biology and life sciences forum

MDPI

Proceeding Paper

Natural Mineral Enrichment in *Solanum tuberosum* L. cv. Agria: Accumulation of Ca and Interaction with Other Nutrients by XRF Analysis †

Ana Rita F. Coelho [1,2,*], Cláudia Campos Pessoa [1,2], Ana Coelho Marques [1,2], Inês Carmo Luís [1,2], Diana Daccak [1,2], Maria Manuela Silva [2,3], Manuela Simões [1,2], Fernando H. Reboredo [1,2], Maria F. Pessoa [1,2], Paulo Legoinha [1,2], José C. Ramalho [2,4], Paula Scotti Campos [2,5], Isabel P. Pais [2,5] and Fernando C. Lidon [1,2]

1 Earth Sciences Department, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus da Caparica, 2829-516 Caparica, Portugal; c.pessoa@campus.fct.unl.pt (C.C.P.); amc.marques@campus.fct.unl.pt (A.C.M.); idc.rodrigues@campus.fct.unl.pt (I.C.L.); d.daccak@campus.fct.unl.pt (D.D.); mmsr@fct.unl.pt (M.S.); fhr@fct.unl.pt (F.H.R.); mfgp@fct.unl.pt (M.F.P.); pal@fct.unl.pt (P.L.); fjl@fct.unl.pt (F.C.L.)
2 GeoBioTec Research Center, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus da Caparica, 2829-516 Caparica, Portugal; abreusilva.manuela@gmail.com (M.M.S.); cochichor@mail.telepac.pt (J.C.R.); paula.scotti@iniav.pt (P.S.C.); isabel.pais@iniav.pt (I.P.P.)
3 ESEAG-COFAC, Avenida do Campo Grande 376, 1749-024 Lisboa, Portugal
4 Plant Stress & Biodiversity Lab, Centro de Estudos Florestais (CEF), Instituto Superior Agronomia (ISA), Universidade de Lisboa (ULisboa), Quinta do Marquês, Av. República, 1349-017 Lisboa, Portugal
5 INIAV-Instituto Nacional de Investigação Agrária e Veterinária, Avenida da República, Quinta do Marquês, 2780-157 Oeiras, Portugal
* Correspondence: arf.coelho@campus.fct.unl.pt; Tel.: +351-21-294-8573

† Presented at the 1st International Electronic Conference on Plant Science, 1–15 December 2020; Available online: https://iecps2020.sciforum.net/.

check for updates

Citation: Coelho, A.R.F.; Pessoa, C.C.; Marques, A.C.; Luís, I.C.; Daccak, D.; Silva, M.M.; Simões, M.; Reboredo, F.H.; Pessoa, M.F.; Legoinha, P.; et al. Natural Mineral Enrichment in *Solanum tuberosum* L. cv. Agria: Accumulation of Ca and Interaction with Other Nutrients by XRF Analysis. *Biol. Life Sci. Forum* **2021**, *4*, 77. https://doi.org/10.3390/IECPS2020-08709

Academic Editor: Yoselin Benitez-Alfonso

Published: 1 December 2020

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract: Calcium is a crucial nutrient for bone development and the normal functioning of the circulatory system, whereas its deficiency can trigger the development of osteoporosis and rickets. On the other hand, *Solanum tuberosum* L. is one of the most important staple food crops worldwide and is a primary component of the human diet. Accordingly, using this staple food, this study aims to develop a technical itinerary for Ca biofortification of cv. Agria. As such, an itinerary of Ca biofortification was promoted throughout the respective production cycle. Seven foliar sprays with $CaCl_2$ or chelated calcium (Ca EDTA) were used at concentrations of 12 and 24 kg ha^{-1}. The index of Ca biofortification and the related interactions with other chemical elements in the tuber were assessed. It was found that, relative to the control at harvest, Ca content increased 1.07–2.22 fold (maximum levels were obtained with 12 kg ha^{-1} Ca-EDTA). Ca(EDTA) at a concentration of 24 kg ha^{-1} showed the second-highest levels in Ca, S and, P content. By adding $CaCl_2$, it was also possible to identify a tendency of increasing contents (in Ca, K, S, and P) when the spraying concentration increased (12 kg ha^{-1} to 24 kg ha^{-1}). Outside of the Ca higher content, dry weight, height, diameter, and the colorimetric parameter L of the tubers did not vary significantly, but minor changes occurred in the colorimetric parameters Chroma and Hue. It was concluded that Ca(EDTA) could trigger a more efficient Ca biofortification of Agria potato tubers with the additional enrichment of K, S, and P.

