Can natural fortification increase Fe and Zn content in organically grown tomatoes?

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• Tomato (*Solanum lycopersicum*) is considered internationally one of the most important agricultural food crop and the second most important vegetable crop.

• Agriculture is facing huge challenges namely, related to natural resources, production methods, quality, and safety of food products.
•Modern consumers are more **attentive to food nutrition** and to practice healthier eating.

• The lack of essential nutrients, as **Fe and Zn**, can lead to several pathologies, namely can lead to anemia and problems related to immune and reproductive system, respectively.
•Also, Fe and Zn are two important **nutrients for plant growth and development**, having a low kinetic mobility.

• Considering the importance of Fe and Zn in plants and the fact that tomato is one of the most consumed horticultural crops worldwide, this study aimed to verify if in the middle of a biofortification process (after two foliar applications) Fe and Zn content in tomatoes of *Solanum lycopersicum* (beef heart variety - also known as Coeur de Boeuf) organically grown can improve.

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Abstract:

Natural fortification can be used to increase the mineral content of the edible part of plants. In horticultural crops, foliar fertilization is used extensively, being a way to provide nutrients through leaves (a faster way compared to soil applications). Moreover, Fe and Zn are two important nutrients for plant growth and development, despite the low kinetic mobility. As such, considering the importance of Fe and Zn in plants and the fact that tomato is one of the most consumed horticultural crops worldwide, this study aimed to verify if in the middle of a biofortification process (after two foliar applications) Fe and Zn content in tomatoes of *Solanum lycopersicum* (beef heart variety - also known as Coeur de Boeuf) organically grown can improve. The experimental field was selected and followed the protocols for tomato growth in accordance with the organic production mode. Two foliar applications were carried out during the production cycle, with a mix of two products of Fe and Zn (Zitrilon – 15% and Maxiblend) with two concentrations (treatment 1 or low mix and treatment 2 or high mix). Through X-ray fluorescence using a XRF analyzer under He atmosphere, leaves of tomatoes submitted to the biofortification process showed an increase of 76.9% of Fe content and double Zn content, in treatment 2. However, treatment 1 only showed increases in Zn content (by 75.5% compared to control). Regarding tomatoes fruits, treatment 2 showed an increase of 7% of Zn content, relative to control content. Naturally enriched tomatoes with Fe and Zn showed minor changes in colorimetric parameters (Chroma and Hue) and no significant differences in L parameter (brightness / luminosity), regarding control. Additionally, biofortification did not affect tomatoes height and diameter at this stage of development, varying between 75.7 – 84.3 mm and 76.7 – 93.3 mm, respectively. In conclusion, two foliar sprays of Fe and Zn can improve tomatoes and leaves content under organic production practices without triggering toxicity to the plants and not affecting tomatoes height and diameter, and only presented some minor changes in color parameters (CieLab scale).

Keywords: Biofortification; *Lycopersicum esculentum* L.; Natural enrichment with Iron and Zinc; Organic tomato productions.

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Introduction

Agriculture is facing huge challenges namely, related to natural resources, production methods, quality, and safety of food products (Perpar and Udovč, 2019). In fact, modern consumers are more attentive to food nutrition and to practice healthier eating (Perpar and Udovč, 2019) and are willing to pay extra prices for organic production considering the environmental benefits and the association with sustainable foods (Maples et al., 2018). Compared to intensive agriculture, that negatively affects the environment and human health, organic production is considered a more sustainable farming method (Perpar and Udovč, 2019). Yet, the feasibility of organic production varies across the countries, mainly because of the weather, pest, and economic challenges (Maples et al., 2018). In 2017, organic farming in Portugal was carried out on 253 786 hectares of agricultural land (more 26.4 % than in 2012) (Perpar and Udovč, 2019), yet despite the fast evolution, the market is still a niche (Ventura-Lucas et al., 2013). Regarding the mineral content, agronomic biofortification can be used to increase mineral content in the edible part of plants and is usually used in horticultural crops (as tomato) through leaves application (Alshaal and El-Ramady, 2017). This strategy (agronomic biofortification) can be used to suppress the lack of essential nutrients being considered a current global problem (Li et al., 2017).

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Results and Discussion

Iron and zinc content were assessed in leaves and tomatoes of beef heart variety after two foliar sprays with a mix of Fe and Zn (**Table 1**). In leaves, regarding control, treatment 2 showed an increase of 76.9 % of Fe and treatment 1 showed lower content. Regarding Zn, there treatment 1 showed an increase of 75.5 % and treatment 2 double the content relative to control content. In tomatoes, Fe content was below the device detention limit value (< 35 ppm) and regarding Zn, only treatment 2 showed a higher content than control (with an increase of 7 %).

Table 1. Mean values ± S.E. (n = 4) of Fe and Zn in dry leaves and in dry tomatoes of *Lycopersicum esculentum* (beef heart variety), after the 2nd foliar spraying with Fe and Zn. Different letters indicate significant differences, between treatments (statistical analysis using the single factor ANOVA test, P ≤0.05). Foliar spray was carried out with two concentrations (T1 or low mix and T2 or high mix). Control was not sprayed.

		Leaves		Tomatoes	
Variety	Treatments	Fe (ppm)	Zn (ppm)	Fe (ppm)	Zn (ppm)
Beef heart	Control	195b ± 5.9	224c ± 1.4	< 35	12.9a ± 0.3
	T1 (low mix)	115c ± 3.2	393b ± 2.8	< 35	10.2b ± 1.2
	T2 (high mix)	345a ± 4.0	468a ± 2.2	< 35	13.8a ± 1.2

Regarding Fe in leaves, treatment 2 (T2) or high mix was the only treatment that showed higher content compared to control. Treatment 1 showed a lower content than control and can be due to poor foliar application, external factors when applying the mix or the fact that no biofortification occurred at this stage with the applied mixture (it is not possible to confirm as the Fe content in tomatoes was lower than the detection limit of the device). In the other hand, Zn content improved in leaves with both mixtures applied, yet increased with the increasing of the applied concentration (high mix > low mix), despite the limited mobility in leaves (Doolette et al., 2018). However, in tomatoes, T1 or low mix showed a lower content of Zn than control, probably due to the low mobility within the plant (Pagani et al., 2013), yet T2 or high mix showed a not significantly increase compared to control. This can be since Zn content in tomatoes can be dependent of the maturation of the fruit and variety and at this stage the tomatoes weren't mature (Costa et al., 2011).

Conclusions

Through foliar spraying with Fe and Zn fertilizers, at concentrations reported in this study (T1 or low mix and T2 or high mix), tomatoes and leaves content can be improved under organic production practices. Yet, better results (higher Fe and Zn content) were obtained with the higher mix applied (T2 or high mix) at the middle of the biofortification process and without triggering toxicity to the plants. Additionally, this improve of Fe and Zn content did not affect tomatoes height and diameter and only showed some minor changes regarding color (Chroma and Hue parameters).

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