Scientific Bulletin. Series F. Biotechnologies, Vol. XXV, No. 1, 2021
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

IMPACT OF SOME ELEMENTS IN THE CULTIVATION TECHNOLOGY ON BIOCHEMICAL AND QUALITATIVE CHARACTERISTICS OF RASPBERRY FRUIT

Stanislava ATANASOVA[1], Maria GEORGIEVA[2], Diyan GEORGIEV[2], Petya IVANOVA[3]

[1]Trakia University, Studentski grad, Stara Zagora, Bulgaria
[2]Research Institute of Mountain Stockbreeding and Agriculture,
281 Vasil Levski Street, Troyan, Bulgaria
[3]Institute of Food Preservation and Quality, 154 Vasil Aprilov Street, Plovdiv, Bulgaria

Corresponding author email: michajlova@abv.bg

Abstract

The biochemical composition of raspberry fruit was studied at two different planting distances. Their qualitative characteristics were determined. The impact of an individual technological element on the studied indicators was analysed. The experiment included raspberry cultivars, such as 'Willamette', 'Meeker', 'Samodiva' and a candidate cultivar 'Magdalena' from the collection plantation of RIMSA-Troyan. The planting material was produced in vitro. The planting distances were: 0.30 m and 0.50 m in the intra row spacing and 3.00 m in the row spacing. The highest amount of anthocyanins (38.87 mg) and total polyphenols (263.37 mg%) were reported for 'Willamette' fruit at 0.50 m planting distances. The highest antioxidant activity was reported in 'Willamette' fruit (7750.00 µmol TE/100 g) (at 0.30 m) and 'Samodiva' (6625.00 µmol TE/100 g) (at 0.50 m). The sensor rating is in the range from 4.63 ('Willamette' - 0.50 m) to 4.93 ('Magdalena' candidate cultivar - 0.30 m).

Key words: *biochemical composition, cultivars, cultivation technology, fruit quality, raspberry.*

INTRODUCTION

Raspberry is a cosmopolitan fruit crop. It is widespread in almost every continent because of its plasticity and taste. Its fruits have an exceptional taste and fine aroma. They are an important dietary source of vitamins, minerals and fiber. Red, violet, purple or blue colour is due to the presence of antioxidants in them that enhance human health. Many authors focus their studies on proving the biological activity in raspberry fruits that has anticancer, antibacterial, antiviral, anti-inflammatory and cardiovascular disease prevention (Wang, 2000; Moyer et al., 2002; Mullen et al., 2003; Cerda et al., 2005; Seeram et al., 2006; Jakobek et al., 2007; Heinonen, 2007; Borges et al., 2007)
The purpose of the present article is to follow the impact of some elements of raspberry cultivation technology on the biochemical composition and quality of the fruit.

MATERIALS AND METHODS

The experiment was set in 2018. The objective of the present experiment was selected Bulgarian cultivars, such as 'Samodiva' and 'Magdalena' (a candidate cultivar) and two cultivars that are products of the world selection, such as 'Meeker' and 'Willamette'. The choice is not accidental. 'Samodiva' is characterized by good fruitfullness, resistance to abiotic and biotic stress factors and the ability to be cultivated without a support structure. Candidate cultivar 'Magdalena' is a prospective cultivar, which is selected in RIMSA Troyan and is characterized by good shoot formation, moderate to strong growth and good taste of the fruits. 'Meeker' and 'Willamette' are introduced cultivars with good characteristics and suitable for cultivation in hilly areas.
The following biochemical characteristics of fruit of the selected cultivars were investigated:
- *dry weight matter* (%) - 5 to 10 g were taken from the sample, using glass weight, glass rod and quartz sand;
- *dry matter* (DM) according to (refractometer) Re (%);
- *sugars* (total, invert and sucrose) and acid, according to the method of Schoorl (Donchev et al., 2001), 25 g of sugars were taken from the

sample; chemicals: 10% $NaCO_3$, $NaHPO_4$, Fehling's solution I, Fehling's solution II (made in the laboratory), 30% KJ, 1: 6 H_2SO_4, titrated by 0.1 n $Na_2S_2O_3$ and starch indicator - sugars; 5 ml of acids were taken from the primary filtrate (as malic) by titration with 0.1 n NaOH (%) and phenolphthalein indicator - acids;

- *tanning substances* according to the method of Levental (Donchev et al., 2000), 25 g of tannins were taken from the sample. Chemicals: 1: 4 H_2SO_4, titrated by 0.1 KM_4O_4 and an indicator (indigo carmine);

