Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2004
Volume 7
Issue 1
**Series HORTICULTURE**


GAJEWSKI M. 2004. POLYPHENOLIC ACIDS CONTENT IN CAULIFLOWER (*Brassica oleracea* L. var. *botrytis*) AS AFFECTED BY GROWING PERIOD, CULTIVAR AND STORAGE CONDITIONS **Electronic Journal of Polish Agricultural Universities**, Horticulture, Volume 7, Issue 1.
Available Online http://www.ejpau.media.pl

# POLYPHENOLIC ACIDS CONTENT IN CAULIFLOWER (*Brassica oleracea* L. var. *botrytis*) AS AFFECTED BY GROWING PERIOD, CULTIVAR AND STORAGE CONDITIONS

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## ABSTRACT

Free polyphenolic acids content in four cauliflower cultivars – 'Panther', 'Isabel' $F_1$, 'Amfora' $F_1$ (cultivars with green curds) and 'Coleman' (cultivar with a white curd) was examined in 2001-2002. Cauliflowers were grown for harvest in spring, summer or autumn. The influence of gas composition of atmosphere during 6-week storage in a cold store (at the ambient atmosphere and at CA 5% $CO_2$ + 3% $O_2$) on polyphenolic acids content in cauliflowers harvested in autumn was also examined. Polyphenolic acids content was affected by period of growing and cultivar. Their concentration varied from 1.2 to 1.8 $mg \cdot g^{-1}$ of f.w. (means of the two years). The highest polyphenolic acids concentration was found in cv. 'Amfora' $F_1$ and the lowest in cv. 'Coleman'. During storage of cauliflowers polyphenolic acids concentration decreased. However, CA conditions inhibited to some degree changes in polyphenolic acids concentration in stored curds.

**Key words:** cauliflower, cultivars, storage, CA, polyphenolic acids

## INTRODUCTION

Several new cultivars of cauliflower with green curds have been introduced to growing practice in Poland lately. They yield very well in Polish climatic conditions. These cultivars are a result of crossing between white cauliflower and broccoli cultivars [4]. Optimum storage conditions for white cauliflower are: temperature of 0-1°C and 95-98% RH. Wrapping curds with a stretch plastic film is also recommended [1, 20, 21]. Controlled atmosphere (CA) storage offers moderate benefit to white cauliflower cultivars, however the best CA gas composition is 3-5% $CO_2$ + 2-3% $O_2$. Storage of cauliflowers for more than 3-4 weeks is not recommended. Some flavour changes of cauliflowers, when $CO_2$ concentration in the atmosphere exceed 5% was observed [1]. Green cultivars show a better storage ability than the white ones and they store well in CA composed of 5% $CO_2$ + 3% $O_2$, or 3% $CO_2$ + 3% $O_2$ [5, 6]. Green cauliflowers have different sensory characteristics than the white ones and they content more dry matter and Vitamin C [7].

Attention is paying last years to phenolic compounds in vegetables. There are reports on immunostimulating, antibacterial and antioxidative properties of polyphenolic acids [3, 15]. These compounds increase also plant resistance to some pathogens [14]. Changes in phenolic compounds content in some vegetables resulted from postharvest factors were investigated by several authors [2, 9, 10, 11, 12, 13, 18, 19]. Since PAc are often present in plants not in a free form, but as esters or glycosides or bounded to lignins or tannins, the concentration of free PAc in plant cells may increase as an effect of hydrolyze. Low $O_2$ concentration in the atmosphere or low temperature during storage may influence phenolic concentration in vegetable tissue. Phenolic accumulation during storage at ambient atmosphere was observed in carrot roots [2, 11]. Storing vegetables in CA conditions may cause an increase of phenolic concentration, and this was observed in case of stored lettuce [9, 12, 13] and zucchini fruits [8].

The aim of this work was to determine free polyphenolic acids content in different cultivars of cauliflower – green and white curd cultivars – and to examine the influence of growing period and storage conditions on a concentration of these compounds in curds.

## MATERIALS AND METHODS

**Plant material.** The two-year experiment was carried out at the Department of Vegetable and Medicinal Plants of Warsaw Agricultural University in 2001-2002. Plants were grown from transplants in the experimental field in Warsaw-Wilanów, on a silt soil, pH of about 7.0. The fertilizing was applied according to results of soil analysis (200 kg N, 100 kg $P_2O_5$ and 200 kg $K_2O$ per hectare) in each year of the experiment. Plants were chemically protected against pests and diseases, according to general recommendations. Climatic conditions during growing seasons 2001 and 2002 are shown in table 1. Three green curds cultivars and one white curd cultivar were chosen for the experiment. Cauliflowers were planted out and harvested at the terms, which are shown in table 2. Harvest was performed at the optimum maturity stage of curds. Curds were then taken to analysis as freshly harvested ones or wrapped with a PE stretch film and put to a cold store for analysis scheduled after their storage.

