TOMATOES NUTRITIONAL CHARACTERISTICS UNDER FARMING TECHNOLOGY

CARACTERISTICILE NUTRIȚIONALE ALE TOMATELOR SUB INFLUENȚA UNOR FACTORI TEHNOLOGICI

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Abstract.
Tomatoes fruits are much nutritionally vegetable around the world. The quality of tomatoes is determined by fibre, vitamins, and minerals, all of which contribute to a healthy diet. Its adaptability and widespread cultivation make it an essential component of global food security and a variety of industries. This study looks at the qualitative characteristics of different tomato varieties grown under organic and conventional systems. The experiment was carried out on the farm of the Iasi University of Life Sciences from Romania. For this study used three tomato varieties: Caprese F_1, Cristal F_1 and Manistella F_1. These varieties are popular and of good production and quality in Romania. The goal was to determine the effect of both factors (cultivars and growing systems) on the quality of tomato fruits. The biochemical compounds were analysed at the Andalusian Institute in Cordoba, Spain. For tomato samples were determined: antioxidant capacity, chlorophyll a, chlorophyll b, lycopene, beta-carotene, tannins, total polyphenols. The findings revealed considerable differences across cultivars and farming practices to improve fruit quality while adhering to food safety norms.
Keywords: tomato varieties, quality attributes, farming systems

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Cuvinte cheie: tomate, calitate, factori tehnologici

INTRODUCTION

The tomato is one of the most important species in the world due to its antioxidant properties and economic importance [Stoleru *et al*., 2020]. Sustainable production should therefore be the main objective, particularly in terms of fertilization and growing systems. The tomato (*Solanum lycopersicum* L.) is the second most important vegetable crop after the potato [Stoleru et al., 2020]. particularly those studying the quality and ripening of fleshy fruits [Bertin & Génard, 2018]. Tomatoes are one of the most crop in the world, with production estimated at 186.82 million tons in 2020. In 2018, the FAO reported that Romania produced 742,899 tons of tomatoes [Bădulescu *et al*., 2020]. Interest in consuming high-quality fresh or processed tomatoes continues to grow. In Romania, the average annual tomatoes consumption per capita was recorded in 2015 of 38.6 kg/person [Soare *et al*., 2017].

Tomatoes are a valuable vegetable because of their high nutritional value (150 calories/100g) and their chemical composition, which includes minerals (P, N, Ca, Mg, and traces of Fe, Cu, Zn, Mn), vitamins (C, E), lycopene (a natural antioxidant that protects against cancer, heart and lung disease), beta-carotene, fiber and water [Periago *et al*., 2002].Tomatoes are an important source of antioxidants for the human diet, include phenolic compounds [Bertin & Génard, 2018]. Recent data shows that organic tomatoes are much healthier and more useful for the body than vegetables treated with synthetic pesticides. Tomatoes are considered functional products [Fernanda & Fonseca, 2005; Willcox *et al*., 2003]. Lycopene and β-carotene are powerful antioxidants in humans. Many health professionals recommend increasing lycopene levels in the diet by eating fresh tomatoes and tomato derivatives [Tonucci *et al*., 1995]. The antioxidant activity of tomato fruit is determined not only by the genotype, but also by the stage of ripening, production practices [De Sio *et al*., 2019]. Consumers are increasingly interested in how, where and when food is produced.as a result, they are increasingly interested in organic vegetables, particularly those grown in greenhouses [Stoleru *et al*., 2019]. The quality of tomato fruit depends on the variety, the growing strategy, the type of fertilizer and the harvesting period [Rusu *et al*., 2023]. Fertilizers are the most important tools for improving plant nutrition. Chemical fertilization is a popular strategy for increasing agricultural yields, but it has been shown to have serious adverse effects on the environment and human health. For example, chemical fertilizers contribute significantly to the greenhouse effect and soil salinization. Organic fertilization is an alternative that mitigates the harmful effects of chemical fertilization [Singh *et al*., 2020]. In addition to the environmental benefits, organic fertilizers have a significant impact on the quality of plant products and the quantity of harvests. In the case of tomatoes, for example, it has been shown that organic farming has a positive impact on increasing the polyphenolic chemical substances and antioxidant capacity of fresh fruit and processed vegetables [De Sio *et al*., 2021]. found that choosing the right cultivar and fertilizations method can result in better bioactive components in tomatoes grown in the field under variable climatic conditions [Rusu *et al*., 2023]. This study aimed to examine the effects of different fertilizations regimes on the quality and nutrient content of three varieties crossing of farming system (conventional and organic).