- *anthocyanins* (mg%) according to the method of Fuleki and Francis (1968), 2 g were taken from the sample. Chemicals: 96% spirt, buffer with pH 1.0; buffer with pH 4.5;

- *pectin* according to the method of Melitz (Donchev et al., 2000), 12.5 g were taken from the sample. Chemicals: 0.1 n NaOH, 1 n CH_3COOH, $CaCl_2$, $AgNO_3$;

- *total polyphenols* (mg GAE/100 g fresh weight) according to the method of Singleton and Rossi (1965). In a test tube, 0.1 ml of sample extract was successively mixed with 0.5 ml of Folin-Ciocalteu - reagent (diluted 1: 4 with distilled water) and 1.5 ml of aqueous sodium carbonate solution (7.5%, w/v), bringing the volume to 10 mL with distilled water. The reaction mixture was allowed to stand for 2 hours in the dark at room temperature before to measure the absorption at 750 nm. The results obtained are presented as (GAE) in mg/100 g sample.

- *total antioxidant capacity* was evaluated by determination of radical-scavenging activity with DPPH (2,2-diphenyl-1-picrylhydrazy) - test. The procedure is based on the method of Brand-Williams et al. (1995). Trolox, a water-soluble vitamin E analogue, was used as a standard and the results were expressed as Trolox equivalents (TE) in μmol per 100 g sample.

- *DPPH-test*

The procedure is based in the following modification: 2250 μl of DPPH methanolic solution (6 x 10^{-5} M) were mixed with 250 μl of sample extract (diluted with distilled water in a 1:3 v/v ratio); absorbance at 515 nm was measured after 15 minutes of staying of the reaction mixture in a closed cuvette in the dark at room temperature.

- *antioxidant activity* (μmol TE/100 g) methodology was adapted according to the method of Brand-Williams et al. (1995).

All spectrophotometric measurements were performed at UV-Vis spectrophotometer Helios Omega, with VISION *lite* software (Thermo Fisher Scientific, Madison, WI, USA).

Quality characteristics of fruit:

- pH; appearance; colour; consistency; aroma; taste; overall tasting evaluation; total sensory evaluation calculated.

Color assessment

Color assessment was evaluated by Gardner with colorimeter Colorgard 05/CIELab 2000 (BYK-Gardner Inc. USA) (Damyanov, 2005a; Damyanov, 2005b). CIE Lab system was used for color measurement (CIE. (1986)). Color was expressed in L*, a* and b* values, where:

L - lightness: 100 for white and 0 for black;

a* - positive values for red color and negative ones for green color;

b* - positive values for yellow color, negative values for blue color.

The measurement was performed in five replicates and the results were expressed as mean values.

The biochemical analyzes of fruits were carried out in the chemical laboratory of RIMSA-Troyan, antioxidant activity and their qualitative characteristics were determined in department "Food technology" of the Institute of Food Preservation and Quality, Plovdiv.

The field experiment was based on the methodology of plant resources (Nedev et al., 1979).

Data processing was performed by the methods of variation and two-way dispersion analysis (Lidanski, 1988), using MS Excel software-2010.

The collection plantation is located on a slope with an eastern exposure and altitude of 460 m. The soils are grey forest. The planting schemes are as follows: 0.30 m and 0.50 m in the intra row spacing and 3.00 m in the row spacing.

The agrotechnics involved naturally grassed row spacing and the intra row spacing was kept as follow.

RESULTS AND DISCUSSIONS

The fresh fruit biochemical composition reported a dry weight ranging from 11.08% ('Samodiva' 0.30 m), for comparison, the other variant at 0.50 m -12.06% to 14.57% ('Meeker' 0.30 m) (Table 1). Dry refractometric substances are represented in values from 6.50% ('Samodiva' 0.30 m) to 12.50% ('Meeker' 0.30 m). Total sugars were in the range of 1.30% ('Willamette' 0.50 m and candidate cultivar 'Magdalena' 0.30 m) to 2.40 ('Meeker' 0.50 m and 'Samodiva' 0.30 m). The lowest amount of inverted sugar was found in candidate cultivar 'Magdalena' (0.50) - 0.65%, while the highest amount was found in 'Meeker' (0.30 m) and 'Samodiva' (0.30 m) - 1.45%. The lowest sucrose values were found in 'Willamette' (0.50 m) - 0.62% and the highest value in candidate cultivar 'Magdalena' (0.50 m) - 1.38%. Organic acids ranged from 0.32% ('Meeker' 0.30 m) to 0.70% ('Willamette' 0.50 m, candidate cultivar). The tannins ranged from
0.019% ('Meeker' 0.30 m) to 0.225% ('Willamette' 0.50 m). The amount of anthocyanins ranged from 6.29 mg/% (a candidate cultivar 'Magdalena' 0.30 m) to 38.87 mg/% ('Willamette' 0.50 m). That is to say there was a considerable variation in the indicator. It is noteworthy that higher values were obtained for variants of cultivars with longer planting distances. Pectin was in high values and ranged from 1.15% ('Meeker' 0.30 m) to 3.45% (a candidate cultivar 'Magdalena' 0.50 m). The total polyphenols content ranged from 104.14 mg/% ('Samodiva' 0.50 m) to 167.77% ('Meeker' 0.50 m). Significant variation is observed in the antioxidant activity ranging from 2625.00 µmol

