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# INFLUENCE OF ECOLOGICAL FRIENDLY MEDIUMS ON CHEMICAL COMPOSITION OF GREENHOUSE-GROWN EGGPLANTS

## WPŁYW EKOLOGICZNYCH PODŁOŻY NA SKŁAD CHEMICZNY OBERŻYNY W UPRAWIE SZKLARNIOWEJ

**Abstract:** The objective of the study was to examine the influence of ecological friendly growing mediums – coconut fiber and wood fiber – on chemical composition of eggplant (*Solanum melongena* L.), grown in the greenhouse, in comparison with standard rockwool medium. Cultivars used in the study were: 'Scorpio', 'Oscar', 'Tango' and DRA 2086. Fruits were harvested in June, at marketable maturity. There were determined in the fruits: soluble solids, dry matter, vitamin C, nitrates(V) and total phenolic compounds. Separation of phenolic acids was performed with HPLC. Antioxidant activity was determined with DPPH method. Nutrients content (N, P, K, Ca) in plants leaves was also determined. Results showed that growing mediums influenced some quality traits of the fruits, but genotype showed stronger influence on their chemical composition. Therefore, the two ecological friendly mediums are suitable for eggplant cultivation and have similar effect on chemical composition of plants, as standard rockwool medium.

**Keywords:** aubergine, ecology, growing mediums, greenhouse, phenols, nitrates, vitamin C, antioxidants

In temperate climate, eggplant (aubergine) can be grown successfully only in greenhouses or foil-made tunnels [1]. Eggplant fruits contain about 7 % of dry matter, 1 % of proteins, 4 % of carbohydrates, and also vitamins $B_1$, $B_2$, $B_6$ and C [2]. The fruits have relatively high amount of phenolics. There are reports on positive influence of phenolics on human health [3, 4]. Polyphenolic acids are components of plant lignins and tannins, but also occure in a free form [5]. During eggplant fruits development reducing total sugars, ascorbic acid, proteins and total phenolics contents increase [2, 6], and during fruits storage sugars content decreases [7]. Antioxidants in foods inhibit or delay the oxidation of other molecules and protect cells against the damaging effects of reactive oxygen species. Antioxidant activity of plant products has been reported in

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literature [3, 4, 8]. Main antioxidants found in plants are phenolic compounds (tocopherols, flavonoids and phenolic acids), carotenoids and ascorbic acid. Soilless plant cultures have been popular in vegetables production during the last decades because of their important advantages [9]. Up to now, in greenhouse cultivation rockwool slabs are most commonly used as a growing medium. This medium has inert characteristics, which is a valuable trait in cultivation. Troubles with rockwool utilization after completing growing cycle stimulate researches to introduce more environmentally friendly mediums. Since peat use in horticulture is negatively rated from ecological reason, other natural organic materials are looking for. Plant fiber has good physical and chemical characteristics for plant growing. Wood fiber and coconut fiber are especially perspective as ecological mediums [10]. Moreover, coconut fiber has a larger oxygen capacity than rockwool and good water holding ability, which makes it particularly suitable for hydroponic systems with intermittent watering cycles.

The aim of this work was to compare chemical composition of eggplants of four cultivars in relation to growing medium used in greenhouse cultivation. Two ecological mediums – coconut fiber and wood fiber were used, and compared with standard rockwool medium.

## Material and methods

Eggplant hybrid cultivars used in the experiment were: ‘Scorpio’, ‘Oscar’, ‘Tango’ and DRA 2086 (De Ruiter Seeds). Fruits of ‘Scorpio’, ‘Oscar’ and DRA 2086 are of violet-black skin, and fruits of ‘Tango’ are of plain creamy-white skin. Growing mediums applied were: slabs made of coconut fiber (Ceres Intern.), slabs made of wood fiber (Steico SA) and standard slabs made of rockwool (Grodan BV). Slabs dimensions were 100 × 15 × 7.5 cm (length × width × height). The experiment was established in a random design, in three replicates, with 8 plants in each. Eggplants were planted in the middle of April. Drip irrigation system was used, and nutrients concentration in the solution, EC and pH were controlled and kept at uniform levels for all objects. The concentrations of nutrients in water were as follows: 140 mg $NO_3$-N, 70 mg P, 360 mg K, 60 mg Mg, 200 mg Ca, 2 mg Fe, 0.6 mg Mn, 0.3 mg B, 0.15 mg Cu, 0.3 mg Zn and 0.05 mg Mo in 1 $dm^3$. During fruits development (since June) temperature in the greenhouse ranged from 20–25 $^{o}$C during the day to about 18–20 $^{o}$C during the night. Fruits for the evaluation were harvested in June, at the peak of plants fruiting, at marketable maturity.