Keywords: calcium accumulation; calcium biofortification; *Solanum tuberosum* L.

1. Introduction

After rice, wheat, and maize [1–4], *Solanum tuberosum* L. is one of the most important staple food crops worldwide [1]. The potato is a primary component of the human diet [5] and can provide 5–15% of dietary calories [6], minerals, vitamins, and carbohydrates [7]. It is rich in K, vitamin C, and B6 [1] and phytochemicals, such as phenolics and carotenoid compounds [8]. Additionally, due to its major consumption all over the world, enrichment of potato tubers with different minerals, such as selenium [9–11] or zinc [12,13], has been carried out [14]. In this context, agronomic biofortification is frequently used to increase the content of different minerals in edible plants through foliar fertilization, which is faster and more cost-effective [15].

Studies with apples [16], peaches [17], potatoes [18], and other vegetables [19] have shown a higher Ca content after foliar spraying. Calcium has a vital role in the anatomy, physiology, and biochemistry of organisms [20]. It is essential for plants (required as Ca^{2+}), as it has a central role in stress responses [21] and acts as a signal transduction agent [22]. Further, it is needed as a cofactor by enzymes taking part in the catabolism of ATP and phospholipids [23] and provides integrity and stability to cell walls [22]. In the human body, it is also a crucial nutrient for bone development and the normal functioning of the circulatory system [24–27]. Ca deficiency can trigger osteoporosis [20] and rickets [25]. In this context, to minimize Ca deficiency in the human population, the aim of this study is to develop an itinerary for Ca biofortification of potato tubers. Regarding the importance of this staple food for agro-industrial processing, the Agria variety was used as a test system because of its range of uses, such as french fries and starch/flakes [28].

2. Experiments

An experimental potato field located in western Portugal was used to grow cv. Agria (*Solanum tuberosum* L.). During the growing period, from 15 March (planting date) to 29 July 2019 (harvest date), air temperatures reached a daily average of 21.9 °C and 13.8 °C (with maximum and minimum values of 34.8 °C and 4.7 °C, respectively). The average rainfall was 0.51 mm, with a daily maximum of 10.4 mm. After the beginning of tuberization, seven foliar sprayings (with a 6–8 day interval) were performed with $CaCl_2$ (12 and 24 kg ha^{-1}). Because Ca(EDTA) might become highly toxic to plants, only one foliar application of 24 kg ha^{-1} with Ca(EDTA) was carried out, whereas seven spraying applications were performed with 12 kg ha^{-1}. Control plants were not sprayed at any time with $CaCl_2$ or Ca(EDTA). All treatments were performed in quadruplicate on plots that measured 20 × 24 m.

Calcium, K, S, and P content were determined in randomized tubers after being cut, dried (at 60 °C until constant weight), and ground using an XRF analyzer (model XL3t 950 He GOLDD+) under He atmosphere, according to [29].

Height, diameter, and dry weight were measured considering four randomized tubers per treatment. Colorimetric parameters, using fixed wavelength, followed [30]. Brightness (L) and chromaticity parameters (a* and b* coordinates) were obtained with a Minolta CR 400 colorimeter (Minolta Corp., Ramsey, NJ, USA) coupled to a sample vessel (CR-A504). Using the illuminant D_{65}, the system of the Commission Internationale d'Éclaire (CIE) was applied. The parameter L represents the brightness of the sample, indicating the variation of the tonality between dark and light, with a range between 0 (black) and 100 (white). Parameters a* and b* indicate color variations between red (+60) and green (−60) and between yellow (+60) to blue (−60), respectively. The approximation of these coordinates to the null value translates neutral colors like white, gray, and black. Chroma is the relationship between the values of a* and b*, where the real color of the analyzed object is obtained. Hue is the angle formed between a* and b*, indicating the saturation of the object's color. To calculate Chroma (C), Equation (1) was used, and to calculate Hue-Angle (H), Equation (2). Measurements were carried out in quadruple in the pulp of fresh tubers at harvest.

$$C^* = \sqrt{a*^2 + b*^2} \tag{1}$$

$$H^* = \text{arctg}\,\frac{b*}{a*} \tag{2}$$

Data were statistically analyzed using a One-Way ANOVA to assess differences among treatments in cv. Agria, followed by a Tukey's for mean comparison. A 95% confidence level was adopted for all tests.

