STUDY ON INFLUENCE OF SOME CONVENTIONAL AND BIOLOGICAL FERTILIZERS ON THE BIOCHEMICAL COMPOSITION OF FRESH AND DRIED FRUITS OF 'TEGERA' PLUM CULTIVAR

Denitsa Hristova[1], Diyan Georgiev[1], Boryana Brashlyanova[2], Petya Ivanova[2]

[1]Research Institute of Mountain Stockbreeding and Agriculture (RIMSA), Troyan, Bulgaria
[2]Food Research and Development Institute (FRDI), Plovdiv, Bulgaria

Corresponding author: den_1986@abv.bg

Abstract
The study presents the results of the effect of different fertilization types on the biochemical composition of fresh and dried plum fruit of 'Tegera' cultivar. The scientific experiment was carried out in 2016 at Research Institute of Mountain Stockbreeding and Agriculture - Troyan. Three fertilization types were applied in the experiment: biological, conventional and granulated chicken manure. Higher values for sugars, anthocyanins, tanning substances and pectin were reported as a result of fertilization in comparison with the control. The highest content of total polyphenols in fresh 210.00 mgGAE/100 and dried 390.00 mgGAE/100 fruit was found in the conventional fertilization. The greatest level of antioxidant activity of fresh fruit was found in the variant of chicken manure - 926.67 µmolTE /100 g and the conventional fertilization - 597.78 µmolTE/100 g, while it was 220.00 µmolTE / 100 g in dried fruit variant with the biological fertilization.

Keywords: plums, antioxidant activity, total polyphenols.

Introduction

Plum belongs to one of the most common groups of fruit trees (Blažek, 2007). It is differentiated as a perspective culture, traditional for Bulgarian agriculture. It takes the fourth place of distribution after apple, peach and pear. Fertilization is an important element in the soil fertility management in order to achieve good results, including fruit plum trees with strong growth, producing quality fruit. The fertilization process is one of the main agro-technical activities. It affects the vegetative and reproductive phenomena of trees. Both the insufficient soil stocking with basic nutrients as well as the high fertilization dose, lead to adverse effects on orchards (Arnhold et al. 1914, Thoden et al. 2011, Burmeister et al. 2015, Chauvin et al. 2015). The biochemical composition of fruit is directly dependent on the specific agrometeorological conditions of the area and plant cultivation technologies, such as soil treatment, fertilizing, pruning, etc. (Vitanova, 1990 Ruiz, 2006, Kader et al. 2004). Researches on the effect of fertilization on the biochemical composition of plum fruits were conducted by (Cuquel et al. 2011). They found that with fertilization with N and K in the amount of 40 and 110 kg / ha / year, fruits had the highest quality during storage.
In recent years, the so-called bio-fertilization, including composting, green fertilization, the use of fertilizers certified for biological application and others (Yadav et al., 2000).One of the main differences between conventional and organic agriculture is how the problem of soil fertility is addressed. Conventional agriculture relies on short-term solutions to improve plant nutrition, mainly by using mineral fertilizers. Organic agriculture uses environmentally-friendly preventive and/or long-term solutions to increase and preserve the organic matter in soil (Reganold et al. 1987, Stoykova, 2004, Stancheva, 2007).
The aim of present research is to study the biochemical composition of fresh and dried plums of 'Tegera' cultivar in different fertilizing variants.

Material and methods

The experiment was carried out in 2016 in a collection plantation of the Research Institute of Mountain Stockbreeding and Agriculture - Troyan. The object of the study is fruits of plum cultivar of

'Tegera'. The planting distances are 4/2.5 m. Inter row spacing is covered with tall fescue and the intra row spacing is kept in black fallow. That culture is grown according to its agro-technical requirements. The following fertilization variants have been applied in the experiment:

- I variant - Bio-fertilization - including the following fertilizers: Agriful (soil) - 5 l/da, Tecamin Flower (foliar) - 0.3%, Teknokel Amino Ca (foliar) - 0.4%
- II variant - Conventional - Yara Mila Complex (soil) - 0.500 kg/tree, YaraVita Frutrel (leaf) - 0.500 ml/da, Yara Vita Universal Bio (leaf) - 0.500 ml/da
- III variant - Granulation of chicken manure - 0.500 kg/tree;
- IV variant - Control