MATERIALS AND METHODS

Plant Material and Growth Conditions

The experiment was carried out in a greenhouse of "V. Adamachi" Farm of Iasi University of Life Sciences (47019'25" N, 27054'99" E, 150 m a.s.l), during 2021-2022. The soil is characterized as a loam-clay chernozem, with pH 7.20; electrical conductivity (EC) 482 $\mu S \cdot cm^{-2}$, $CaCO_3$ 0.42%, organic matter (OM) 28.32 $mg \cdot kg^{-1}$, C/N 5.87, N 2.8 $g \cdot kg^{-1}$, P 34 $mg \cdot kg^{-1}$, was used for the experiment 3 hibrid cultivars were use in experiment Caprese, Cristal, respectively Manistella. Organic fertilization represented by chicken manure was applied by 2500 $kg \cdot ha^{-1}$ of commercial Orgevit® in three phases: 50% of the total amount in coincidence with the final soil preparation prior to planting; 25% when the first fruit reached a 1 cm diameter; the last dose (25%) when the first fruit of the third cluster reached a 1 cm diameter. Chemical fertilization used a complex fertilizer N:P:K -20:20:20, 400 $kg \cdot ha^{-1}$, applied to the soil at land preparation and Nutrispore®, N:P:K -8:24:24, $kg \cdot ha^{-1}$, applied in three applications during the growing season. Growing practices (training, pruning and treatments for pests and diseases) were applied for all the plants, according to the techniques described by [Zhang et al., 2023] During the experiment, when fruits were fully ripened (BBCH 805–808), a minimum of three fruits from each cluster/level (3–5) were collected for further analyses. Table 1 displays Sample codes and classification according to variety, fertilization system.

Table 1

Sample codes

ID CODE	***Variety***	***Treatment***
1	Caprese F1	Conventional
2	Caprese F1	Organic
3	Cristal F1	Conventional
4	Cristal F1	Organic
5	Manistella F1	Conventional
6	Manistella F1	Organic

Material and sample preparation

A total of 5 tomato fruits from each version were collected from group at phenotypic and physiological maturity (809 BBCH scale). The material was divided into small pieces and homogenised before being freeze-dried in an ECO EVO freeze-dryer (Tred Technology S.R.L., Ripalimosani, Italy). The dried samples were powdered and stored at -80°C for analysis.

Hydrophilic extraction

A mixed solution of deionised water and methanol (20:80, v/v) containing 1% formic acid was used for hydrophilic extraction. 0.2 g of freeze-dried sample was extracted with 1 ml of extraction solvent, sonicated for 10 minutes in an ultrasonic bath and then centrifuged at 15,000 rpm for 15 minutes. The supernatant was collected and the pellet re-extracted using the same procedure. Samples were stored in vials at -80°C until analysis. This extraction was tested for antioxidant activity, total phenolic compounds and total condensed tannins.

Antioxidant activity

The antioxidant activity of tomatoe samples was determined using two separate tests: ABTS and DPPH, both performed on a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski, VT, USA). The phenolic extract was tested for ABTS free radical scavenging activity using procedures previously published by [Ordóñez-Díaz *et al*., 2020]. Antioxidant activity was calculated in mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW). The DPPH method was developed for microplate readers [Ordóñez-Díaz *et al*., 2020]. Antioxidant activity was calculated in mmol Trolox equivalents per 100 g dry weight (mmol TE 100 g-1 DW).

