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USEFULNESS OF SELECTED BROCCOLI VARIETIES FOR FREEZING

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K e y w o r d s: broccoli, freezing, vitamin C, carotenoids, polyphenols.

A b s t r a c t

The purpose of this investigation was to evaluate the usefulness for freezing of new broccoli varieties. The evaluation was based on chemical composition of fresh and frozen broccoli stored for three months. The study was conducted on seven broccoli varieties, namely: SVR 97, SVR 99, SVR 1002, SVR 1017, Ironman, Beneforte and Bellaverde. The broccoli were obtained directly from the producer (Moszna, near Nałęczów). Physico-chemical analysis which were conducted on the samples involved determination of: dry mass, soluble solids, acidity, vitamin C, total carotenoids, total sugars and polyphenols content. Our results let us to conclude that it is unable to type the variety that would have the highest values of all analysed parameters. Beneforte variety could be of particular interest as it possesses high levels of sugars, carotenoids, polyphenolics, acidity, soluble solids and dry mass. In this variety, the smallest drop of analysed chemical compounds was noticed, as the result of blanching and freezing.

PRZYDATNOŚĆ WYBRANYCH ODMIAN BROKUŁA DO MROŻENIA

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S ł o w a k l u c z o w e: brokuł mrożenie, witamina C, karotenoidy, polifenole.

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Abstrakt

Celem pracy było określenie przydatności technologicznej nowych odmian brokuła do mrożenia w oparciu o charakterystykę fizykochemiczną surowca i produktu zamrożonego, przechowywanego przez trzy miesiące. Do badań wykorzystano 7 odmian brokuła: SVR 97, SVR 99, SVR 1002, SVR 1017, Ironman, Beneforte i Bellaverde. Surowiec uprawiano w prywatnym gospodarstwie ogrodniczym w Mosznej koło Nałęczowa. Analiza obejmowała oznaczenie zawartości suchej masy, ekstraktu ogółem, kwasowości, witaminy C, sumy karotenoidów, cukrów ogółem i związków fenolowych ogółem. Na podstawie przeprowadzonych analiz stwierdzono, iż nie można jednoznacznie wskazać jednej odmiany, która charakteryzowałaby się najwyższymi wartościami wszystkich analizowanych parametrów. Niemniej jednak, na szczególną uwagę zasługuje odmiana Beneforte, charakteryzująca się wysoką zawartością cukrów, karotenoidów, polifenoli, kwasów ogółem, ekstraktu i suchej masy. W odmianie tej stwierdzono najmniejsze straty poszczególnych związków chemicznych, będące wynikiem obróbki wstępnej surowca oraz przebiegiem procesu mrożenia i 3 miesięcznego przechowywania.

Introduction

Cultivation of broccoli in Poland dates to the beginning of the XX century when they started to be grown thank to appropriate climate conditions. Broccoli were accepted by consumers due to their extraordinary nutritional value which results from the high content of provitamin A (β -carotene), vitamin B_1, and vitamin C, minerals and fiber. Additionally, good sensory features (mild taste and flavor) along with anticancer properties make them highly attractive (SZYDŁOWSKA and CZARNIECKA-SKUBINA 2006, GĘBCZYŃSKI 2003, KRALA et al. 2007, ZALEWSKA-KORONA 2004).

Spain is the biggest broccoli producer is Europe (the annual production is approximately 280.000 tons) followed by Italy and Great Britain. In Poland its cultivation covers approximately 5.000 hectares, whereas the crop is estimated to be 50.000 tons. The production is concentrated mainly near the cities like Cracow, Warsaw and Kujawy region (GRABOWSKA and KUNICKI 2013).

However, seasonal character of the crop causes the necessity to ensure the continuity of delivery during the late autumn, winter and spring. The most useful method to preserve broccoli is freezing as it enables to retain attractive appearance along with the high quality (LEE and KEDDAR 2000, BĄKOWSKI 2002).

The most important features that affect the usefulness for freezing are: the size, density and colour of flower heads and lack of woody stems. Another relevant factor is capability to retain high nutritional value, appropriate consistency, mild taste and flavour and intense green colour.