Table 1. Biochemical composition of fresh fruit of raspberry cultivars in 2018

Sample No	Dry weight matter (%)	DM in Re (%)	Total sugars (%)	Inverted sugar (%)	Sucrose (%)	Acids (as malic) (%)	Tannins (%)	Anthocyanins in (mg %)	Pectin (%)	Total polyphenols (mg %)
'Willamette' 0.50 m	12.53	9.00	1.30	0.65	0.62	0.70	0.225	38.87	2.11	263.37
'Willamette' 0.30 m	12.29	9.50	1.75	0.65	1.05	0.51	0.094	14.35	2.59	110.30
'Meeker' 0.50 m	14.57	11.00	2.40	1.30	1.05	0.64	0.037	20.97	2.69	167.77
'Meeker' 0.30 m	12.88	12.50	2.10	1.45	0.62	0.32	0.019	10.30	1.15	147.20
'Samodiva' 0.50 m	12.06	8.50	2.10	0.95	1.09	0.64	0.056	26.29	2.88	104.14
'Samodiva' 0.30 m	11.08	6.50	2.40	1.45	0.90	0.70	0.056	24.35	3.39	172.37
candidate cultivar 'Magdalena' 0.50 m	11.44	7.00	2.10	0.65	1.38	0.51	0.037	22.26	3.45	162.30
candidate cultivar 'Magdalena' 0.30 m	13.14	8.50	1.30	1.30	-	0.70	0.037	6.29	2.30	115.12
$\bar{x} \pm SE$	0.38	0.70	0.16	0.13	0.15	0.05	0.02	3.62	0.26	18.17
St Dev	1.08	1.97	0.44	0.37	0.42	0.13	0.07	10.23	0.74	51.41
VC %	8.64	21.74	22.8	35.24	50	22.03	100	50	28.79	33.1
LSD-0.05	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s

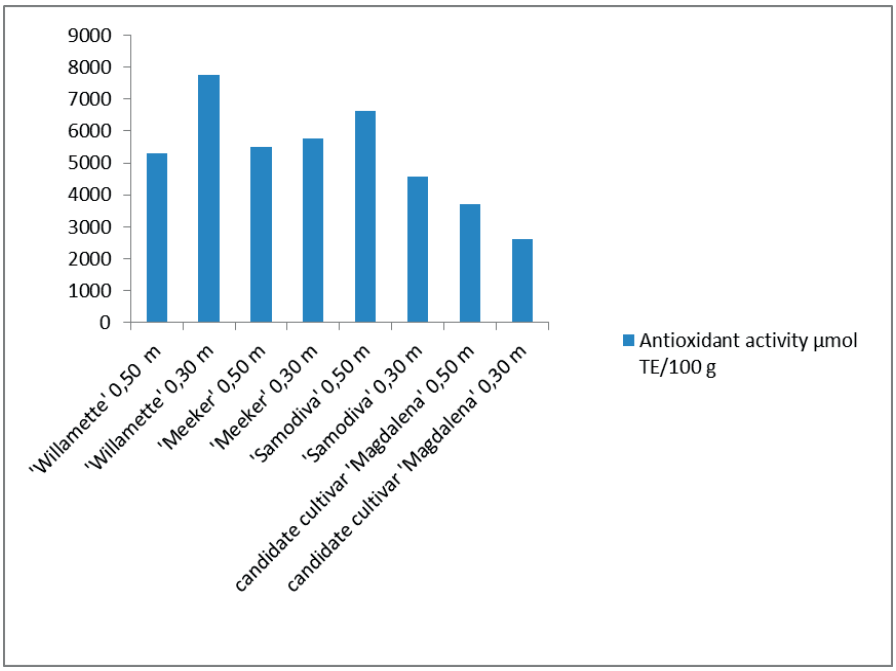

Figure 1. Antioxidant capacity of raspberry fruit of different variants and cultivars

TE/100 g (candidate cultivar 'Magdalena' 0.30 m) to 7750.00 µmol TE/100 g for 'Willamette' in the same variant (Figure 1). There is no pronounced tendency among the variants.