3. Results

After harvest, Ca, K, S, and P accumulation in the tubers was assessed in cv. Agria, (Table 1). Relative to the control, the content of Ca was significantly higher in all treatments (except in $CaCl_2$–12 kg ha^{-1}), with an increase in Ca content ranging between 1.07 and 2.22 fold (maximum levels obtained with 12 kg ha^{-1} Ca-EDTA). Considering all the four macronutrients analyzed, the treatment of 12 kg ha^{-1} Ca(EDTA) showed the maximum content, with significant differences regarding the control, whereas the control showed the lowest content (Table 1). Regarding both fertilizers, the highest content prevailed in the treatments of Ca(EDTA), despite only one application for treatment with 24 kg ha^{-1} being carried out. Ca(EDTA) at a concentration of 24 kg ha^{-1} showed the second-highest levels in Ca, S, and P content. Regarding only the treatments applied with $CaCl_2$, it is possible to identify a tendency of increasing content (in Ca, K, S, and P) when spraying concentration is increased (12 kg ha^{-1} to 24 kg ha^{-1}).

Table 1. Mean values ± S.E. (n = 4) of Ca, K, S, and P in tubers of *Solanum tuberosum* L., cv. Agria, at harvest. Different letters indicate significant differences of each parameter between treatments ($p \leq 0.05$). Foliar spraying was carried out with two concentrations (12 and 24 kg·ha^{-1}) of $CaCl_2$ and Ca(EDTA). Control was not sprayed.

Treatments	**Ca**	**K**	**S**	**P**
	g kg^{-1}			
Control	0.57 d ± 0.01	30.73 e ± 0.19	1.13 c ± 0.06	0.80 d ± 0.05
$CaCl_2$ (12 kg ha^{-1})	0.61 d ± 0.02	31.57 d ± 0.08	1.15 c ± 0.01	0.62 e ± 0.01
$CaCl_2$ (24 kg ha^{-1})	0.72 c ± 0.00	35.40 b ± 0.02	1.24 c ± 0.00	1.00 c ± 0.00
Ca(EDTA) (12 kg ha^{-1})	1.27 a ± 0.01	41.23 a ± 0.15	2.07 a ± 0.03	1.72 a ± 0.01
Ca(EDTA) (24 kg ha^{-1})	1.07 b ± 0.00	32.28 c ± 0.09	1.49 b ± 0.01	1.34 b ± 0.01

Independently of the Ca higher content, dry weight, height, and diameter of the tubers did not vary significantly (Table 2). However, 24 kg ha^{-1} $CaCl_2$ tubers showed the lowest dry weight comparing the applied treatments. Also, treatment with 12 kg ha^{-1} $CaCl_2$ showed the highest percentage of dry weight.

Table 2. Mean values ± S.E. (n = 4) of dry weight, height, and diameter in tubers of *Solanum tuberosum* L., cv. Agria, at harvest. Letter a indicates no significant differences of each parameter between treatments ($p \leq 0.05$). Foliar spraying was carried out with two concentrations (12 and 24 kg·ha^{-1}) of $CaCl_2$ and Ca(EDTA). Control was not sprayed.

Treatments	**Dry Weight (%)**	**Height (cm)**	**Diameter (cm)**
Control	17.12 a ± 0.69	8.20 a ± 0.49	7.57 a ± 0.48
$CaCl_2$ (12 kg ha^{-1})	21.89 a ± 0.89	10.10 a ± 1.01	8.03 a ± 0.52
$CaCl_2$ (24 kg ha^{-1})	16.77 a ± 2.52	9.20 a ± 0.96	6.63 a ± 0.52
Ca(EDTA) (12 kg ha^{-1})	20.97 a ± 1.87	8.20 a ± 0.61	6.60 a ± 0.42
Ca(EDTA) (24 kg ha^{-1})	18.99 a ± 0.44	12.67 a ± 2.27	7.97 a ± 0.38

Considering the colorimetric parameters in the fresh tubers of cv. Agria, it was found that (Table 3) the brightness/luminosity had no significant changes. However, the Chroma parameter (saturation) did vary significantly, with the more intense color obtained in 12 kg ha^{-1} Ca(EDTA) treatment. The control and 24 kg ha^{-1} Ca(EDTA) treatment showed similar values of Chroma. Concerning the Hue parameter, only 12 kg ha^{-1} Ca(EDTA) showed significant differences regarding the remaining treatments and control.

Table 3. Mean values ± S.E. (n = 4) of colorimetric parameters (L, Chroma, and Hue) in fresh tubers of *Solanum tuberosum* L., cv. Agria, at harvest. Letters a and b indicate significant differences of each parameter between treatments (statistical analysis using the single factor ANOVA test, $p \leq 0.05$). Foliar spraying was carried out with two concentrations (12 and 24 kg·ha^{-1}) of $CaCl_2$ and Ca(EDTA). Control was not sprayed.