Fertilization schedule:

- Agriful - applied five times from the beginning of vegetation over a period of 15-20 days;
- Tecamin Flower - imported twice. Applied before blossoming and during the formation of a fruit-set;
- Tecnokel Amino Ca - imported twice. Applied after blossoming and a month before harvesting;
- Yara Mila Complex - imported once in the intra row spacing;
- YaraVita Frutrel - four-fold application. First in the phase of winter buds, in phase of white button, during the formation of fruit-set and a month before the harvest;
- Yara Vita Universal Bio - three-fold application. Applied before and after blossoming and after harvest.
- Granulation of chicken manure - one application in the intra row spacing.

The biochemical composition of fruits is studied at the chemical laboratory of RIMSA - Troyan. The following indices are studied: dry matter according to Re (%), dry weight (%), sugars (%) (total, invert and sucrose) - according to Schoorl and Regenbogen method, acids (%) - by titration with 0.1n NaOH; ascorbic acid (mg %) - according to Fialkov method; anthocyanins (mg %) - according to Fuleki and Franciss method; pectin (%) - according to Melitz method, tanning substances (%) - according to Levental method. The total polyphenols (mgGAE / 100) and the antioxidant activity (µmolTE / 100 g) of fruits were determined at the laboratory of Food Research and Development Institute in Plovdiv.
The fruit drying process was carried out at FRDI - Plovdiv, by means of a heat pump. Drying took place at temperatures up to 45 ° C, which preserved high quality and native properties of the product. The process runs in a closed cycle using the same air and eliminates the additional microbial visitation from outside air.

Results and discussion

Fruits of 'Tegera' cultivar usually ripen in the second half of July, which characterizes it as an early ripening cultivar for Troyan region. The harvest in 2016 took place on 18 July.
The results of the biochemical analysis of plum fruits are presented in Table 1. The content of total polyphenols (mgGAE/100) and antioxidant activity (µmolTE / 100 g) are presented in Figure 1 and Figure 2.
For fresh fruit, dry weight matter is 18% to 20%. As a result of the narrow boundaries between variants, the reported variance coefficient is low.
The amount of soluble dry matter is almost identical for all four variants ranging from 17% to 18% at a very low variation coefficient.
There is also a slight variation in the content of total sugars. It is 9.55% for the conventional fertilization (II variant), while the fertilization with the chicken manure shows 10.25%. Variation coefficient is low (2.99%). Almost identical results ranging from 10.31% to 11.78% were obtained by the analysis of seven plum hybrids and three control varieties (Milosevic and Milosevic 2012).

Table 1. Biochemical composition of fresh plums of 'Tegera' cultivar

Indicators / Variants	Dry weight, %	Dry matter in Re, %	Total sugars, %	Invert sugar, %	Sucrose, %	Acids as malic , %	Ascorbic acids, mg %	Tannin substances, %	Anthocyanins, mg %	Pectin, %
I	19.10	17.3	10.05	4.85	4.94	0.64	4.40	0.270	19.19	0.87
II	19.53	17.5	9.55	6.50	2.90	0.64	5.28	0.270	16.61	0.71
III	18.53	17.5	10.25	5.20	4.80	0.64	6.16	0.208	10.00	0.45
IV	18.70	17.5	10.05	4.05	5.70	0.64	5.28	0.249	48.39	0.51
CV %	2.35	0.57	2.99	19.82	25.97	-	13.61	11.73	72.23	30.25

A more significant difference is found in invert sugar values. The highest values are found in the conventional fertilization - 6.50% and the lowest in the control - 4.05%. The variation coefficient is high as a result of these differences. Concerning the amount of sucrose, a strong variation between the variants has been reported in its values. It is 2.90% for conventional fertilization, while the results of the control were twice higher - 5.70%. A high variation coefficient is reported. With respect to the organic acid indicator, it is 0.64%. The ascorbic acid indicator ranges from 4.40 mg /% in bio-fertilization to 6.16 mg /% in chicken manure at a low variation coefficient. The value of the result recorded in conventional fertilization corresponds to the value recorded for the control - 5.28 mg /%. There are no significant differences in the amounts of tanning substances. The results obtained are in the range of 0.208% for chicken manure to 0.270% for organic and conventional fertilization. Differences between variants have low variance coefficient (11.7%).