The aim of this investigation was to evaluate the suitability for freezing of new broccoli varieties and to assess the influence of freezing on chemical composition and the content of biologically active compounds after three months storage.

Materials and Methods

The study was conducted on seven broccoli varieties, namely: SVR 97, SVR 99, SVR 1002, SVR 1017, Ironman, Beneforte and Bellaverde. The broccoli were obtained directly from the producer (Moszna, near Nałęczów). They were washed and divided into florets. One part of the material, referring as the fresh, was analysed two hours after the harvest. The second part was blanched at 95°C for four minutes (blanching parameters were set according to peroxidise test) cooled and frozen in a chest freezer. The samples were kept at -20°C for three months. Physico-chemical analyses, which were conducted on the samples, involved determination of: dry mass, soluble solids, acidity, vitamin C and total carotenoids content, all of which were done according to Polish Norms. Additionally, total sugar and polyphenolics content were determined according to Somogyi-Nelson and Folin-Ciocalteu methods, respectively (Staniec and Bojarska 1997, Radzki et al. 2014). All measurements were done in triplicate and the obtained data was expressed as mean ±SD (standard deviation). The data was compared using analysis of variance ANOVA with a level of significance set at $\alpha = 0.05$. Statistically different data was evaluated by Tukey's test.

Results and Discussion

The results on fresh broccoli are presented in table 1, while the data on frozen broccoli in table 2. All the data were calculated on fresh weight basis. Dry mass content of the seven broccoli varieties differed statistically and ranged from 12.20% to 14.19% in fresh samples and from 9.72% to 12.26% in the frozen ones. The highest dry mass content was observed in Beneforte and Bellaverde varieties (14.19% and 14.05%, respectively) (Table 1). The highest level of dry mass noticed for the frozen samples was 12.26% (Beneforte), while the lowest was 9.72% (Ironman). The decrease of dry mass content in frozen broccoli could result from blanching. Similar effect was noticed by GĘBCZYŃSKI and LISIEWSKA (2006). An analogue relation was observed in the content of soluble solids, total sugars, and vitamin C. According to GĘBCZYŃSKI (2003) dry mass content in fresh and frozen broccoli amounted of 10.4% and 9.01%, respectively. In different work researchers observed that dry mass content in fresh and frozen broccoli (stored for four months) reached 10.34% and 9.17–11.22, respectively. Other author noted that dry mass content amounted of approximately 10% and 8.5%, correspondingly in fresh and frozen broccoli (WIECZOREK 2007).

Table 1

The basic quality parameters in fresh broccoli

Variety	Dry matter [%]	Total soluble solids [%]	Acidity [%]	Total sugars [%]	Vitamin C [mg 100 g^{-1}]	Total corotenoids [mg 100 g^{-1}]	Polyphenols [mg 100 g^{-1}]
Bellaverde	$14.05^{c} \pm 0.88$	$6.57^{b} \pm 0.15$	$0.36^{b} \pm 0.08$	$4.75^{c} \pm 0.06$	$17.05^{b} \pm 0.00$	$5.16^{b} \pm 0.00$	$97.53^{b} \pm 0.55$
Beneforte	$14.19^{c} \pm 0.20$	$5.40^{a} \pm 0.17$	$0.32^{a-b} \pm 0.00$	$5.53^{d} \pm 0.05$	$14.20^{a} \pm 0.00$	$4.30^{a} \pm 0.00$	$173.41^{d} \pm 0.61$
Ironman	$12.54^{a-b} \pm 0.15$	$5.33^{a} \pm 0.12$	$0.30^{a-b} \pm 0.07$	$2.99^{a} \pm 0.04$	$16.10^{a-b} \pm 1.65$	$4.99^{b} \pm 0.00$	$87.33^{a} \pm 1.51$
SVR 97	$12.72^{a-b} \pm 0.25$	$7.40^{c} \pm 0.10$	$0.20^{a} \pm 0.03$	$4.23^{b} \pm 0.13$	$14.20^{a} \pm 0.00$	$7.17^{d} \pm 0.08$	$103.26^{c} \pm 0.46$
SVR 99	$13.49^{b-c} \pm 0.14$	$8.37^{e} \pm 0.06$	$0.31^{a-b} \pm 0.02$	$4.27^{b} \pm 0.05$	$17.05^{b} \pm 0.00$	$6.39^{c} \pm 0.28$	$85.48^{a} \pm 0.84$
SVR 1002	$12.74^{a-b} \pm 0.10$	$5.33^{a} \pm 0.12$	$0.25^{a-b} \pm 0.00$	$3.00^{a} \pm 0.03$	$20.84^{c} \pm 1.64$	$7.37^{d} \pm 0.41$	$102.49^{c} \pm 0.61$
SVR 1017	$12.20^{a} \pm 0.31$	$7.87^{d} \pm 0.06$	$0.26^{a-b} \pm 0.05$	$5.81^{e} \pm 0.04$	$17.05^{b} \pm 0.00$	$7.13^{d} \pm 0.11$	$102.42^{c} \pm 0.90$