The quality characteristics of fruits are presented in Table 2. pH values were almost even and highly acid. Fruit appearance was at maximum values for 'Willamette' (both variants), 'Meeker' (0.50 m), 'Samodiva' (0.50 m) and candidate cultivar 'Magdalena' (0.30 m) with a grade of 5.00. In other words, the greater the planting distance higher the values. Colour is an important indicator of cultivar specificity. The variation range was close to 4.75 ('Meeker' 0.50 m, and 'Samodiva' 0.30 m) to 5.00 (for other cultivars and variants). The fruit consistency was rated with a maximum score of 5.00 with the exception of 'Samodiva' (0.30 m). Fruit aroma determines to a great extent the attractiveness of raspberry fruit. The highest grades were obtained by 'Willamette' and candidate cultivar 'Magdalena' at planting distances of 0.30 m and the lowest by 'Meeker' in the same variant. The results show that there is no definite relationship between the variants. Fruit taste is next indicator that determines the complex evaluation. The results show that no maximum score was obtained. The highest value for all cultivars was 4.75 (except 'Willamette' 0.50 m). A value giving a high degree of that indicator. The same parameters were obtained when calculating the total tasting score of fruit.

Table 2. Quality characteristics of raspberry cultivars in 2018

Sample No	pH	Appearance	Colour	Consis-tency	Aroma	Taste	overall taste evaluation	total sensory evaluation	L	a	B
'Willamette'0.50 m	3.45	5.00	5.00	5.00	4.00	4.50	4.5	4.63	22.60	44.22	15.22
'Willamette'0.30 m	3.53	5.00	5.00	5.00	5.00	4.75	4.75	4.94	27.91	39.51	14.14
'Meeker' 0.50 m	3.43	4.50	4.75	5.00	4.75	4.75	4.75	4.73	25.94	42.77	16.25
'Meeker' 0.30 m	3.47	5.00	5.00	5.00	4.5	4.75	4.75	4.88	23.75	38.45	12.38
'Samodiva' 0.50 m	3.49	5.00	5.00	5.00	4.75	4.75	4.75	4.88	20.68	45.47	14.81
'Samodiva' 0.30 m	3.48	4.50	4.75	4.75	4.75	4.75	4.75	4.70	26.34	34.65	10.09
candidate cultivar 'Magdalena' 0.50 m	3.36	4.75	5.00	5.00	4.75	4.75	4.75	4.83	29.29	39.60	20.93
candidate cultivar 'Magdalena' 0.30 m	3.43	5.00	5.00	5.00	5.00	4.75	4.75	4.93	28.10	42.31	14.04
ẋ ±SE	0.02	0.08	0.04	0.03	0.11	0.03	0.03	0.04	1.06	1.24	1.11
St Dev	0.05	0.23	0.12	0.09	0.32	0.09	0.09	0.11	2.99	3.51	3.14
VC %	1.45	4.75	2.43	1.81	6.82	1.91	1.91	2.28	11.69	8.59	21.32

The analysis of the total sensory evaluation shows that all cultivars are approaching the maximum evaluation. The highest value was obtained by 'Willamette' and candidate cultivar 'Magdalena' at planting distances of 0.30 m.

The analysis of colour parameters shows that the highest fruit brightness was observed in candidate cultivar 'Magdalena' in both variants: 29.29 (0.50 m) and 28.10 (0.30 m). The lowest value of 20.68 was observed in 'Samodiva' (0.50 m). High value is observed in the 'Wilamette' and 'Samodiva' varieties of 0.30 m variant. Fruit colour characteristics show that red colour tone is significantly higher than yellow. The highest red colour values were obtained in 'Samodiva' (0.50 m) and 'Willamette' 0.50 m). The values were higher in greater planting distances, with the exception of candidate cultivar 'Magdalena'. A certain correlation may be sought between the applied agricultural technology. Higher values of yellow colour were found in the variant of larger planting distance. There was a distinctive difference in the variant with candidate cultivar 'Magdalena' (20.93) in comparison with the other cultivars.

CONCLUSIONS

The results obtained allow us to make the following findings about the relationship between plant agrotechnics and the indicators studied:

A higher content of anthocyanins was reported at larger planting distances of cultivars and variants.