The lowest content of anthocyanins are recorded in the variant with chicken manure - 10.00 mg /% and the highest for the control - 48.39 mg /%. The variance coefficient is high for them (72.2%).

Pectin content is an indicator with significant differences between fertilizer variants. Its amount is high for bio fertilization - 0.87%, for conventional fertilization is less - 0.71% and it is the lowest for the other two variants (CV 30.2%). The highest values of total polyphenols in fruits were recorded in conventional fertilization - 210.00 mgGAE / 100, followed by control - 190.00 mgGAE / 100, organic fertilization - 127.00 mgGAE / 100 and chicken manure - 124.00 mgGAE / 100 (Figure 1). The results are of high variation coefficient, where the influence of fertilization on the values of the indicator can be taken into account. A similar amount of common polyphenols was analyzed by (Kaulmann et al. 2014) ranging from 5 to 209 mg GAE / 100 g FW. (Kim et al. 2003) also reported similar results where the total polyphenols in fresh fruit were in the range of 181.3 mgGAE / 100 g for 'Stanely' cultivar to 372.6 mg GAE / 100 g for 'Beltsville Elite' cultivar. In a study by (Chun et al. 2003), their amount also ranges from 138.1 mgGAE / 100 g for 'NY 9' (New York 9) cultivar to 684.5 mgGAE / 100 g for 'Beltsville Elite' cultivar.

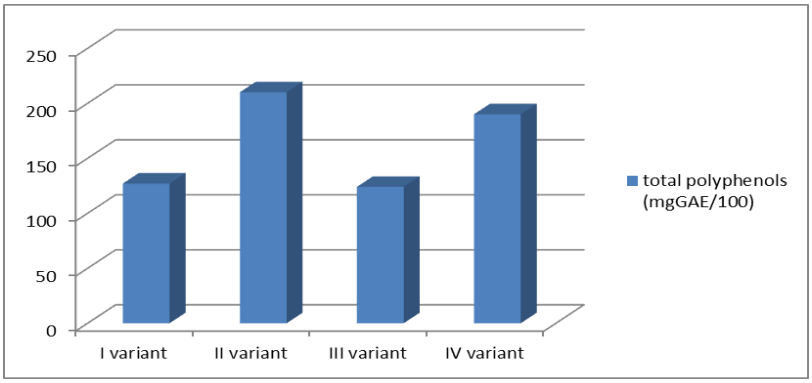

Figure 1. Influence of different fertilization variants on total polyphenols (mgGAE /100) and the antioxidant activity in fresh plums of 'Tegera' cultivar

There is a significant variation in the antioxidant activity in the fruits of the variants. It is highest for chicken manure - 926.67 µmolTE / 100 g and conventional fertilization - 597.78 µmolTE / 100 g. The lowest content was recorded in the control - 114.44 µmolTE/100 g (Figure 2). The results obtained have an extremely high variation coefficient (82.5%)

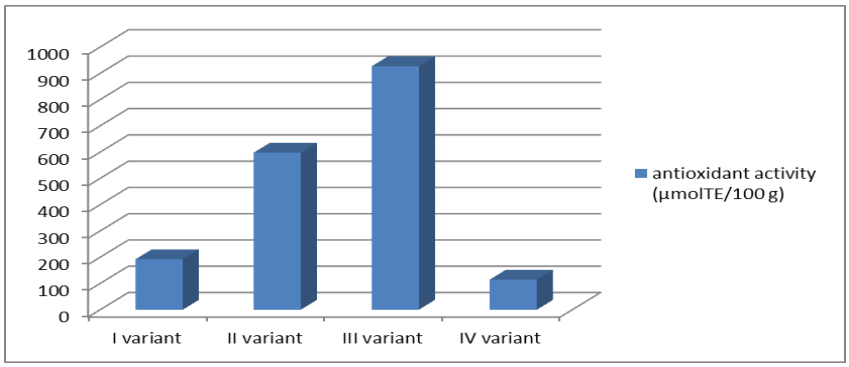

Figure 2. Effects of different fertilization variants on the antioxidant activity (µmolTE / 100 g) in fresh plums of 'Tegera' cultivar

