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Degree of the impact of fertilizing and drying process on the colour indicators of plum cultivar Elena

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Abstract

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The impact of the applied fertilizers and the drying process on the quality characteristics of the plums was determined.

It was found that the applied agrotechnics had an impact on certain characteristics of fresh fruits from the studied variants. The measured colour coordinates of fresh plums showed that the method of cultivation ($P < 0.05$) had an impact on the brightness of the variants. The colour saturation had significantly been affected by the fruits with applied chicken manure, while the fruits of the other variants had values close to the control.

It was found that the drying, using a heat pump dryer with temperature of $t = 43 \pm 2°C$ and $\varphi = 10\%$, did not significantly affect the quantitative values of fruit colour, brightness, red colour tone, colour tone and saturation ($P > 0.05$).

Keywords: cultivars; plums; fertilizing; heat pump drying; colour parameters

Introduction

Modern fruit production of fresh and dried plums is directly dependent on consumer and market requirements. In order to increase yields, more and more farmers are using different types of fertilizers. Agricultural practices affect the metabolism of fruit trees and the subsequent fruit quality (Cuquel et al., 2011; Bai & Huang, 2021). The main qualitative indicators, such as size, colour, taste and aroma are much in demand and appreciated by consumers in the market (Mitrović et al., 2013; Akhijahani et al., 2017). The fruit colour resulting from the available natural pigments (chlorophyll, carotenoids, anthocyanins, flavonoids and betalains) **(**Barrett et al., 2010) is one of the most important indicators in choosing the consumption of fresh fruits (Silva et al., 2019) and dried products (Krokida & Maroulis, 2000; Bonazzi & Dumoulin, 2011), but during storage or processing of fruit products can occur not only food (Karam et al., 2016), but also color changes (Krokida et al., 2001; Montefiori et al., 2005; Michalska et al., 2017). Drying is used for the production of stable food products with reduced water activity. As an ancient method, it has long been the objective of research with a huge number of drying methods applied in practice. The quality of the product is the criterion for evaluating the applied drying technology (Nemzer et al., 2018). The effect of drying on fruit quality depends on the drying technique, variety and production technology (conventional or organic) (Sablani et al., 2011).

The main objective of the present study is to observe the effect of the applied conventional and organic fertilizers on the quality and colour characteristics of fresh and dried fruit of Elena plum cultivar.

Material and Methods

In 2016, variant of foliar and soil fertilizng were applied both in conventional and organic fertilizing in the plum plantations with Elena plum cultivar. The analyzed fresh and dried plums were harvested in August.

Raw materials

The Elena cultivar is a German plum cultivar, selected by Dr. Hartmann, derived from a crossing between Fellenberg x Stanley. The fruit skin is dark blue, sometimes slightly rusty, the flesh is greenish – yellow, juicy, with a pleasant plum aroma. The biochemical fruit composition allows the consumption of fresh and dried fruits (Družić et al., 2007).

Experimental setup of fertilizing

The soil fertility was improved by fertilizing of plum plantation with Elena cultivar in four variants.

Fertilizing variants and application of fertilizers

I variant – Organic fertilizing, which included fertilizers, such as: Agriful (soil) – 5 l/da, applied five times from the beginning of vegetation in the period of 15-20 days; Tecamin Flower (foliar) – 0.3%, applied twice. It is applied before blossoming and during the formation of fruits; Teknokel Amino Ca (foliar) – 0.4%, applied twice. It is applied after blossoming and a month before fruit harvesting

II variant – Conventional fertilizers – Yara Mila Complex (soil) – 0.500 kg/tree, imported once in the intra-row space;

YaraVita Frutrel (leaf) – 0.500 ml/da, applied four times. Yara Vita Universal Bio (leaf) – 0.500 ml/da, three times application. Applied before and after blossoming and after fruit harvesting.

