Monitorization of mineral content and location after 3 months of storage of naturally enriched potato (*Solanum tuberosum* L.) with Calcium

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- Worldwide population is expected to reach 9 billion by 2050
- To feed the future population → food production must increase by 25 to 70 %
- It's important to **reduce the post-harvest food losses**, to avoid waste which are especially high in perishable crops.

- Potato is considered the 3rd most important (non-grain) food crop worldwide and more than a billion people around the world eat potato.
- As a perishable crop correct **post-harvest management** is required to reduce food losses.

- The lack of essential nutrients in individuals who are attaining healthy levels of calories are a major world problem, so it's important to have more food production and with quality (able to provide the daily nutritional dietary requirements).

- The aim of this study is to monitor the mineral content and location of Ca, K, P, S, Fe and Zn and analyze important quality parameters in tubers of *Solanum tuberosum* L. (Agria variety) after three months of storage, submitted to a Ca biofortification process with four foliar sprays with calcium nitrate and calcium chloride.

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Abstract: Potato (*Solanum tuberosum* L.) is one of the most important staple food crops and one of the most consumed worldwide. As such, is a suitable food matrix for biofortification studies, namely with Ca, as it is an essential mineral for plant growth and development, being required for several structural issues. In this context, this study aimed to monitor the mineral content and location of Ca and other essential minerals (K, P, S, Fe, and Zn) and assess some quality parameters (color of the pulp, total soluble solid and dry weigh content) in tubers of *Solanum tuberosum* L. (Agria variety) after three months of storage, submitted to a Ca biofortification process with four foliar sprays with three concentrations of calcium nitrate (0.5, 2 and 4 $kg.ha^{-1}$) and two concentrations of calcium chloride (3 and 6 $kg.ha^{-1}$). It was found out that in most treatments, Ca, K, P, S, Fe, and Zn have higher content in the epidermis region and that control tubers showed a lower dry weight content compared to the biofortified ones. Moreover, after three months of storage, naturally enriched tubers maintain a preferential accumulation of Ca in the epidermis region (as seen in harvest) and showed a decrease in the dry weight content in control and biofortified tubers (compared to harvest data). Additionally, no significant differences were observed in the colorimetric parameters of pulp tubers and in the total soluble solid content, presenting similar data to the harvest ones. In conclusion, the storage process of biofortified tubers affected a quality parameter – dry weight content – being relevant for industrial processing and a criterion for potato tubers classification. In this context, only $Ca(NO_3)_2$ 2 $kg.ha^{-1}$, $CaCl_2$ 3 and 6 $kg.ha^{-1}$ treatments presented suitable for industrial processing after 3 months under storage conditions.

Keywords: Calcium biofortification; Natural enrichment with calcium; Postharvest analysis; *Solanum tuberosum* L.

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Introduction

Potato is a perishable crop and correct post-harvest management is required to reduce food losses (Booth & Burton, 1983). In fact, potato is considered the 3rd most important (non-grain) food crop worldwide and more than a billion people around the world eat potato (CIP, 2021), being widely grown (Pinheiro et al., 2009).

As a perishable commodity, to allow the later use of potatoes, it's important to understand the factors that affect potatoes storage, to ensure a correct storage for 3 to 10 months. Therefore, potato tubers have an active metabolism during post-harvest, leading to losses of mass and quality. The loss of quality during storage depends on storage conditions and on culture management since early stage (seed storage), during growth and harvest (Pinheiro et al., 2009). Due to the metabolic process of respiration, potatoes must be under refrigeration or cool temperatures during the post-harvest stage, to slow down this process and maintain tuber quality (Hossain & Miah, 2009). Additionally, considering that potato tubers is mainly water (about 80 %) and dry matter (around 20 %, mostly starch) (FAO, 2008), due to low external vapor pressure or even relative humidity can lead to losing the internal water and starting to shrink. Therefore, two of the major causes of post-harvest losses are the water loss and sprouting (that can decrease nutritive quality of potato tubers) (Hossain & Miah, 2009).In this context, the aim of this study is to monitor the mineral content and location of Ca, K, P, S, Fe and Zn and analyze important quality parameters (namely, color of the pulp, total soluble solids and dry weight content) in tubers of *Solanum tuberosum* L. (Agria variety) after three months of storage (under low temperatures), submitted to a Ca biofortification process with four foliar sprays with three concentrations of calcium nitrate (0.5, 2 and 4 $kg.ha^{-1}$) and two concentrations of calcium chloride (3 and 6 $kg.ha^{-1}$), in order to verify if the storage process as any effect on mineral content and location on tuber tissue and in quality parameters.