Table 2. Biochemical composition of dried plums of 'Tegera' cultivar

Variants \ Indicator	Dry weight , %	Total sugars, %	Invert sugar, %	Sucrose, %	Acids as malic , %	Ascorbic acid, mg %	Tannins, %	Anthocyanins, mg %	Pectin, %
I	83.23	36.50	32.70	3.61	2.32	7.04	0.540	17.26	0.68
II	82.85	42.70	34.40	7.88	2.19	8.80	0.457	20.32	0.41
III	79.09	38.90	35.40	3.32	1.93	7.04	0.457	10.81	0.11
IV	84.95	38.20	34.40	3.61	2.19	7.04	0.706	12.74	1.31
CV %	1.17	6.70	3.27	47.50	7.58	11.76	21.73	28.21	81.45

Dry weight matter of dried fruit has significantly higher results than the fresh ones. The variations between the variants are narrow and as a result the variance coefficient is very low. The value for the control is higher - 84.95%. The lowest value was recorded in the third variant - 79.09% (Table 2). The highest content of total sugars is found in the conventional fertilization - 42.70% and lowest in bio-fertilization - 36.50%.

Almost similar results were obtained for invert sugar values at low CV% in the different fertilization variants. The highest content of sucrose was found in the conventional fertilizers - 7.88%. It is 2 times lower in the third variant than the conventional fertilizer application. A high variation coefficient (47.50%) has been reported.

The organic acid content is in the range of 1.93% for the chicken manure to 2.32% in the bio-fertilization variant with a low variation coefficient.

The ascorbic acid content is 8.80 mg /% for conventional fertilization and 7.04 mg /% for the other three variants. Tanning substances are in the range from 0.46% to 0.71% with a high variation factor. The highest content of anthocyanins is found in the second variant - 20.32 mg /%, as they decrease in the first variant to 17.26 mg /%. The lowest content is found in the third variant - 10.81 mg/% and for the control it is 12.74/%. The coefficient of variation is high for this indicator. Pectin results are different. The lowest content is reported for fruit fertilized with chicken manure and the highest for the control - 1.31%. Variation coefficient is high (81.4%). The highest values of total polyphenols are found in the conventional fertilization - 390.00 mgGAE / 100 (Figure 3), followed by bio-fertilization - 266.00 mgGAE/100, control - 264.00 mgGAE/100 and chicken manure - 260.00 mgGAE/100. In the study of (Cinquanta et al. 2002), the total content of polyphenols in dried plums ranges from 340 to 610 mg of GAE / 100 g of dry weight. The antioxidant activity is greatest in fruit with bio-fertilization - 220.00 µmolTE / 100 g and the control - 200.00 µmolTE / 100 g. It is the smallest for the chicken manure variant - 160.00 µmolTE / 100 g. (Figure 4). A low variation coefficient is reported. Identical result of 159.0 mM Trolox / g d.m. was analyzed by (Walkowiak-Tomczak et al. 2008) for plum brandy "Bluefre".

According to (Forni et al. 1992), the quality plum fruits must have an acidic coefficient between 12 and 24. The results obtained by the indicator are in the indicated range. The highest acidimetric coefficient for both types of fruit was recorded in the chicken manure variant, as for the fresh fruit it was 16.01 and for dried fruit - 20.15 (Table 3). The variation coefficient reported by the indicator for both fresh and dried fruit is low.