III variant – Granulated chicken manure – 0.500 kg/tree, one application in the intra-row space

IV variant – Control

Composition of fertilizers

Agriful – Total humic extract – 306 g/l; Fulvic acid – 306 g/l; Nitrogen(N) – 55g/l; Phosphorus (P_20_5) – 13 g/l; Potassium (K_2O) – 13 g/l; Total organic matter – 551 g/l; pH – 4.7

Tecamin Flower – Seaweed Extract – 51g/l; Free "L" amino acids – 38 g/l; Nitrogen (N) – 38 g/l; Phosphorus (P_2O_5) – 127g/l; Boron (B) -13g/l; Molybdenum (Mo) – 6.5 g/l; pH – 2

Teknokel Amino Ca – Calcium oxide (CaO) water soluble-148 g/l; Boron (B) water soluble-3 g/l; Free "L" amino-acids-89 g/l; pH-4.0-4.5

Yara Mila Complex – Nitrogen (N)-12%; Potassium (K)-18%; Magnesium (MgO)-2.7%; Boron (B) – 0.015%; Manganese (Mn) – 0.02%; Phosphorus (P) – 11%; Sulfur (SO3)- 20%; Iron (Fe) – 0.2%; Zink (Zn)- 0.02%.

YaraVita Frutrel – Calcium Oxide (CaO) – 280 g/l; Phosphorus (P) – 104 g/l; Nitrogen (N) – 69 g/l; Magnesium (MgO) – 100 g/l; Zinc (Zn) – 40 g/l; Boron (B) – 20 g/l

YaraVita Universal Bio – Nitrogen (N) – 100 g/l; Phosphorus (P_2O_5) – 40 g/l; Potassium (K_2O) – 70 g/l; Manganese (Mn) -1.3 g/l; Copper (Cu) – 1.0 g/l; Zinc (Zn) – 0.7 g/l; Boron (B) – 0.2 g/l; Molybdenum (Mo) – 0.03 g/l

Granulated chicken manure Vita Organic – Nitrogen (N) – 1.2%; Phosphorus (P) – 1.99%; Potassium (K) – 2.5%; Calcium (Ca) – 10.85%; Magnesium (Mg) – 0.75%; Zinc (Zn) – 350 mg/kg; Copper (Cu) – 50 mg/kg; Manganese (Mn) – 443 mg/kg; Iron (Fe) – 3450 mg/kg.

Experimental setup for drying blue plums

The process of fruit drying was carried out in a heat pump dryer, developed by a team from IFPQ-Plovdiv.

Drying was carried out at temperatures up to 45°C, which preserves the high quality and natural properties of the product. The process took place in a closed cycle, using the same air and eliminating additional microbial contamination from outside air. The technological processes of the obtained dried fruits are: fruit acceptance, qualification of the fruits – removal of rotten and damaged fruits, washing, cutting (into halves), stone removal, drying, storage at room temperature at t=20 ± 5°C in the dark until the analyzes are performed.

Colour measurements

The colour characteristics of fresh and dried fruits from the fertilizing variants in the laboratory of the Institute of Food Preservation and Quality of Plovdiv were reported.

Estimation of colour by the Gardner colour scale – conducted instrumentallly by a colorimeter "Colorgard 2000", by BYK-Gardner Inc. USA. The indicators were reported according to the CIE Lab system.

The samples of the analyzed variants of fresh and dried fruits were previously ground and homogenized. The indicators were reported according to the CIE Lab system. During the measurement 3 colour coordinates L, a and b were taken: L is colour brightness (L = 0 black and L = 100 white); + a is red colour; – a is green colour; + b is yellow colour; – b is blue colour.

The colour tone value or the dominant wavelength is represented by the a/b ratio.

The colour saturation (C) was determined by the formula

$$\sqrt{a^2 + b^2} \quad (1)$$

The colour differences were calculated by the following formulas:

$$\Delta L = L - L_0, \quad (2)$$

$$\Delta a = a - a_0 \quad (3)$$

$$\Delta b = b - b_0 \quad (4)$$

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}, \quad (5)$$

where for fresh fruits L_0, a_0 and b_0 are the control values, while L, a and b are the measured values of the fruits from the fertilizing variants.

In the case of dried fruit, the colour difference was calculated by the same formulas, but L_0, a_0 and b_0 are the values of the fresh fruit from the fertilizing variants, and L, a and b are the measured values of the dried fruit from the variants.