Treatments	L	Chroma	Hue
Control	62.88 a ± 1.36	22.76 b ± 0.37	105.8 a ± 0.2
$CaCl_2$ (12 kg ha^{-1})	62.74 a ± 2.03	24.18 a,b ± 0.89	104.9 a ± 0.4
$CaCl_2$ (24 kg ha^{-1})	63.51 a ± 0.74	25.09 a,b± 0.38	108.5 a ± 0.1
Ca(EDTA) (12 kg ha^{-1})	62.92 a ± 0.71	30.47 a ± 2.91	102.3 b ± 1.1
Ca(EDTA) (24 kg ha^{-1})	64.98 a ± 3.12	23.27 b ± 0.82	105.3 a ± 0.2

4. Discussion

Calcium accumulation in potato tubers relies upon the interaction of different factors, such as the development of the tuber, phloem and xylem delivery, and other chemical interactions within the tuber [31]. In fact, Ca depends on its delivery via the xylem because, in the phloem, it is almost immobile [32]. Different types of cultures provided with Ca, showed an increase in this mineral content, mainly using $CaCl_2$ [33]. However, despite that, Ca-EDTA is not usually used. There were studies carried out, namely with sweetcorn [34] and apples [35], that applied this type of Ca chelate. In this context, $CaCl_2$ and Ca(EDTA) were applied in similar concentrations in the tuber plants cv. Agria. Yet, despite just one foliar application with 24 kg ha^{-1} Ca(EDTA), it showed the second-highest Ca content regarding the remaining treatments. In fact, the two concentrations applied with Ca(EDTA) showed higher Ca content, as with the two treatments of $CaCl_2$ (Table 1). Comparing the number of foliar applications of both treatments with Ca(EDTA), it was possible to verify that treatment with 24 kg ha^{-1} (applied only once) presented just less (15.75%) Ca content than the treatment with 12 kg ha^{-1} (that was applied seven times). However, as seen in tomato plants, Ca(EDTA) is toxic to plants when applied repeatedly [36]. Regarding the nutrient content (Table 1), cv. Agria varied among the treatments. Potassium is one of the main minerals present in tubers [37], and the contents of Ca and P obtained were higher compared to another study that used the same cultivar [38]. Also, it can be seen that, with the increase in Ca content, S content also increased, which was reported previously by [39]. On the other hand, higher content of S can also improve the absorption of K and P [39], as found in our study (Table 1).

We considered the importance of the dry matter content since it is an important characteristic for industrial processing and one criterion for the classification of potato tubers [40]. It was possible to verify any significant differences compared to the control. Also, the industry has a requirement for potatoes to have a dry matter content higher than 20% (which is the case of 12 kg ha^{-1} $CaCl_2$ and Ca(EDTA) treatments (Table 2)), since higher dry matter content reduces fat absorption during the frying process, producing more crispy chips [40]. A positive relationship between Ca application and the hardness of fries was found in other potato varieties, improving this quality parameter [41]. Considering the dry matter obtained in this study, it was further possible to verify a similarity to the values obtained by other authors for the same variety [42,43]. Regarding the height and diameter of tubers, there was no interference relatively to the Ca-biofortification process (Table 2), maintaining its industrial characteristics. According to Portuguese law, the tubers' caliber should be higher than 3.5 cm [44], which agrees with our data for cv. Agria, and therefore, the biofortified potatoes are suitable for industrial processing [45]. Also, the diameter of tubers acquired in this study is in accordance with values obtained by other authors for the same variety [46,47].

The perception of color as a definition of quality for agricultural products, such as in coffee [30,48], strawberries, grapes, plums [49], sweet potatoes [50], apples [51,52], and potatoes [1,8], is very important to consumers [53]. Regarding the L parameter, the data obtained showed lower values compared to other studies for the same cultivar [47,54–56].

Also, the Chroma parameter showed lower values compared to other studies for the same cultivar (except in Chroma—12 kg ha^{-1} Ca(EDTA) treatment) [5,55]. However, it showed a higher Hue value compared to other authors [5]. In this context, there were minor effects among the different Ca treatments; for example, the treatment that showed higher Ca content (Table 1) showed the maximum value for Chroma and the lowest value for Hue (Table 3).

5. Conclusions

In all treatments, pulverized with $CaCl_2$ and Ca(EDTA), *S. tuberosum* cv. Agria showed a significant increase in Ca contents. Nevertheless, for both applied concentrations of Ca(EDTA), a higher Ca content was found relative to $CaCl_2$ treatments (being 12 kg ha^{-1} Ca(EDTA) treatment, the one that showed the higher Ca biofortification). Additionally, Ca biofortification did not trigger any changes in the dry matter, height, diameter, or L parameter of color. However, minor changes occurred in the colorimetric parameters Chroma and Hue.

