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Influence of agricultural cultivation methods on the physicochemical and colour parameters of Florina variety apples immediately after harvest

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Abstract

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The scientific experiment was conducted in 2020-2021 on the trial fields of Agricultural University – Plovdiv in order to assess the influence of different cultivation methods on the physicochemical and colour parameters of Florina variety apple fruits.

The assessment is based on the content of soluble dry substances, %; active acidity; total polyphenols content, mg GAE/100g; as well as antioxidant capacity, μmol TE/100g. The CieLab system was applied to determine colour properties by using tool-assisted measurements of colour brightness, red/green and yellow hues.

Research findings demonstrated that biologically-cultivated apple fruits had higher active acidity and contained less soluble dry substances in comparison to conventionally-cultivated varieties. The implemented agricultural technique affected the active acidity values of biologically-cultivated fruits, as well as the percentage content of soluble dry substances in conventionally-cultivated fruits.

Out of all experimental variants, the antioxidant activity, total polyphenols content and red colour hue have the highest values in the fruits of the second-biologically-cultivated variant as a result of the applied agricultural technique.

The Florina variety fruits demonstrate a dominating yellow hue as opposed to the red and green hues of all studied variants in the experiment. Colour brightness is higher among conventionally-cultivated apples when compared to biologically-cultivated ones.

Keywords: apple; colour parameters; physicochemical indicators

Introduction

Apple is a fruit crop with rich biochemical composition and health benefits (Hussain et al., 2021).

The chemical composition of fruits depends on meteorological conditions, harvest timing, the choice of rootstock, agrotechnical interventions and other factors (Petkova et al., 2020).

The Florina apple variety has a French origin. It was imported in 1977 and has been properly adapted and quite common. It is a fast-growing variety with a reliable and abundant yield. It is not strictly soil- and climate- dependent and resists the economically-significant ailments of scab and powdery mildew (Dimitrova & Sotirov, 2019). Fruits are of average to large size, with a pale green to pale yellow base and red, fuzzy or striped covering colour. They also have a waxy surface. Harvest maturity occurs at the end of September (Lichev et al., 2012).

The aim of this report is to assess the effect of the applied agricultural techniques on the colour parameters and physicochemical indicators of Florina variety fruits.

Material and Methods

The experiment was conducted in 2020-2021 with biologically- and conventionally-cultivated Florina variety ap-

ple fruits in the orchard of the Agrarian University – Plovdiv.

Traditional technology is applied in the case of conventionally-cultivated plants. This includes crop-protection interventions (three prophylactic winter interventions against the hibernating forms of the economically-significant diseases, pests, as well as various vegetation ailments), nourishing fertilization, localized drip irrigation and several tillages. The treatments were conducted with specialized equipment for deep and shallow treatment of orchards (Stamatov et al., 1982, Todorov et al., 1974). The inter-row spacing was maintained in two ways – through the "black fallow" system and grassing. In connection with the first method, several shallow treatments are performed in the inter-row space which would lead to higher saturation of nutrients, as well as proper air and water exchange. These activities are also instrumental in removing weeds. Another deep treatment was conducted during the autumn in the inter-row space at a depth of 18-20 cm. Under the latter system, the inter-row spaces were grassed over as the grass was periodically mowed. Grass roots contribute for soil loosening; thereby, leading to favorable air and water exchange within. This also fosters the microbiological activity by enriching the soil with organic substances (Lichev et al., 2020; Stamatov et al., 1982).

The plants from biological production field were cultivated according to a technology excluding the use of mineral fertilizers and synthetic pesticides. Only bio-fertilizers, as well as plant-protection agents were used. The soil surface in the inter-row space was maintained according to the aforementioned two systems. Localized drip irrigation was precisely-dosed.

The applied agricultural technique in the apple orchards is presented in Tables 1 and 2.

The analyses were conducted in the Laboratory for Food Testing at the Institute of Food Preservation and Quality – Plovdiv, according to standardized methods and adapted techniques.