Nitrates ($NO_3$) in the fruits were determined with spectrophotometrical method, with Fiastar (Tecator, Sweden), at wavelength of $\lambda$ = 440 nm. Vitamin C was determined with Tillmans’ method. Soluble solids ($^{o}$Bx) in raw and roasted fruits were determined with digital refractometer. Dry matter was determined by drying samples at 105 $^{o}$C, until stable weight. Antioxidant activity was determined spectrophotometrically [4], as the percent of DPPH (2,2-diphenyl-1-picrylhydrazyl) inhibition in methanol extracts. Fresh fruit samples of 5 g were ground and extracted in methanol. Light inhibition was measured after 10 min of reaction, with the wavelength of $\lambda$ = 517 nm. Total phenolic compounds were determined with Folin-Ciocalteu method [8]. The absorbance was read at $\lambda$ = 725 nm, with UV Shimadzu spectrophotometer.

Free phenolic acids in the fruits were determined with HPLC. For this purpose, ground raw material was extracted with methanol in Büchi B-811. After evaporation of solvent, the residue was dissolved in methanol, filtered and subjected to HPLC. Shimadzu chromatograph with SPD-M10A VPDAD detector, equipped with Luna 5 μm C18(2) 250 mm × 4.6 mm column was used. The gradient of 10 % ACN(A) and 55 % ACN(B) was used. Injection volume was 1.0 $cm^3 \cdot min^{-1}$, oven temperature 36 $^oC$, time of analysis 40 min.

Plants leaves were analyzed after growing cycle for macronutrients (N, P, K, Ca) content, according to Nowosielski [11].

Data obtained were subjected to the ANOVA with 'Statgraphics Plus 4.1' software. Tukey's HSD test was used to separate homogenous groups at $p = 0.05$.

## Results and discussion

Nutrients availability for plants in greenhouse cultivation, related to soil conditions, is one of the most important factors influencing chemical composition of vegetables [12]. There is shortage of data concerning the influence of ecological friendly mediums on quality of vegetables grown under protection. Nitrates content in vegetables is of major concern due to negative influence on human health. Acceptable intake of nitrates was established by FAO/WHO Expert Committee on the level of 3.7 $mg \cdot kg^{-1}$ of body per day in 2002 [13]. In the study, nitrates(V) content in eggplant fruits was generally on a high level (about 400–500 $mg \cdot kg^{-1}$ f.m.), but on average the content was the lowest for plants grown in coconut fiber (Table 1). The lowest nitrates content was found in DRA 2086 fruits.

Vitamin C content in fruits was rather low (about 14–15 $mg \cdot 100\ g^{-1}$ f.m.), but typical to eggplant [2]. Fruits of plants grown in wood fiber showed the lowest vitamin C content, but the differences were only marginal. The highest dry matter content was characteristic to fruits from plants grown in coconut fiber, and the lowest for ones grown in wood fiber. The lowest dry matter content showed fruits of 'Tango' cv. The influence of mediums on soluble solids content was insignificant in the case of raw fruits and significant in the case of roasted fruits. Roasted fruits of plants grown in wood fiber showed the lowest soluble solids content. 'Oscar' cv. had fruits of the highest soluble solids content in the raw fruits from the examined cultivars.

Total phenolics content in the fruits was related to growing mediums and was the highest in the case of coconut fiber, where it reached level of 14 $mg \cdot g^{-1}$ d.m. in the case of fruits of 'Oscar'. On average, the highest content of phenolics showed fruits of 'Oscar' cv. Phenolic acids content in eggplant fruits can influence their sensory characteristics, and fruits high in these compounds are rated as more bitter [6]. Phenolic acids in the fruits were: chlorogenic acid, 3,4-dihydroxycinnamic acid and rosmarinic acid (Table 2). Chlorogenic acid was found in the highest amount. Sum of polyphenolic acids determined was much lower than total phenolics amount, and was related to growing mediums and cultivars. The influence of growing medium was evident in the case of chlorogenic acid, which was found in the lowest concentration in fruits of plants grown in coconut fiber. Chlorogenic acid concentration was the highest in fruits of 'Tango' cv.