Total phenolic content

Total phenolic content was determined using the Folin-Ciocalteau reagent according to the procedure of Slinkard and Singleton. Results were expressed as milligrams of gallic acid equivalents per 100 grams of fresh weight (mg GAE 100 g-1 FW) [Cuevas *et al*., 2017].

Total condensed tannin content

Condensed tannins were assessed using the vanillin test described by Broadhurst and Jones [1978]. Data were provided in milligrams of catechin equivalents per 100 grams of dry weight (mg TE 100 g-1 DW).

Pigment extraction

Lipophilic pigments were extracted using the technique described by Nagata and Yamashita [Nagata & Yamashita, 1992]. In brief, 0.2 g of lyophilized sample was extracted in the dark with 1 ml of a mixture of hexane and acetone (4:6, v:v) and centrifuged at 15,000 rpm for 15 minutes. The supernatant was collected, and the pellet was extracted again using the same technique. The samples were transferred to vials and kept at -80°C until analysis.

Pigment Analysis

The absorbance of pigment extracts was measured at 453, 505, 645, and 663 nm using a Synergy HTX multimode microplate reader (Biotek Instruments, Winooski, VT, USA). The content of chlorophyll a, b, β-carotene, and lycopene was determined using Nagata and Yamashita's [1992] formulae.

Statistical analysis

Univariate statistical analyses were used to discover differences between samples using Statistix v. 9.0 software. Data were subjected to analysis of variance (ANOVA), followed by comparison of means using Tukey post hoc tests. The significance criterion was set at $p \leq 0.05$.

RESULTS AND DISCUSSION

Pigment content (chlorophyll A and B)

Figure 1 shows the impact of the interaction between tomato cultivars and farming practices on pigment content. Chlorophyll A concentration varies from 0.55 in the cultivar Caprese to 2.09 in the cultivar Cristal using the same Conventional technique. These results indicate that chlorophyll A content varies greatly according to cultivar and fertilization strategy.

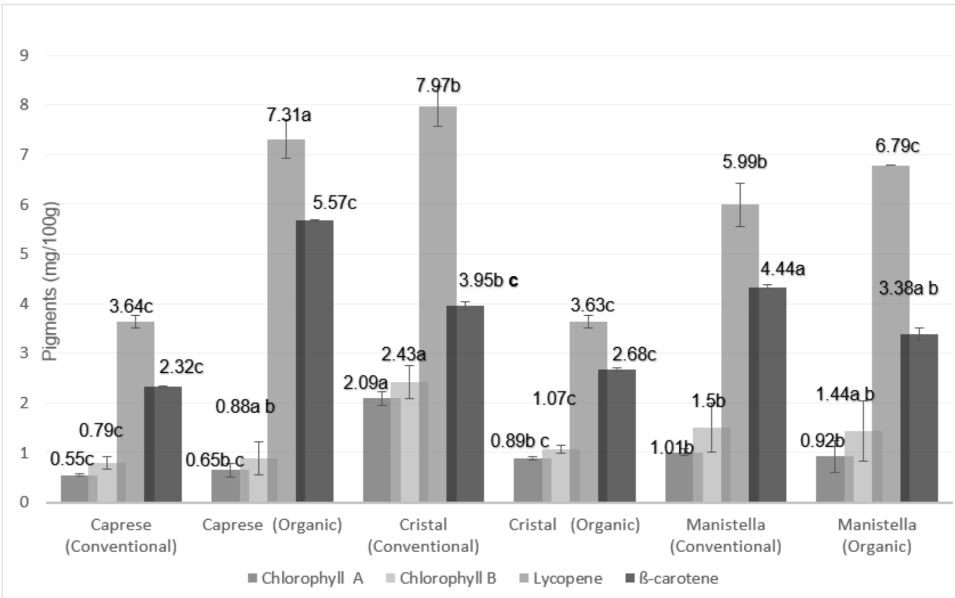

Fig. 1. Pigment contents from tomato fruits

Notably, the Cristal cultivar shows the greatest difference in chlorophyll A concentration between the Conventional and organic systems, with the Conventional system producing 134% more chlorophyll A than the organic system. The other two hybrids (Caprese and Manistella) show smaller differences. Interestingly, the Caprese cultivar responded better to organic fertilization, showing increased chlorophyll content under organic conditions, while the overall difference was less striking than for Cristal.