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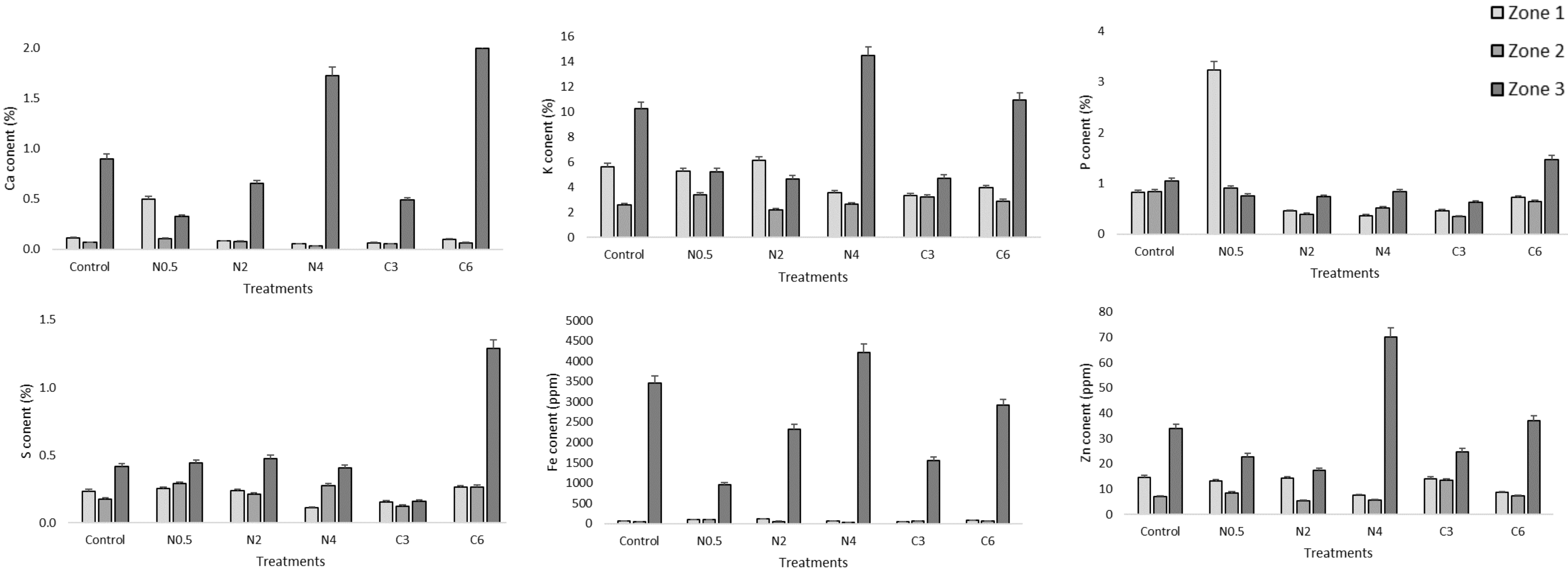
Results and Discussion

Regarding the most treatments, Ca, K, P, S, Fe and Zn showed a higher content in the epidermis/peel region (zone 3). Calcium showed a higher content relatively to control, in $CaCl_2$ 6 kg.ha^{-1} and $Ca(NO_3)_2$ 4 kg.ha^{-1} treatments, respectively.



Comparison of data obtained at harvest (Coelho et al., 2021) and after three months of storage suggest that there was a migration of Ca to the epidermis of the tubers, probably due to the beginning of sprouting in the tubers (that implies cellular growth) and consequentially, minerals stored/accumulated in the tuber can be transported to the sprout leading to decrease in the inner regions of the tuber (zone 1 and 2).

Regarding the remaining elements assessed (K, P, S, Fe, and Zn) with a greater concentration prevailing in epidermis/peel region than in flesh regions (zone 1 and 2), as also reported by Subramanian et al. (2011). Considering Ca, Fe, and Zn, they were found out in greater quantities in the epidermis region than in the middle and center tissues (quite lower contents), probably due to being less immobile (NRCCA, 2021), as such this preferential location can be associated with the fact that these elements are delivered (at least) by direct movement across the epidermis during the developing of the tuber (Subramanian et al.,2011).

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Conclusions

Through the monitorization of mineral content and location of Ca, K, P, S, Fe, and Zn and the assessment of some quality parameters (color of the pulp, total soluble solid and dry weigh content) in *Solanum tuberosum* L. (Agria variety) after three months of storage, submitted to a Ca biofortification process with four foliar sprays with calcium nitrate or calcium chloride was possible to conclude that the deposition in tubers tissue of Ca, K, P, S, Fe and Zn prevailed close to the epidermis /peel region. Furthermore, there was a dry weigh content decrease in control and all the biofortified treatments (compared to harvest), concluding that only $Ca(NO_3)_2$ 2 $kg.ha^{-1}$, $CaCl_2$ 3 and 6 $kg.ha^{-1}$ treatments presented suitable for industrial processing after 3 months stored under low temperatures. Additionally, there wasn't a clear tendency regarding total soluble solids due to opposite behaviors (increase in half of the treatments and decrease in the other half).

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