Mean values denoted by different letters in the columns differ statistically significantly ($p \leq 0.05$).

Table 2

The basic quality parameters of frozen broccoli

Variety	Dry matter [%]	Total soluble solids [%]	Acidity [%]	Total sugars [%]	Vitamin C [mg 100 g^{-1}]	Total corotenoids [mg 100 g^{-1}]	Polyphenols [mg 100 g^{-1}]
Bellaverde	$10.04^{a} \pm 0.25$	$5.20^{c} \pm 0.10$	$0.18^{b} \pm 0.01$	$2.45^{c-d} \pm 0.05$	$14.2^{b-c} \pm 0.00$	$11.25^{b} \pm 0.13$	$68.74^{c} \pm 0.61$
Beneforte	$12.26^{b} \pm 0.77$	$5.33^{c-d} \pm 0.15$	$0.30^{c} \pm 0.01$	$3.38^{e} \pm 0.12$	$12.31^{a-b} \pm 0.00$	$11.72^{b} \pm 0.03$	$111.45^{d} \pm 0.55$
Ironman	$9.72^{a} \pm 0.17$	$5.53^{d-e} \pm 0.15$	$0.19^{b} \pm 0.00$	$2.39^{c} \pm 0.04$	$15.15^{c} \pm 1.54$	$13.95^{c} \pm 0.20$	$69.39^{c} \pm 0.57$
SVR 97	$10.18^{a} \pm 0.27$	$4.60^{b} \pm 0.00$	$0.13^{a} \pm 0.01$	$1.98^{b} \pm 0.04$	$11.36^{a} \pm 0.00$	$16.75^{d} \pm 0.55$	$51.75^{a} \pm 0.54$
SVR 99	$10.31^{a} \pm 0.07$	$4.27^{a} \pm 0.58$	$0.19^{b} \pm 0.01$	$1.33^{a} \pm 0.06$	$14.2^{b-c} \pm 0.00$	$21.84^{e} \pm 0.54$	$68.53^{c} \pm 0.80$
SVR 1002	$11.71^{b} \pm 0.22$	$5.83^{e} \pm 0.12$	$0.18^{b} \pm 0.01$	$2.43^{c} \pm 0.11$	$18.00^{d} \pm 1.41$	$4.41^{a} \pm 0.13$	$65.12^{b} \pm 0.49$
SVR 1017	$10.57^{a} \pm 0.54$	$5.20^{c} \pm 0.10$	$0.18^{b} \pm 0.00$	$2.73^{d} \pm 0.20$	$11.37^{a} \pm 0.00$	$11.64^{b} \pm 0.44$	$66.45^{b} \pm 0.49$

Mean values denoted by different letters in the columns differ statistically significantly ($p \leq 0.05$).

The amount of soluble solids showed wide variation among the frozen samples and ranged from 5.33 to 8.37%. The highest soluble solids level in fresh broccoli was observed of SVR 99 variety (Table 1). In frozen product the highest content was observed in SVR 1002 varieties (the values reached above 5.83%) (Table 2).

An average total sugar content in the fresh samples ranged from 2.99% for Ironaman variety to 5.81% for SVR 1017 variety (Table 1). The frozen broccoli contained lower amounts of total sugars which varied between 1.33% (SVR 99 variety) to 3.38% (Beneforte variety) (Table 2).