**Table 1. Temperature and rainfalls during growing seasons in 2001 and 2002**

| Month | Decade | Mean temperature, °C | | Rainfalls, mm | |
|---|---|---|---|---|---|
| | | 2001 | 2002 | 2001 | 2002 |
| May | 1 | 18.1 | 18.9 | 1.8 | 0.0 |
| | 2 | 15.6 | 16.5 | 20.3 | 9.7 |
| | 3 | 13.6 | 18.0 | 17.6 | 68.5 |
| June | 1 | 14.5 | 16.4 | 3.8 | 28.3 |
| | 2 | 15.8 | 19.4 | 12.1 | 26.2 |
| | 3 | 17.8 | 18.7 | 17.8 | 4.3 |
| July | 1 | 20.5 | 21.3 | 36.2 | 34.9 |
| | 2 | 22.1 | 22.2 | 44.2 | 7.6 |
| | 3 | 21.5 | 20.8 | 68.2 | 0.1 |
| August | 1 | 19.8 | 21.3 | 17.6 | 64.8 |
| | 2 | 21.6 | 20.8 | 0.3 | 29.5 |
| | 3 | 18.8 | 20.7 | 17.2 | 0.8 |
| September | 1 | 14.7 | 19.1 | 17.2 | 0.0 |
| | 2 | 13.2 | 12.3 | 31.9 | 18.4 |
| | 3 | 10.0 | 10.1 | 24.1 | 12.2 |

**Table 2. Schedule of experiments carried out in 2001 and 2002**

| Growing period | Terms of sowing | Terms of planting out | Terms of harvest |
|---|---|---|---|
| I (spring) | 1st decade of March | 2nd decade of April | 3rd decade of June |
| II (summer) | 3rd decade of April | 3rd decade of May | 3rd decade of July |
| III (autumn) | 3rd decade of May | 3rd decade of June | 3rd decade of September |

Two different experiments were performed:

**Experiment No. 1**. The influence of growing period on free polyphenolic acids (PAc) content in four cauliflower cultivars.

The two factors of this experiment were:

- Factor A: period of growing – spring (I period), summer (II period), autumn (III period);
- Factor B: cultivar – 'Panther', 'Isabel' $F_1$, 'Amfora' $F_1$ (green curd cultivars), 'Coleman' (white curd cultivar).

The experiment was performed in four replications, with 30 plants used for each replication. For the analysis whole curds were cut immediately after harvest on smaller parts and homogenized. Then samples of homogenized material were taken from each replication.

**Experiment No. 2.** The influence of storage conditions (gas composition of atmosphere) on PAc content in four cauliflower cultivars.

- Factor A: cultivar – as in the experiment No. 1 (see above).
- Factor B: storage conditions – freshly harvested cauliflowers, cauliflowers stored at the ambient atmosphere, cauliflower stored at controlled atmosphere (CA 5% $CO_2$ + 3% $O_2$).

Only cauliflowers from the autumn period of growing were taken for this experiment. The temperature of storage was 0°C, and RH 95%. Cauliflowers were stored for 6 weeks. The experiment was carried out in four replications and 8 curds in each replication were stored. For analyses the material was prepared immediately after storage period with the method described above.

Free PAc concentration in cauliflowers were determined according to the Polish Standard [17]. Polyphenolic acids were extracted from the plant material with water and then their concentration was determined by a spectrophotometer at light wavelength 490 nm. For the analysis of variance Anova program was applied and HSD Tukey's test was performed to show which mean numerical values differ significantly at P = 0.05.

## RESULTS AND DISCUSSION

Data presented show that sums of rainfalls were differentiated for months (tab. 1). The heaviest rainfalls took place in July 2001 and August 2002. The two seasons of the experiment were quite warm and the temperature during all months was a little higher than the mean value for last 60 years.

Freshly harvested cauliflowers contained 1.2-1.8 $mg \cdot g^{-1}$ of PAc (tab. 3). It corresponds well with values 0.7-3.2 $mg \cdot g^{-1}$, which were determined for cauliflower by other authors [16, 22]. It was noted that period of growing significantly influenced PAc content in curds in both years of the experiment. Means of the two years show a tendency to the lowest PAc concentration for the second (summer) period of growing. However, differences between 2001 and 2002 in PAc concentration in curds were noticeable. For 2001 differences in PAc concentration between cauliflowers grown in spring (I) and summer (II) period were nonsignificant. For 2002 these differences were significant and the lowest PAc concentration was found in cauliflowers grown in summer period. This might be caused by big differences in rainfalls during the vegetation period of 2002. In both years of

the experiment PAc concentration in the autumn cauliflowers was relatively high. PAc content was also significantly influenced by a cultivar (in both years of the experiment). The lowest value of PAc concentration was observed for cv. 'Coleman' (the white one) and the highest value – for cv. 'Amfora' $F_1$ (the green one).