Table 1

Chemical related traits of eggplant fruits as affected by growing mediums and cultivars

| Cultivar | Growing medium | Nitrates [mg $NO_3 \cdot kg^{-1}$ f.m.] | Vitamin C [mg · 100 $g^{-1}$ f.m.] | Total phenolics [mg · $g^{-1}$ d.m.] | Dry matter [%] | Soluble solids | |
|---|---|---|---|---|---|---|---|
| | | | | | | Raw fruits | Roasted fruits |
| | | | | | | [°Bx] | |
| Scorpio | Coconut fiber | 461 | 15.1 | 11.2 | 6.15 | 4.7 | 4.1 |
| | Wood fiber | 549 | 13.6 | 9.3 | 5.79 | 5.3 | 3.4 |
| | Rockwool | 530 | 14.9 | 7.5 | 6.13 | 4.3 | 3.4 |
| Oscar | Coconut fiber | 373 | 15.3 | 13.9 | 6.69 | 5.6 | 4.2 |
| | Wood fiber | 559 | 13.3 | 11.4 | 6.00 | 5.2 | 3.8 |
| | Rockwool | 504 | 15.3 | 11.8 | 6.61 | 6.2 | 4.7 |
| Tango | Coconut fiber | 447 | 15.2 | 9.6 | 6.07 | 5.2 | 3.4 |
| | Wood fiber | 449 | 13.7 | 9.5 | 5.33 | 4.7 | 2.8 |
| | Rockwool | 513 | 14.8 | 9.5 | 5.37 | 5.5 | 3.3 |
| DRA 2086 | Coconut fiber | 433 | 15.0 | 11.1 | 6.63 | 5.5 | 4.3 |
| | Wood fiber | 469 | 13.3 | 8.1 | 6.30 | 5.3 | 3.7 |
| | Rockwool | 427 | 15.5 | 8.1 | 6.49 | 5.2 | 3.9 |
| Means for mediums | Coconut fiber | 429 a | 15.2 b | 11.5 b | 6.39 c | 5.3 a | 4.0 b |
| | Wood fiber | 507 b | 13.5 a | 9.6 a | 5.86 a | 5.1 a | 3.4 a |
| | Rockwool | 494 b | 15.2 b | 9.2 a | 6.15 b | 5.3 a | 3.8 b |
| Means for cultivars | Scorpio | 513 b | 14.5 a | 9.3 a | 6.02 b | 4.8 a | 3.6 b |
| | Oscar | 479 ab | 14.6 a | 12.4 b | 6.43 c | 5.7 c | 4.2 c |
| | Tango | 470 ab | 14.5 a | 9.5 a | 5.59 a | 5.1 b | 3.2 a |
| | DRA2086 | 443 a | 14.6 a | 9.1 a | 6.47 c | 5.3 b | 4.0 c |

Note: means which do not differ according to Tukey's HSD test at $p = 0.05$ are marked with the same letters.

Table 2

Free phenolic acids in raw eggplant fruits as affected by growing mediums and cultivars [mg · 100 $g^{-1}$ d.m.]

| Cultivar | Growing medium | Chlorogenic acid | Dihydroxycinnamic acid | Rosmarinic acid | Total free phenolic acids |
|---|---|---|---|---|---|
| Scorpio | Coconut fiber | 179.4 | 1.0 | 1.6 | 182.0 |
| | Wood fiber | 160.4 | 0.6 | 1.2 | 162.2 |
| | Rockwool | 205.0 | 1.5 | 1.1 | 207.5 |
| Oscar | Coconut fiber | 180.7 | 0.7 | 0.7 | 182.1 |
| | Wood fiber | 170.8 | 0.7 | 1.5 | 173.0 |
| | Rockwool | 194.6 | 1.2 | 0.7 | 196.5 |
| Tango | Coconut fiber | 197.9 | 1.5 | 1.7 | 201.2 |
| | Wood fiber | 378.8 | 1.8 | 1.2 | 381.8 |
| | Rockwool | 345.8 | 1.9 | 1.6 | 349.4 |
| DRW 2086 | Coconut fiber | 161.8 | 0.6 | 1.5 | 163.8 |
| | Wood fiber | 221.4 | 1.0 | 0.6 | 223.0 |
| | Rockwool | 154.4 | 0.5 | 1.0 | 155.9 |
| Means for mediums | Coconut fiber | 180.0 a | 1.0 a | 1.4 a | 182.3 a |
| | Wood fiber | 232.9 b | 1.0 a | 1.1 a | 235.0 b |
| | Rockwool | 225.0 b | 1.3 a | 1.1 a | 227.3 b |
| Means for cultivars | Scorpio | 181.6 a | 1.0 a | 1.3 a | 183.9 a |
| | Oscar | 182.0 a | 0.9 a | 1.0 a | 183.9 a |
| | Tango | 307.5 b | 1.7 b | 1.5 a | 310.8 b |
| | DRA2086 | 179.2 a | 0.7 b | 1.0 a | 180.9 a |

Note: see Table 1.