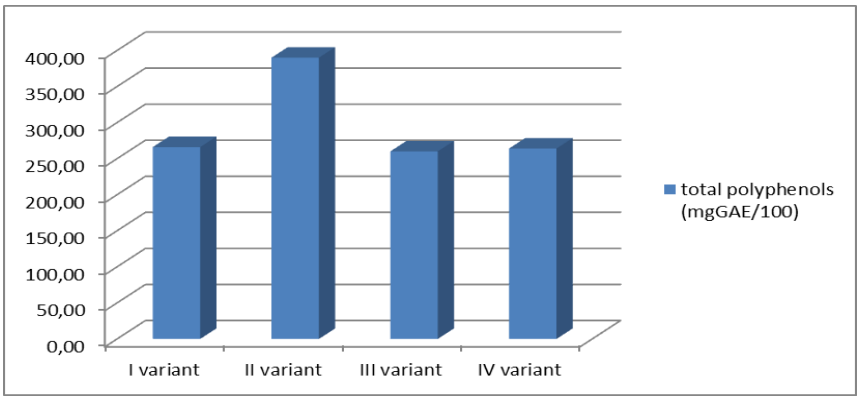

Figure 3. Influence of different fertilization variants on total polyphenols (mgGAE/100) in dried plums of 'Tegera' cultivar

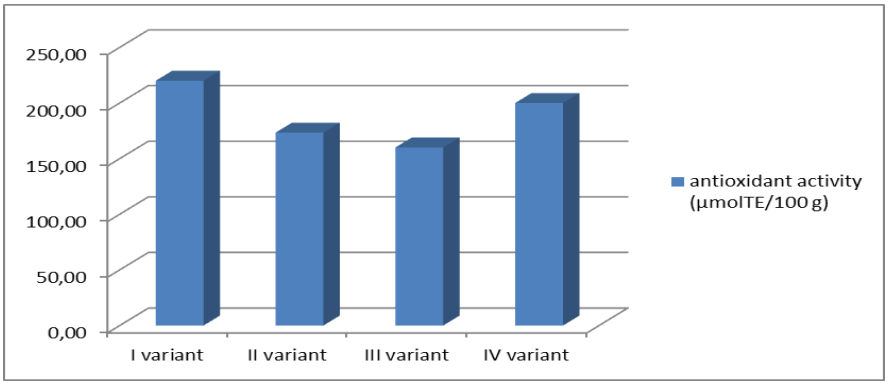

Figure 4. Effect of different fertilization variants on the antioxidant activity (µmolTE/100 g) in dried plums of 'Tegera' cultivar

Table 3. Acidimetric coefficient values for fresh and dried plums of 'Tegera' cultivar

Variant	Acidimetric coefficient	
	Fresh fruits	Dried fruits
I	15,7	15,73
II	14,92	19,5
III	16,01	20,15
IV	15,7	17,44
CV %	2,98	11,06

Conclusions

A study has been conducted on the influence of certain types of fertilizers on the biochemical composition of fresh and dried 'Tegera' fruit. Their positive influence on the values of inverted sugar and sucrose, anthocyanins, tanning substances and pectin was found in some fertilization options. The highest content of total polyphenols in fresh (210.00 mgGAE/100) and dried (390.00 mgGAE / 100) fruits is found in conventional fertilization. The highest antioxidant activity of fruit is registered in the conventional fertilization and chicken manure, while for dried fruit it is in the variants with bio-fertilization and the control.

Acidimetric coefficient values are most distinct in the chicken manure variant.

References

1. Arnhold, S., Lindner, S., Lee, B., Martin, E., Kettering, J., Nguyen, T T., Koellner, T. and Sik Ok Huwe, Y. B. (1914). Conventional and organic farming: soil erosion and conservation potential for row crop cultivation. Geoderma 219–220, 89–105.
2. Burmeister, J., Walter, R. and Fritz, M. (2015). Dungung mit Biogasgarresten –Auswirkungen auf Bodentiere. In: Biogas Forum Bayern Nr. I - 27/2015, Hrsg. ALB Bayerne.V., http://www.biogasforumbayern.de/publikationen/Auswirkung_der_Dungung_mit_Biogasgarresten_auf_die_Bodentiere.pdf.
3. Blazˇek, J. (2007). A survey of the genetic resources used in plum breeding. Acta Horticulturae, 734: 31–45.
4. Cinquanta, L., Di Matteo, M. and Esti, M. (2002). Phisical pre-treatment of plums (Prunus domestica. Part 2. Effect on the quality characteristics of different prune cultivars. Food chemistry, 79: 233-238.
5. Chauvin, C., Dorel, M., Villenave, C., Roger-Estrade, J., Thuries, L. and Risede, J. M. (2015). Biochemical characteristics of cover crop litter affect the soil food web, organic matter

