435.99µg/g, respectively.), No significant difference could be found between the bottom and the neck of the 'LL0220-10'.

Total flavonols was the second group in abundance with 7.89% of the total PC. The bottom and the neck fruit parts of 'Chambly' had the highest content of the total flavonols (86.32 µg/g and 85.39µg/g), while no significant difference could be found between the bottom and the neck of the 'LL0220-10'.

The highest levels of total hydroxycinnamic and benzoic acids were found in the bottom fruit part of 'Chambly' (60.70 µg/g, 46.06 µg/g) and it was significantly different from the neck. No significant difference could be found between the bottom and the neck of 'LL0220-10'. The level of ellagic acids in the neck fruit part of 'LL0220-10' was significantly higher than in the bottom while no significant difference was observed in the neck and the bottom fruit part of 'Chambly'.

The amount of total phenolics (sum of five groups) in the frozen fruit parts analyzed by HPLC ranged between 1079.45µg/g and 477.27 µg/g. The highest total phenolics was found in the bottom fruit part of 'Chambly'(1079.45µg/g) compared to the neck (901.88µg/g). No significant difference was observed in the neck and the bottom fruit part of 'LL0220-10'.

Table 1. Distribution of TPC and TAC of the different fruit part of the two selected strawberry lines

Genotype	TPC[a] (µgGAE/g)	TAC[b] (µgAAE/g)
Chambly1 neck	774.87bc	1178.00a
Chambly2 bottom	1093.11a	1350.30a
Chambly3 whole fruit	893.34ab	1022.00a
LL0220-10(2) neck	585.09cd	1247.00a
LL0220-10(3) bottom	459.85d	1259.70a
LL0220-10(1)whole fruit	903.10ab	1449.30a
Mean	784.89	1266.67
$LSD_{0.05}$	280.53	588.24

FC and FRAP analysis were performed in triplicates.
[a]TPC is expressed as µg gallic acid equivalent (GAE) per gram, fresh-frozen weight.
[b]TAC is expressed as µg ascorbic acid equivalent (AAC) per gram, fresh-frozen weight.
$LSD_{0.05}$: Least significant difference at 0.05 level.

Discussion

Strawberries are a good source of natural antioxidants. Hébert *et al.* (2001, 2002), using a similar bioassay methodology to Jersch *et al.* (1989), found that aqueous extracts of immature strawberry, cv. 'Chandler' fruit, did have direct antifungal activity against *B. cinerea* conidial germination and mycelial growth. Cultivars with higher concentrations of free and bound catechin, epicatechin and gallic acid were more resistant to *B. cinerea*. A decline in the inherent natural disease resistance was correlated with a decrease in specific proanthocyanins with antifungal activity during fruit development. The greatest antifungal activity was found in green stage I of fruit extracts, especially in achenes (Terry, Leon A. *et al.*, 2004). In the present study, highest phenolics (sum of five groups) was found in the bottom fruit part of 'Chambly' compared to neck while no difference was observed in the neck and bottom fruit part of 'LL0220-10' line. As previously reported, there is a positive correlation or no correlation between free phenolics and TAC in a number of different fruits (Kalt *et al*., 2003; Wang and Lin, 2000; Rekika *et al*., 2005). According to Macheix *et al.* (1990), strawberries contain numerous phenolic compounds, and not all cultivars contain the same phenolic profile. Furthermore, they reported relative proportions of compounds within the profile and differences within these profiles might subsequently result in complex changes in antioxidant activity or other bioactivities. It is indicated that, at least for 'Chambly', compounds of different chemical classes other than phenolics may have contributed to their high antioxidant capacity.

Anatomically, strawberries with raised neck and reflexed calyxes have less water persisting which increase the circulation of air that may reduce infections by pathogens. Literature reported that strawberries contain 1% achenes, on a fresh weight basis; however, they contribute to about 11% of the total phenolics and have 14% of antioxidant activities in strawberries. Mature achenes contain more phenolics and have greater antioxidant activities than immature ones (Aaby, K. *et al*, 2005). In this study, total phenolics in the bottom fruit part of 'Chambly' was significantly higher than that in the neck which might be due to the higher number of achenes in the bottom fruit part compare to the neck .

In summary, our study revealed that total phenolics and antioxidant capacity of strawberries may be mainly due to their genetic background but may also be due to their morphological and anatomical characteristics which might be related to the susceptibilities of strawberries to gray mold.

References

Aaby, K., Skrede, G. and Wrolstad, R. E. 2005. Phenolic Composition and antioxidant activities in flesh and achenes of strawberries (*Fragaria ananassa*). *J. Agric. Food Chem.* 53: 4032-4040.

Boff, P., DE Krader, J., Gerlagh, M. & Köhl, J. 2003. The role of petals in development of Grey mold in strawberries. *Fitopatologia Brasileira*. 28: 76-83.

Guinebretiere, M.H., Nguyen-The, C., Morrison, N., Reich, M., Nicot, P., 2000. Isolation and characterization of antagonists for the biocontrol of the postharvest wound pathogen *Botrytis cinerea* on strawberry fruits. J. Food Prot. 63: 386–394.

Hébert, C., M. T., Charles, L. Gauthier, C. Willemot, S. Khanizadeh, and J. Cousineau. 2002., Strawberry Proanthocyanidins: Biochemical markers for *Botrytis cinerea* resistance and shelf life predictability. *Acta Hort.* 567: 659- 662.

Khanizadeh, S., Behrouz, E.M. Levasseur, A., 2006. Antioxidant capacity in June-bearing and day-neutral strawberry. *Can. J. Plant Sci*. 86: 1387-1390..

Kovach, J., Petzoldt, R., Harman, G.E., 2000., Use of honey bees and bumble Bees to disseminate *Trichoderma harzianum* 1295-22 to strawberries for botrytis control. *Biol. Control* 18: 235–242.

Nicholson, R. L., Hammerschmidt, R., 1992. Phenolic compounds and their role in disease resistance. *Annu. Rev. Phytopathol.* 30: 369-389.

Olcott-Reid, B. and Moore, J. 1995., Fruit firmness, calyx and neck ratings correlated with field fruit rot reactions of nine strawberry cultivars. *Fruit varieties journal.* 49(1): 14-19.

Khanizadeh, S., Tsao, R., Rekika, D., Yang, R., DeEll, J., 2007. Phenolic composition and antioxidant activity of selected apple genotypes, Journal of Agrcultural, Food, and Environmental Sciences 5 (1), 61-66.

Rekika, D., Khanizadeh, S., Deschenes, M., Levasseur, A., Charles, M.T., 2005. Atioxidant cpacity and phenolic content of selected strawberry genotypes. HortScience 40(6), 1777-1781.

Tsao, R., Yang, R., 2003b. Optimization of a new mobile phase to know the complex and real polyphenolic composition: towards a total phenolic index using high-performance liquid chromatography. *Journal of Chromatography A* 1018, 29–40.

Tsao, R., Yang, R., Young, J.C., 2003. Antioxidant Isoflavones in Osage Orange, Maclura pomifera (Raf.) Schneid. Journal of Agricultural and Food Chemistry 51, 6445-6451.

Corresponding Author: khanizadehs@agr.gc.ca **www.khanizadeh.info**

Canada