Red colour value was higher at planting distances of 0.50 m, except for candidate cultivar 'Magdalena'.

Yellow colour was more prevalent at longer planting distances.

The content of total polyphenols was higher in planting distance of 0.50 m, with the exception of 'Samodiva'.

The overall sensory evaluation was higher for 'Willamette', 'Meeker' and candidate cultivar 'Magdalena' than the shorter planting distances.

The antioxidant activity was higher in 'Willamette', 'Meeker' and 'Magdalena' than the variant with 0.30 m planting distance.

REFERENCES

Borges, G. G., Roowi, S., Rouanet, J.-M., Duthie, GG, Lean, MEJ, Crozier, A. (2007). The bioavailability of raspberry anthocyanins and ellagitannins in rats. *Mol. nutr. food res.*, 6, 714-725.

Brand-Williams, W., M. Cuvelier, C. Berst. (1995). Use of a free radical method to evaluate antioxidant activity. *Lebensmittel wissenschaft and technologie*, 28, 25-30.

CIE. (1986). Colorimetry. Ed. CIE # 15 centrally. *Bureau committee. intern. l'eclairage Vienna*.

Cerda, B., Tomás-Barberán FA, Espín JC. (2005). Metabolism of antioxidant and chemopreventive ellagitannins from strawberries, raspberries, walnuts, and oak-aged wine in humans: identification of biomarkers and individual variability. *J. Agric. food chem.,* 53. 227–235.

Damyanov, Ch. (2005a). Color and Quality - *Food processing magazine,* 2, 20-24.

Damyanov, Ch. (2005b). Color and Quality - *Food processing magazine,* 3, 13-15.

Donchev, Hr., Zlateva D, Pashova S. (2000). Food science, laboratory exercise guide, (pp. 61-63). Part Two, Varna, BG: University of Economics Publishing House.

Donchev, Hr., Zlateva D, Pashova S, Ivanov A. (2001). *Food science, laboratory exercise guide* (pp.103-106). Part First, Varna, BG: University of Economics Publishing House.

Fuleki T., Francis F.J. (1968). *Journal of food science,* 33(5), 471.

Heinonen, M. (2007). Antioxidant activity and antimicrobial effect of berry phenolics – a Finnish perspective. *Molecular nutrition and food research,* 51, 684-691.

Jakobek, L., Šeruga, M., Novak I., Medvidović-Kosanović, M. (2007). Flavonols, phenolic acids and antioxidant activity of some red fruits. *Deutsche lebensmittel-rundschau,* 103, 369-378.

Moyer, R. A., Hummer, K. E., Finn, C. E., Frei, B., Wrolstad, R. E. (2002). Anthocyanins, phenolics and antioxidant capacity in diverse small fruits: Vaccinium, Rubus and Ribes. *Journal of agricultural and food chemistry,* 50, 519-525.

Mullen, W, Yokota, T., Lean, MEJ, Crozier, A. (2003). Analysis of ellagitannins and conjugates of ellagic acid and quercetin in raspberry fruit by LC-MS, *Phytochemistry*, 64, 617-624.

Lidanski T. (1988). *Statistical methods in biology and in agriculture*. (pp. 43-62; 135-160), Zemizdat, Sofia (Bg).

Nedev, N., Grigorov, Y., Baev, Hr., Serafimov, S., Strandzhev, Al., Kavardzhikov, L., Lazarov, Kr., Nikolov, N., Dzhuvinov, V., Popova, L., Slavov, N., Iliev, P., Stoyanov, D., Kanev, Il., Krinkov, H., Vishanska, Yu., Topchiyska, M., Petrova, L. (1979). *Methods for studying of planting resources of fruit crops.* (pp. 111-116). Plovdiv, BG.

Seeram, N.P., Adams, LS, Zhang Y., Lee, R., Sand, D., Scheuller, HS, Heber D. (2006). Blackberry, black raspberry, blueberry, cranberry, red raspberry. and strawberry extracts inhibit growth and stimulate apoptosis of human cancer cells in vitro. *J. agric. food chem.,* 54, 9329-9339.

Singleton, V., Rossi, J. (1965). Colorimetry of total phenolics with phosphomolybdic- phosphotungstic acid reagents. *American journal of enology and viticulture,* 50, 3828-3834.

Wang, S.Y., Lin, H.S. (2000). Antioxidant activity in fruits and leaves of blackberry, raspberry and strawberry varies with cultivar and developmental stage. *J. agric. food chem,* 48, 140-14.

FOOD BIOTECHNOLOGY