Table 1. Agricultural technique applied for conventional cultivation

Conventional production	Applied agricultural techniques
Version 1	Winter and vegetation plant protection measures with conventional pesticides; Mineral fertilization; Tillage in connection with the black fallow system; Irrigation.
Version 2	Winter and vegetation plant protection measures with conventional pesticides Mineral fertilization; Cutting the lawn in rows; Irrigation.

Table 2. Agricultural technique applied for biological cultivation

Bio production	Applied agricultural techniques
Version 1	Winter and vegetation plant protection measures with bio pesticides; Bio fertilization; Tillage in connection with the black fallow system; Irrigation
Version 2	Winter and vegetation plant protection measures with bio pesticides; Bio fertilization; Cutting the lawn in rows; Irrigation.

The following physicochemical indicators were considered:

- **Dry substances substance, refractometric**, %-BSS EN 120143-00
- **Active acidity**- BSS 11688;
- **Determination of total polyphenols**. The content of total polyphenols is determined according to the Singleton and Rossi (1965) method in its following adaption: in a 10-milliliter measuring tube, 0.1 ml of sample extract, ~7 ml of distilled water, 0.5ml of Folin-Ciocalteu reagent (diluted at 1:4 with distilled water) and 1.5 ml of 7.5% (w/v) aqueous sodium carbonate solution were dosed in the outlined sequence. Distilled water was topped up to the marking. After letting it rest for 2 hours at a temperature of 20 – 25°C, the absorbance of the reacting mixture is measured at 750 nm. Similarly, a blank solution was prepared using distilled water instead of the extract. The achieved results are presented as gallic acid equivalents (GAE) per 100 g of extract.
- **Determination of total antioxidant capacity.** The total antioxidant capacity was assessed by determining the radical scavenging ability with a DPPH test. Trolox, a water-soluble analogue of vitamin E, was used as a standard and the results were expressed as equivalents of Trolox (TE) in μmol per 100 g sample.
- **DPPH-test.** The procedure was based on the method by Brand-Williams et al. (1995) which was applied in its following variant: 2250 μl of methanolic DPPH solution (6 x 10-5 M) were mixed with 250 μl of sample extract (diluted with distilled water in a ratio of 1:3, v/v); the absorbance at 515 nm was measured after the reacting mixture stayed in a closed cuvette for 15 min in a dark place at a room temperature of 20-25°C. Similarly, a blank solution was prepared using methanol instead of the extract.

- **Determining colour according to Gardner Colour Scale** – Instrumentally performed with a "Colorgard 2000" colourimeter made by BYK-Gardner Inc. USA. The indicators were measured according to the CIE Lab system.

Three types of colour coordinates were used during the measurement process: L, a and b;

L – colour brightness (L = 0 – black, L = 100 – white);

a – the positive values of the indicator display the amount of red, while the negative values signify the intensity of green;

b – the positive values are determinant of the yellow hues, while the negative values indicate blue.

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

- **Statistical analysis –** the presented results are the arithmetic mean values taken from at least three parallel extrapolations, while keeping the variation coefficients at fewer than 5%. Statistical data processing was performed the ANOVA and Microsoft Excel applications (Kune).

Results and Discussion

The results from the studied physicochemical indicators related to apples, which are cultivated by biological and conventional methods, are presented in Figures 1 and 2.

Results indicate that the soluble dry substances in respect to the two variants of biologically cultivated apples show similar and statistically insignificant values of around 20%. The applied agricultural technique does not affect the amount of soluble dry substances.

The apples from the variant involving tillage have a higher value of active acidity – 4.51, as compared to the apples,