Antioxidant activity (ABTS and DPPH)

ABTS antioxidant activity (Figure 2) ranged from 0.94 mmol TE/100 g DW in cultivar Cristal under organic fertilization to 1.18 mmol TE/100 g DW in cultivar Caprese under the same conditions. Most cultivars showed no significant differences between fertilization methods, with the exception of cultivar Caprese, which showed a modest increase in antioxidant activity with organic fertilization.

DPPH antioxidant activity showed a similar trend, with values ranging from 1.07 mmol TE/100 g DW in Manistella under organic fertilization to 1.40 mmol TE/100 g DW in the same cultivar under Conventional fertilization.

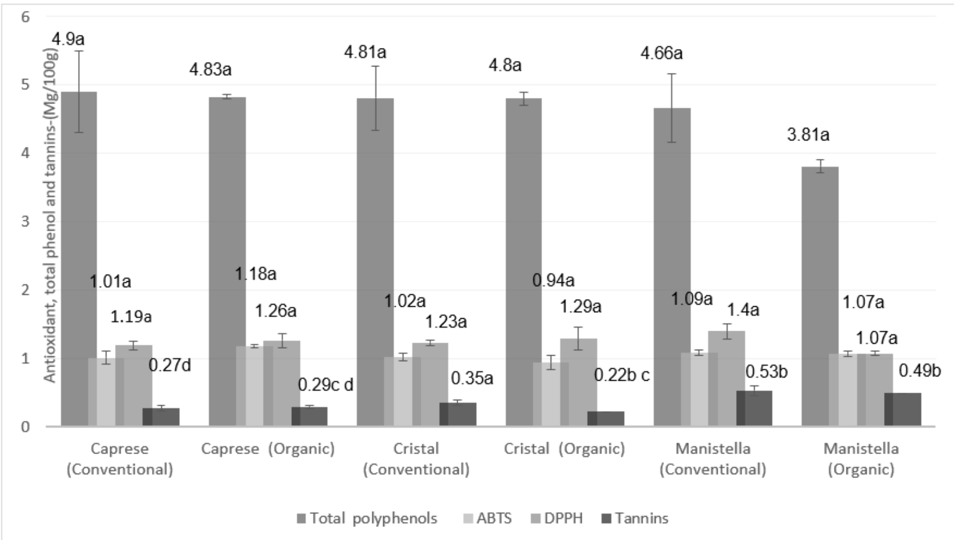

Fig. .2 Antioxidants, total phenol and tannins from tomato fruits

Total polyphenols

Total polyphenol content differs little between cultivars and fertilization techniques. Caprese has the highest value under Conventional fertilization (4.90 mg GAE/100 g FW), while Manistella has the lowest value under organic fertilization (3.81 mg GAE/100 g FW). Overall, polyphenol content varies slightly according to fertilization method, but the changes are not statistically significant.

Lycopene and ß-carotene

Lycopene content was significantly higher in organically fertilized tomatoes, with the highest values observed in Cristal under Conventional fertilization (7.97 mg/100 g). ß-carotene content followed, with Caprese having the highest value (5.67 mg/100 g FW) under organic fertilization. These results indicate that organic fertilization increases carotenoid concentrations, particularly lycopene, which is important for its antioxidant capacities.

Tannins

Tannin content was generally higher in tomatoes grown with chemical fertilizers, with the Manistella variety showing the highest content (0.53 mg TE/100 g). However, changes in tannin content between organic and chemical systems were less pronounced than those observed for the other components.