Total acidity in the analysed fresh samples varied from 0.20 to 0.36%. The highest values were noticed for Bellaverde and Beneforte varieties (0.36 and 0.32%, respectively) (Table 1). Among the frozen samples Beneforte variety contained the highest level of total acids (0.30%), while the lowest was observed for SVR 97 variety (Table 2). Our data are in agreement with KOWALCZYK et al. (2010) who reported that acidity content of fresh broccoli reached up to 0.3%.

With respect to vitamin C contents in fresh broccoli, the highest value was noticed for SVR 1002 variety (20.84 mg 100 g^{-1}), while the lowest for SVR 97 and Beneforte varieties (14.20 mg 100 g^{-1}). In frozen broccoli its quantity reached the maximum for SVR 1002 variety (18.00 mg 100 g^{-1}), whereas the lowest content was noticed for SVR 97 and SVR 1017 varieties (11.36 mg 100 g^{-1} and 11.37 mg 100 g^{-1}, respectively). Storing at -20°C lead to substantial loss of vitamin C content. The observed decrease ranged from 5.9% for Ironman variety to 33.3% for SVR 1017 variety (Table 1, 2). According to GĘBCZYŃSKI fresh broccoli contained 11.4 mg 100 g^{-1}d.w. of vitamin C, while frozen ones 7.01 mg 100 g^{-1}d.w. Other studies reported that the content of vitamin C in fresh and frozen broccoli amounted of 106 mg 100 $g^{-1}$and 29 to 60 mg 100 g^{-1}, respectively (GĘBCZYŃSKI and LISIEWSKA 2006). On the other hand, other researchers, who investigated 80 different varieties grown in California, observed much higher vitamin C content, ranging from 57.35–131.35 mg 100 g^{-1} fresh weight (KOH et al. 2009). According to SINGH at al. (2007) the levels of vitamin C in broccoli cultivated in India varied from 25.5 to 82.3 mg 100 g^{-1}fresh weight.

The content of total carotenoids in fresh and frozen broccoli varied between 4.30–7.37 mg 100 g^{-1} and 4.41 to 21.84 mg 100 g^{-1}, respectively. Among the fresh samples, SVR 1002 variety contained the highest amounts of carotenoids, while Beneforte variety showed the lowest value. In frozen broccoli the highest concentration of caroteoids was noticed for SVR 99 variety and the lowest for SVR 1002 (Table 1, 2). The increase of carotenoids content in frozen samples could be attributed to the applied thermal processing. As a result of blanching, carotenoids that were bound to tissue structure could be released. According to

DRUŻYŃSKA et al. (2009) an average content of total carotenoids measured in fresh broccoli was 27.2 mg 100 g^{-1} dry weight, while in cooked broccoli 36.4 mg 100 g^{-1} d.w. Other authors demonstrated that fresh and frozen broccoli contained 3.5 mg 100 g^{-1} and 2.8–3.6 mg 100 $g^{-1}$of carotenoids, respectively (GĘBCZYŃSKI and LISIEWSKA 2006).

Regarding to the total polyphenolics content, its quantity ranged from 85.48 to 173.41 mg 100 g^{-1} in fresh samples and from 51.75 to 111.45 mg 100 g^{-1} in frozen samples. The highest level of phenolics was noticed in Beneforte variety, both fresh and frozen. WIECZOREK (2007) stated that average content of phenolics in fresh broccoli amounted of 129 mg 100 g^{-1}, whereas frozen broccoli contained 90 mg 100 g^{-1} of phenolics. Our data are higher than those obtained by GĘBCZYŃSKI and LISIEWSKA (2006) who reported that the level of phenolics in fresh and frozen broccoli reached 87.4 mg 100 g^{-1} and 47.4 to 64.5 mg 100 g^{-1}, respectively.

Conclusions

1. The analysed varieties differed in the tested physico-chemical parameters.

2. Beneforte variety could be of particular interest as it possess high contents of sugars carotenoids, polyphenolics, acidity, soluble solids and dry mass.

3. In Beneforte variety, the smallest drop of analysed chemical compounds was noticed, as the result of blanching and freezing.

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