**Table 3. Free polyphenolic acids content in cauliflower curds as affected by growing period and cultivar**

| Factor | | Free polyphenolic acids content, $mg \cdot g^{-1}$ f.w. | | |
|---|---|---|---|---|
| growing period (A) | cultivar (B) | 2001 | 2002 | means of the two years |
| I (spring) | Amfora | 1.34 | 1.54 | 1.44 |
| | Isabel | 1.23 | 1.76 | 1.50 |
| | Panther | 1.21 | 1.62 | 1.42 |
| | Coleman | 1.18 | 1.56 | 1.37 |
| II (summer) | Amfora | 1.28 | 1.33 | 1.31 |
| | Isabel | 1.32 | 1.32 | 1.32 |
| | Panther | 1.25 | 1.35 | 1.30 |
| | Coleman | 1.16 | 1.24 | 1.20 |
| III (autumn) | Amfora | 1.58 | 2.01 | 1.80 |
| | Isabel | 1.46 | 1.58 | 1.52 |
| | Panther | 1.51 | 1.48 | 1.50 |
| | Coleman | 1.44 | 1.34 | 1.39 |
| Means for growing period (A) | I | 1.24 a | 1.62 b | 1.43 b |
| | II | 1.25 a | 1.31 a | 1.28 a |
| | III | 1.50 b | 1.60 b | 1.55 b |
| Means for cultivar (B) | Amfora | 1.40 b | 1.63 c | 1.52 c |
| | Isabel | 1.34 ab | 1.55 bc | 1.45 bc |
| | Panther | 1.32 ab | 1.48 ab | 1.40 ab |
| | Coleman | 1.26 a | 1.38 a | 1.32 a |
| LSD A×B (P = 0.05) | | n.s. | n.s. | n.s |

**Different letters in the same column indicate that means differ significantly according to HSD Tukey's test at P = 0.05.**
**n.s. – interaction nonsignificant at P = 0.05**

A significant effect of storage at different gas composition on PAc content in cauliflowers was observed in both years of the experiment (tab. 4). Freshly harvested curds showed higher concentration of PAc than the stored ones, but CA storage slightly inhibited changes in PAc concentration compared with ambient atmosphere storage. Results of the experiment showed that CA storage of cauliflowers did not cause any increase of PAc concentration in curds. However, in the author's other experiment [8] was observed that an increase of PAc concentration took place in stored zucchini fruits. Other authors noted an increase of phenolic concentration during storage of lettuce [12].

**Table 4. Free polyphenolic acids content in cauliflower curds as affected by cultivar and storage conditions**

| Factors of the experiment | | Polyphenolic acids content, $mg \cdot g^{-1}$ f.w. | | |
|---|---|---|---|---|
| cultivar (A) | storage (B) | 2001 year | 2002 year | means of the two years |
| Amfora | before storage | 1.58 | 2.01 | 1.80 |
| | ambient atmosphere | 1.02 | 1.04 | 1.03 |
| | CA 5 + 3 | 1.20 | 1.24 | 1.22 |
| Isabel | before storage | 1.46 | 1.58 | 1.52 |
| | ambient atmosphere | 1.12 | 1.26 | 1.19 |
| | CA 5 + 3 | 1.30 | 1.32 | 1.31 |
| Panther | before storage | 1.51 | 1.48 | 1.50 |
| | ambient atmosphere | 0.84 | 0.68 | 0.76 |
| | CA 5+3 | 1.15 | 0.96 | 1.06 |
| Coleman | before storage | 1.44 | 1.34 | 1.39 |
| | ambient atmosphere | 0.82 | 0.78 | 0.80 |
| | CA 5 + 3 | 1.18 | 0.99 | 1.09 |
| Means for cultivar (A) | Amfora | 1.27 b | 1.43 b | 1.35 b |
| | Isabel | 1.29 b | 1.39 b | 1.34 b |
| | Panther | 1.17 a | 1.04 a | 1.11 a |
| | Coleman | 1.15 a | 1.05 a | 1.10 a |
| Means for storage conditions (B) | before storage | 1.50 b | 1.60 b | 1.55 b |
| | ambient atmosphere | 0.95 a | 0.94 a | 0.95 a |
| | CA 5 + 3 | 1.21 ab | 1.13 a | 1.17 ab |
| LSD A×B (P = 0.05) | | n.s. | n.s. | n.s |

**CA 5+3 - controlled atmosphere 5% $CO_2$ + 3% $O_2$**
**Note: see table 3**

The influence of cultivar on PAc concentration in cauliflowers after storage was also significant (tab. 4). The two green cultivars – 'Amfora' $F_1$ and 'Isabel' $F_1$ showed higher PAc content than other cultivars. In other author's experiments it was observed that cv. 'Amfora' $F_1$ showed better storage ability than other cauliflower cultivars [5, 6] and also better sensory quality [7].

## CONCLUSIONS

1. Polyphenolic acids concentration in cauliflower curds is affected by a cultivar and growing period. Green cauliflower cultivars ('Amfora' $F_1$, 'Isabel' $F_1$, 'Panther') showed a higher concentration of polyphenolic acids than the white one ('Coleman'). The highest concentration of polyphenolic acids was found in cauliflowers grown for autumn harvest.
2. During storage of all cauliflower cultivars a decrease in polyphenolic acids concentration take place and CA storage slightly inhibits these changes, compared to the ambient atmosphere storage.

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