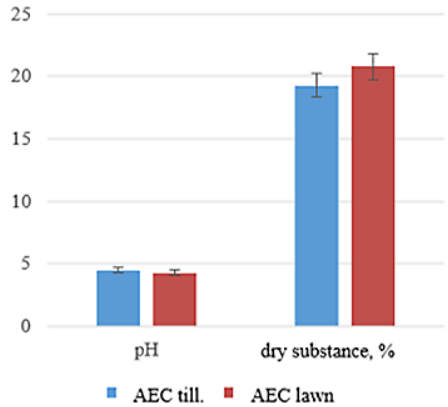

Fig. 1. Physicochemical parameters of biologically-cultivated apple fruits

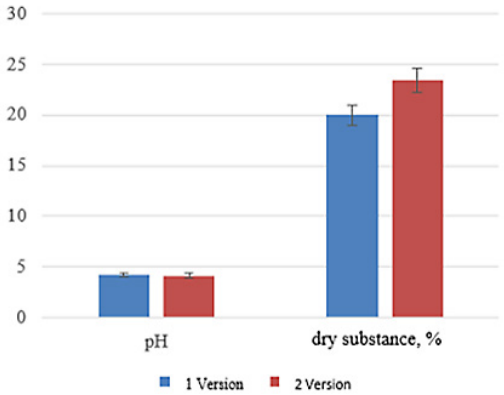

Fig. 2. Physicochemical parameters of conventionally-cultivated apple fruits

whose rows were grassed over. The applied agricultural technique has a significant impact on this indicator.

The data show that the active acidity does not measure a statistically significant difference with both variants of conventionally cultivated fruits. Active acidity surpasses the value of 4.15 in both cases.

There is a statistically significant difference in the measurements of dry soluble dry substances in respect to the second variant – 23.4%, as compared to the fruits cultivated according to the first method at a level of 20%. The applied agricultural technique influences the values of this performance indicator.

Out of all the studied variants of apple cultivation, the applied agricultural techniques influence the values of active acidity in biologically-cultivated fruits, as well as the amount of dry soluble matter in conventionally-cultivated fruits. When taking into consideration the performance of dry soluble dry substances, apples from the two biologically-cultivated variants and the first variant from the conventionally-cultivated method demonstrate close and statistically insignificant values.

The determined antioxidant activity and total polyphenols in the first variant of the biologically-cultivated fruits were respectively 1.5 and 1.6 times the amount in fruits grown by the second variant. The applied agricultural technique influences the values of the studied indicators.

Referring to the biologically-cultivated apples, the fruits from the first variant of this method exhibit the highest statistically significant values of antioxidant activity at 390.45 µmol TE/100 g, as compared to the values in the second variant – 303.22 µmol TE/100 g. Contrary to the trend observed in biologically-cultivated fruits, the variant with the higher antioxidant activity here does not necessarily measure higher contents of total polyphenols. The apples of the second variant

of cultivation with conventionally-applied agricultural techniques contain 1.3 times the total polyphenols observed in fruits of the first variant. Thus, the applied agricultural method influences the aforementioned indicators (Figures 3 and 4).

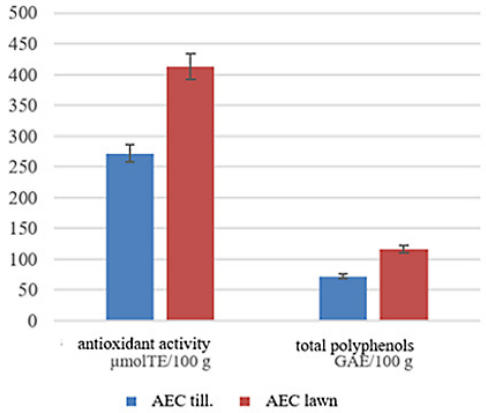

Fig. 3. Antioxidant activity and polyphenols content of biologically-cultivated fruits

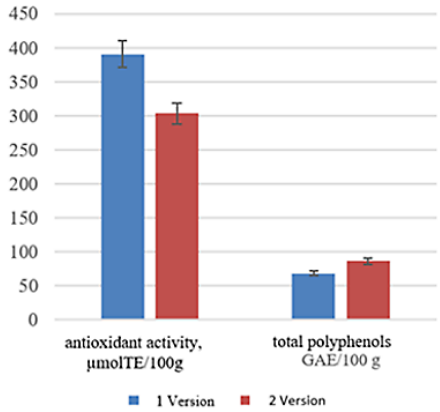

Fig. 4. Antioxidant activity and polyphenols content of fruits cultivated according to conventional method

In summary, out of all variants in the experiment, the biologically-cultivated apples of the second variant exhibited the highest values when studying their antioxidant activity and content of total polyphenols with a proven impact of the applied agricultural techniques.