Statistical processing

The presented results are arithmetic mean values of at least three parallel determinations, with coefficients of variation less than 5%. Statistical data processing was performed with ANOVA programs, Microsoft Excel.

Results and Discussion

Colour characteristics

The values of CIE Lab colour coordinates of fresh fruits from the cultivation variants are presented in Figures 1, 2, 3 and 4.

The measured colour coordinates of fresh plums show that the brightness of the variants is influenced by the method of cultivation ($P < 0.05$), as the lowest value was measured in fresh fruits with conventional cultivation technology (Figure 1). Different dependence on fruit brightness was found in conventional kiwi fruit (Amodio et al., 2007) and strawberries (Reganold et al., 2010), which have a higher value of the indicator compared to organically grown fruits.

The red colour tone in fresh fruits treated with chicken manure has the lowest values compared to the control fruits and the other two variants (conventional and organic fertilizing). The data are statistically different due to the applied agricultural techniques ($P < 0.05$), (Figure 1).

The yellow colour tone has twice lower quantitative values compared to the red colour tone for fresh fruit. The quantified indicator has the lowest value in fresh fruits from organic fertilizing and here again the data are influenced by the cultivation method ($P < 0.05$).

The quality indicator of colour tone has statistically indistinguishable values, as the way the agricultural techniques were applied does not affect the quality of the colour of fresh fruits ($P > 0.05$).

The colour saturation was significantly affected the fruits with applied chicken manure, while the fruits of the other variants had values close to the control. The data are statistically different due to the applied agricultural techniques ($P < 0.05$).

The colour differences from the measured indicators of the selected fresh fruit variants were calculated according to the data of the control fruits.

The data are presented in Figure 2.

The colour differences in terms of brightness of the fresh fruit variants have the highest value in the fruits of conventional fertilizing, followed by the organic fertilizing. The red colour tone in the fruits fertilized with chicken manure is significantly different. The yellow colour tone in the fruits treated with organic fertilizers has the highest difference compared to the values of the control fruits. There are minimal colour differences in the values of colour tone in the cultivation variants for fresh fruit, which is an evidence for the colour quality of the studied fruits (Figure 2).

The change in colour characteristics (L, a, b) in turn can lead to a significant change in the value of the total colour difference (ΔE). According to (Adekunte et al., 2010) ΔE can be used to classify differences in visual colour, which can be classified as very different ($\Delta E > 3$), different ($1.5 < \Delta E < 3$) and with a small difference ($1,5 < \Delta E$). According to (Nowacka et al., 2017) if ΔE is higher than 2, then the observer will see a clear and visible difference in color between fresh fruit and processed fruit.