decomposition, and regulation of plant-parasitic nematodes in a banana field soil. Applied Soil Ecology, 96: 131-140.
6. Chun, O.K., Kim, D.O., Moon, H.Y., Kang, H.G. and Lee, C.Y. (2003). Contribution of Individual Polyphenolics to Total Antioxidant Capacity of Plums. Journal of Agricultural and Food Chemistry, 51: 7240-7245.
7. Forni, E., Erba, M. L., Maestrelli, A. and Polesello, A. (1992). Sorbitol and free sugar contents in plums. Food Chem., 44: 269-275.
8. Cuquel, F.L., Motta, A. C. V., Tutida, I. and May de Mio, L. L. (2011). Nitrogen and potassium fertilization affecting the plum postharvest quality, Rev. Bras. Frutic., Jaboticabal - SP, Especial, E., Outubro: 328-336.
9. Reganold, J., Elliott, L. and Unger, Y. (1987). Long-term effects of organic and conventional farming on soil erosion. Nature., 330: 370-372
10. Ruiz, R. (2006). Effects of different potassium fertilizers on yield, fruit quality and nutritional status of 'Fairlane' nectarine trees and on soil fertility. Acta Horticulturae, The Hague, 721: 185-190.
11. Kader, A. A. and Rolle, R.S. (2004) .The role of post-harvest management in assuring the quality and safety of horticultural produce. FAO Bulletin, Washington, 152: 52.
12. Kaulmann, A., Jonville, M. C., Schneider, Y. J, Hoffmann, L. and Bohn, T. (2014). Carotenoids, polyphenols and micronutrient profiles of Brassica oleraceae and plum varieties and their contribution to measures of total antioxidant capacity., Food Chemistry 155 Oxford: Elsevier Ltd: 240-250.
13. Kim, D.O., Chun, O.K., Kim, Y.J., Moon, H.Y. and Lee, C.Y. (2003). Quantification of Polyphenolics and Their Antioxidant Capacity in Fresh Plums. Journal of Agricultural and Food Chemistry, 51: 6509-6515.
14. Milošević, T. and Milošević, N. (2012). Main physical and chemical traits of fresh fruits of promising plum hybrids (Prunus domestica L.) from Cacak (Western Serbia), Romanian Biotechnological Letters, 17(3): 7358-7365.
15. Stancheva, Y. (2007). Analysis of factors inducing instability in agricultural production in Bulgaria, http://chm.moew.government.bg/SLM/files/1- Sust_agr.pdf
16. Stoykova, G. (2004). Organic agriculture in Bulgaria - origin, characteristics and advantages; – Scientific and Practical Conference with International Participation (Reports – vol. 2); Svishtov, 11-13.11.2004.
17. Thoden, T. C., Korthals, G. W. and Termorshuizen, A. J. (2011). Organic amendments and their influences on plant-parasitic and free-living nematodes: a promising method for nematode management. Nematology, 13(2): 133-153.
18. Vitanova, I. M. (1990). Determination of needs for fertil¬izer of plum trees. Acta Horticulturae, The Hague, 274: 501-508.
19. Walkowiak-Tomczak, D., Reguia, J. and Jysiak, G. (2008). Physico-chemical properties and antioxidant activity of selected plum cultivars fruit, Acta Sci. Pol., Technol. Aliment, 7(4): 15-22
20. Yadav, R. L., Dwivedi, B. S. and Pandey, P. S. (2000). Rice–wheat cropping system: assessment of sustainability under green manuring and chemical fertilizer inputs, Field Crop Res. 65: 15–30.