Fruit colour parameters of the studied variants, both biologically and conventionally cultivated, are shown in Figures 5 and 6.

Data show that the brightness indicator (L) in biologically-cultivated apples among all variants does not exhibit a statistically significant difference regardless of the applied agricultural technique.

In the case of conventionally-cultivated apples, the brightness is higher as compared to biologically-cultivated fruits. The apples from the first variant of conventional cultivation exhibit the highest values of brightness.

For the "a" indicator, it is evident that the applied agricultural techniques have a significant influence in the case of biologically-cultivated apples. Fruits from the first variant exhibit values of green hues, while the apples from the second variant have red hues.

There is not such a tendency in the conventionally-cultivated apple variants, as the measured values of red in apples under the second variant are 1.8 times the respective level in fruits grown under the first variant. The applied agricultural techniques influence the values of this indicator in the case of conventionally cultivated fruits.

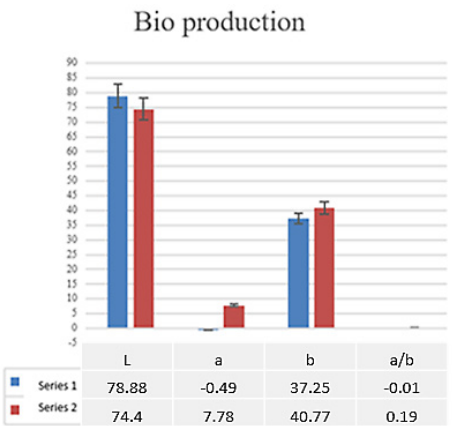

Fig. 5. Colour space of biologically-cultivated Florina apples

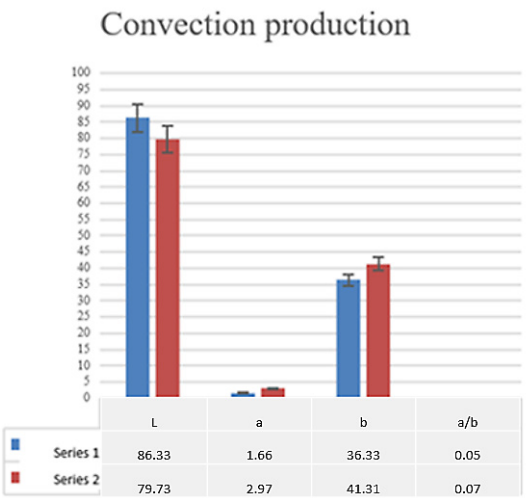

Fig. 6. Colour space of conventionally-cultivated Florina apples

Out of the studied variants, the apples from the second variant of the method of biological cultivation exhibit the highest values of red.

Apples of the Florina variety ordinarily exhibit a domineering yellow hue as compared to the red and green colour all of other variants in the experiment.

Data show that both the biological and conventional methods yield apples of the respective second variants with more pronounced yellow hues as opposed to the primary variants.

The applied agriculture technique has an influence on the colour parameters in the case of biologically-cultivated fruits. The apples obtained by its first variant exhibit negative colour hue values as opposed to the representatives of the second variant.

The qualitative indicator colour hue exhibits statistically insignificant values for all conventionally-cultivated fruits.

Conclusions

The significance of agricultural techniques in relation to the physicochemical and colour parameters of Florina variety apples was studied.

The applied agricultural techniques influences the values of active acidity for the biologically-cultivated fruits, as well as their relative content of dry soluble dry substances in the case of conventionally-cultivated fruits.

Among all variants in the experiment, the antioxidant activity, the content of total polyphenols and the red colour hue exhibit the highest values for those cultivated under the second variant of the biological method; thereby, indicating the significant role of the applied agricultural technique.

Florina variety apples exhibit a domineering yellow colour hue as opposed to the red and green exhibited by all of the fruits grown in the experiment. The brightness and yellow spectrum colour components achieve their highest values in the case of conventionally-cultivated apples in comparison to the biologically-cultivated alternatives.

Acknowledgments

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