The DPPH method of antioxidant activity (AA) determination is based on free radicals scavenging by plant extracts and is used in direct comparison of plant raw materials in this respect [14]. AA of eggplant fruits was generally rather low and did not relate to growing mediums, but to genotype only (Table 3). AA was the highest for fruits of 'Scorpio' cv., but was only a little higher than that for other cultivars. Phenolic compounds are believed to be very active free radicals scavengers [3]. However, it seems that AA of the fruits used in the study did not related to phenolics content.

Table 3

Antioxidant activity of raw eggplant fruits in relation to growing mediums and cultivars [% DPPH]

| Cultivar | Growing medium | | | Means for cultivars |
|---|---|---|---|---|
| | cocos fiber | wood fiber | rockwool | |
| Scorpio | 9.72 | 7.93 | 7.16 | 8.27 b |
| Oscar | 7.09 | 6.27 | 5.82 | 6.39 a |
| Tango | 4.64 | 5.66 | 5.52 | 5.27 a |
| DRA2086 | 4.64 | 7.29 | 5.79 | 5.91 a |
| Means for mediums | 6.52 a | 6.79 a | 6.07 a | |

Note: see Table 1.

Amount of nutrients accumulated in eggplant leaves during growing cycle was similar for plants cultivated in the three mediums (Table 4). Small differences were found in the case of nitrogen and phosphorus content, which were lower in plants grown in rockwool slabs than in plants grown in the two ecological-friendly mediums.

Table 4

Nutrients content in eggplant leaves after growing cycle, in relation to growing mediums [mg · $g^{-1}$ d.m.]

| Nutrient | Growing medium | | |
|---|---|---|---|
| | coconut fiber | wood fiber | rockwool |
| $NO_3$-N | 1.00 b | 1.10 b | 0.80 a |
| P | 0.55 b | 0.62 b | 0.38 a |
| K | 3.50 a | 3.50 a | 3.51 a |
| Ca | 0.47 a | 0.45 a | 0.49 a |

Note: see Table 1.

## Conclusion

Kind of growing medium used in greenhouse influenced some quality attributes of eggplant fruits, including their chemical composition, but the differences between the fruits related to growing mediums were small, compared with the differences related to cultivars. Basic nutrients contents in plants leaves, related to growing mediums, were similar, except nitrogen and phosphorus. Generally, all three growing mediums proved their suitability in eggplant cultivation. Therefore, it can be concluded that both ecological-friendly mediums, ie coconut fiber and wood fiber, could be used in horticultural practice as the replacement of standard rockwool medium for growing eggplant in greenhouses.

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## WPŁYW EKOLOGICZNYCH PODŁOŻY NA SKŁAD CHEMICZNY OBERŻYNY W UPRAWIE SZKLARNIOWEJ

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**Abstrakt:** Celem pracy było zbadanie wpływu dwóch ekologicznych podłoży – włókna kokosowego i włókna drzewnego na skład chemiczny oberżyny (*Solanum melongena* L.) w uprawie szklarniowej, w porównaniu z konwencjonalnym podłożem z wełny mineralnej. W badaniach użyto odmian 'Scorpio', 'Oscar', 'Tango' i DRA 2086. Owoce zbierano w czerwcu, w fazie dojrzałości handlowej. W owocach oznaczano zawartość ekstraktu, suchą masę, witaminę C, azotany(V) oraz związki fenolowe ogółem. Rozdział kwasów polifenolowych przeprowadzono metodą HPLC. Aktywność antyoksydacyjną określono metodą DPPH. Oznaczono zawartość składników pokarmowych (N, P, K, Ca) w liściach pod koniec wegetacji.

Rodzaj podłoża miał wpływ na niektóre cechy jakościowe owoców, ale genotyp wykazywał większy wpływ na jakość oberżyny. Badane ekologiczne podłoża nadają się do uprawy oberżyny, wpływając na jakość owoców w sposób zbliżony do podłoża z wełny mineralnej.

**Słowa kluczowe:** oberżyna, ekologia, podłoża, szklarnia, związki fenolowe, azotany, witamina C, antyoksydanty