DISCUSSIONS

This study's findings revealed that fertilization methods have a substantial impact on the nutritional and antioxidant qualities of tomatoes. Organic and chemical fertilization treatments were compared across three tomato varieties, revealing differences in total polyphenols, antioxidant activity (ABTS and DPPH), chlorophyll content, lycopene, beta-carotene, and tannins.

Antioxidant properties and polyphenol content

Organic fertilizers often produced higher levels of antioxidant activity, as evidenced by DPPH and ABTS assays. *Caprese x Daymsa* and *Manistella x Daymsa* types had greater DPPH values after organic fertilization, with *Caprese x Daymsa* having the highest value. These findings are consistent with prior research, which found that organic farming promotes better antioxidant capacity due to stress produced by limited nutrient availability when compared to chemical fertilizers. This can be attributed to the higher phenolic chemicals found in organically cultivated tomatoes. The organically fertilized *Caprese* and *Cristal* types have somewhat greater total polyphenols. These findings are consistent with those of De Sio *et al*. [2019], who found that organic fertilization increases antioxidant activity in some tomato types but not all.

The polyphenol and tannin content

Organic fertilization encourages the synthesis of secondary metabolites like as polyphenols, which are linked to antioxidant qualities. Organically fertilized tomatoes, particularly the Manistella x Daymsa variety, have a greater total polyphenol content, supporting prior studies [Rosa-Martínez *et al*., 2021]. These findings underscore the potential health benefits of organic farming, as tomatoes with higher polyphenolic content and antioxidant capacity are more appealing to consumers because they are associated with a lower risk of chronic disease. The difference in tannin concentration across treatments was likewise minor, indicating that organic and chemical approaches are successful at maintaining tannin levels, which are an essential flavour and astringency element.

Chlorophyll and carotenoid content

The form of fertilization had a substantial effect on chlorophyll levels (both A and B), with Conventional fertilization providing increased chlorophyll content, particularly in the hybrids Cristal x Conv and Manistella x Conv. This is most likely owing to the easily available nutrients in Conventional fertilizers, which may encourage photosynthesis and pigment production more effectively than organic fertilizers. Interestingly, organically fertilized tomatoes, particularly the Caprese x Daymsa type, contained higher levels of lycopene and beta-carotene, both of which have documented health advantages. Organic tomatoes include higher quantities of lycopene and beta-carotene, which have been linked to antioxidant activity and potential protection against diseases including cancer. These results suggest that while chemical fertilization may enhance chlorophyll content, organic fertilization has a deeper effect on carotenoid synthesis.

Implications for agricultural practices

These findings highlight the necessity of selecting fertilization strategies depending on nutritional goals. Organic fertilizers, despite increasing antioxidant activity and carotenoid content, may reduce chlorophyll accumulation. In contrast, Conventional fertilizers increase chlorophyll concentration while decreasing beneficial molecules like lycopene and beta-carotene. Given the growing consumer demand for nutrient-dense meals, organic agricultural procedures appear to provide considerable benefits in improving the health-promoting characteristics of tomatoes.

CONCLUSION

The findings of this study show that organic fertilization improves the nutritional quality of tomatoes, particularly their antioxidant capacity, lycopene, and beta-carotene levels. These findings have substantial implications for agricultural operations, implying that organic methods may be better suited to growing tomatoes with more health advantages. However, fertilization should be adapted to the specific goals of the growing operation, as Conventional fertilization may bring benefits in terms of growth and chlorophyll concentration. More research is needed to look into the long-term effects of these approaches on tomato productivity and environmental sustainability.

Future directions (Recommendations)

More research is needed to compare the long-term impacts of organic versus Conventional fertilization on tomato yield, particularly in varied environmental conditions. Furthermore, studying the microbial content and influence of these fertilizers on soil health may provide more thorough insights into sustainable farming practices. Finally, customer preferences for flavor and texture, which are influenced by fertilization methods, should be evaluated to better align agricultural practices with market expectations.

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