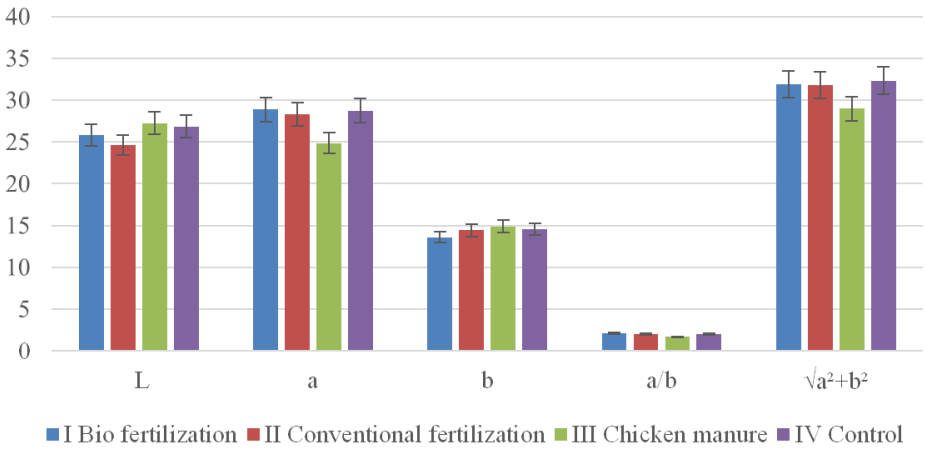

Fig. 1. Colour parameters of fresh plum fruit of Elena cultivar

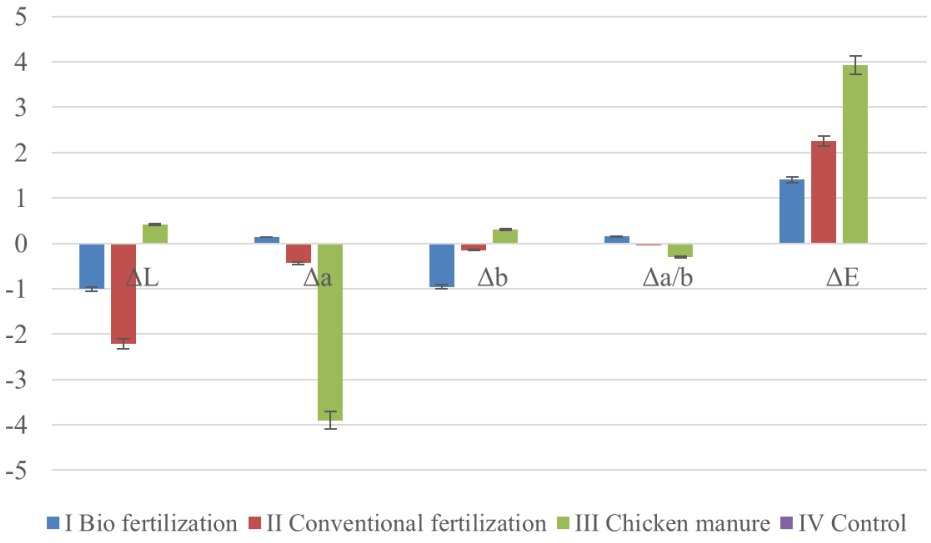

Fig. 2. Colour differences of fresh plum fruit of Elena cultivar

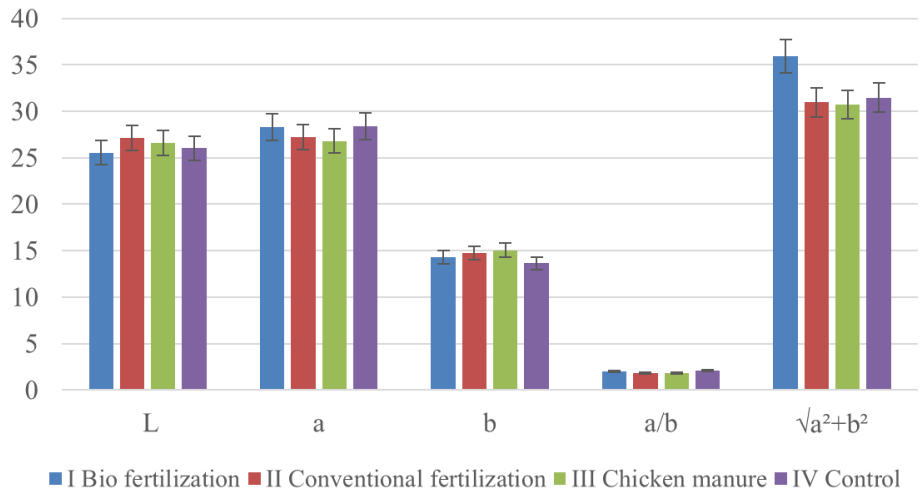

Fig. 3. Colour parameters of dried fruits of Elena cultivar

In the present study, insignificant colour differences were found in the fruits from the conventional and organic fertilizing in comparison with the control.

The colour difference of the fruits from the studied variants of fertilizing is influenced only by the organic chicken manure ($\Delta E = 3.93$), ($P < 0.05$).

The colour indicators of dried prunes of Elena cultivar are presented in Figures 3 and 4.

The impact of drying process on the quantitative and qualitative indicators of prunes from the different variants of fertilizing and the control was studied.

After the drying process of different variants, the quantitative indicator of colour brightness had stable and close values to the control and fresh fruit. The drying process did not affect the brightness of the measured fruits ($P > 0.05$).

The red colour tone is dominant compared to the yellow colour tone in dried fruits (Figure 2). The values of dried fruits do not differ significantly from the values of fresh fruits. The red tone is stable in dried prunes grown conventionally. The drying process does not affect the quantitative indicator of red colour ($P > 0.05$).

The yellow component of the colour has the lowest values for prunes from the control variant. The drying process had an impact on the quantitative indicator of yellow colour only in that variant ($P > 0.05$).

The dried fruits from the other studied variants have close statistically indistinguishable values and the applied drying process did not affect the measured values ($P > 0.05$).

The colour tones of dried fruits are stable and indistinguishable from each other and from the values of fresh fruits.

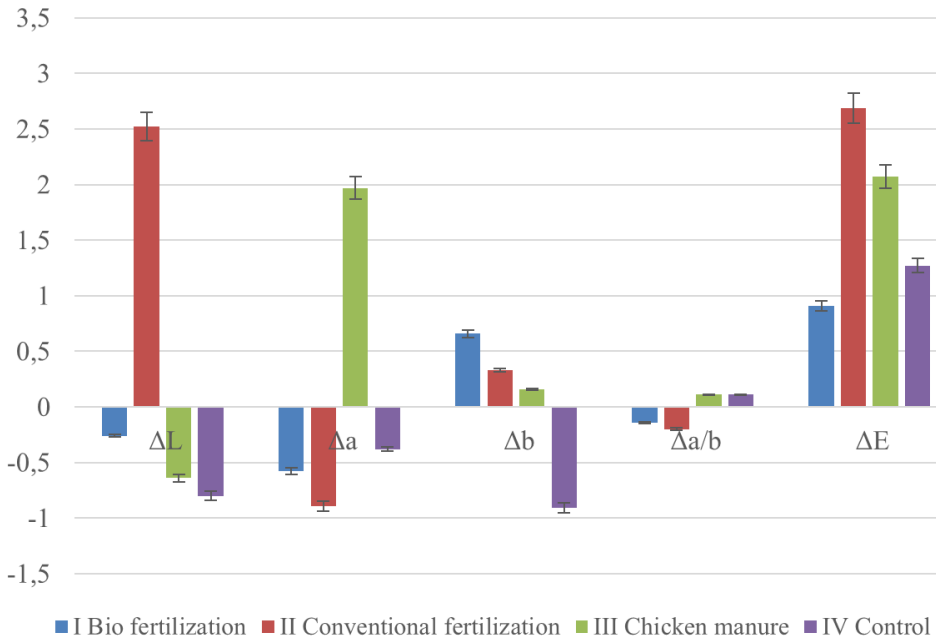

Fig. 4. Colour differences of dried fruits of Elena cultivar

The drying process does not affect the quantitative indicator of red colour ($P > 0.05$).

The quality indicator of colour saturation is significantly higher in fruits treated with organic fertilizers and the applied temperature regime affects the calculated value. For the other dried fruits (conventional fertilizing and chicken manure) and the control, the values are indistinguishable and the applied drying process does not affect the colour quality ($P > 0.05$).

The colour differences of prunes are compared to the data of fresh fruits and are presented in Figure 4.

The data in the figure show that the prunes from the conventional fertilizing variant have the highest colour difference in terms of colour brightness. There is a significant colour difference in the red color tone of dried fruits treated with chicken manure, and in the the yellow colour of the control fruit.

For all tested variants of dried fruits, the most stable colour was observed in plums treated with biofertilizers, followed by prunes of the control variant.

Significant generalized colour difference and impact of the applied drying process was found in conventionally grown prunes ($P < 0.05$) (Figure 4).

Conclusions

The impact of fertilizers and drying process on the quality characteristics of the Elena cultivar plums were determined.

It was found that the applied agrotechnics had an impact on certain characteristics of fresh fruits from the studied variants. The measured colour coordinates of fresh plums show that the brightness in the different variants was influenced by the cultivation method ($P < 0.05$). The colour saturation had significantly affected the fruits with applied chicken manure, while the fruits of the other variants had values close to the control.

It was found that the drying process through a heat pump dryer with the applied temperature regime at $t = 43 \pm 2°C$ and $\varphi = 10\%$, did not have a significant impact on the quantitative values of fruit colour, brightness, red colour tone, colour tone and saturation ($P > 0.05$).

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