Supplementary Materials: The poster presentation is available online at https://www.mdpi.com/article/10.3390/IECPS2020-08709/s1.

Author Contributions: F.C.L. conceived and designed the experiments; A.R.F.C., A.C.M., C.C.P., I.C.L., and D.D. performed the experiments; A.C.M., and F.C.L. analyzed the data; M.M.S., M.S., F.H.R., M.F.P., J.C.R., P.L., P.S.C., I.P.P., and F.C.L. contributed reagents/materials/analysis tools; A.R.F.C., and F.C.L. wrote the paper. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors' thanks to Eng. Nuno Cajão (Cooperativa de Apoio e Serviços do Concelho da Lourinhã- LOURICOOP) for technical assistance in the agricultural parcel as well as to project PDR2020-101-030719 for the financial support. We also thank the Research Centers (GeoBioTec) UIDB/04035/2020 and (CEF) UIDB/00239/2020.

Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

References

1. Xiao, Q.; Bai, X.; He, Y. Rapid Screen of the Color and Water Content of Fresh-Cut Potato Tuber Slices Using Hyperspectral Imaging Coupled with Multivariate Analysis. *Foods* **2020**, *9*, 94. [CrossRef]
2. FAO (Food and Agriculture Organization). Potato World: Production and Consumption—International Year of the Potato 2008. Available online: http://www.fao.org/potato-2008/en/world/ (accessed on 3 November 2020).
3. CIP—International Potato Center. Potato Facts and Figures. 2018. Available online: https://cipotato.org/crops/potato/potato-facts-and-figures/ (accessed on 4 November 2020).
4. Muthoni, J.; Mbiyu, M.; Nyamongo, D. A review of potato seed systems and germplasm conservation in Kenya. *J. Agric. Food Inf.* **2010**, *11*, 157–167. [CrossRef]
5. Yang, Y.; Achaerandio, I.; Pujolà, M. Classification of potato cultivars to establish their processing aptitude. *J. Sci. Food Agric.* **2016**, *96*, 413–421. [CrossRef]
6. Thompson, M.; Thompson, H.; McGinley, J.; Neil, E.; Rush, D.; Holm, D.; Stushnoff, C. Functional food characteristics of potato cultivars (*Solanum tuberosum* L.): Phytochemical composition and inhibition of 1-methyl-1-nitrosourea induced breast cancer in rats. *J. Food Compos. Anal.* **2009**, *22*, 571–576. [CrossRef]
7. Ali, M.; Nasiruddin, K.; Haque, M.; Faisal, S. Virus elimination in potato through meristem culture followed by thermotherapy. *SAARC J. Agric.* **2014**, *11*, 71–80. [CrossRef]
8. Cima, F.F.; Pereira, E.D.S.; Schiavon, M.V.; Munhoz, P.C.; Lenz, E.A.; Wolter, D.D.; Pereira, A.D.S. Bioactive compounds, processing quality and yield of colored flesh potato clones. *Horti. Bras.* **2020**, *38*, 139–145. [CrossRef]
9. Poggi, V.; Arcioni, A.; Filippini, P.; Pifferi, P. Foliar application of selenite and selenate to potato (*Solanum tuberosum*): Effect of a ligand agent on selenium content of tubers. *J. Agric. Food Chem.* **2000**, *48*, 4749–4751. [CrossRef] [PubMed]
10. Oliveira, V.; Faquin, V.; Andrade, F.; Carneiro, J.; Júnior, E.; Souza, K.; Pereira, J.; Guilherme, L. Physiological and physicochemical responses of potato to selenium biofortification in tropical soil. *Potato Res.* **2019**, *62*, 315–331. [CrossRef]
11. Zhang, H.; Zhao, Z.; Zhang, X.; Zhang, W.; Huang, L.; Zhang, Z.; Yuan, L.; Liu, X. Effects of foliar application of selenate and selenite at different growth stages on Selenium accumulation and speciation in potato (*Solanum tuberosum* L.). *Food Chem* **2019**, *286*, 550–556. [PubMed]

12. Mousavi, S.; Galavi, M.; Ahmadvand, G. Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum* L.). *Asian J. Plant Sci.* **2007**, *6*, 1256–1260. [CrossRef]
13. White, P.; Thompson, J.; Wright, G.; Rasmussen, S. Biofortifying scottish potatoes with zinc. *Plant Soil* **2016**, *411*, 151–165. [CrossRef]
14. Díaz-Gómez, J.; Twyman, R.M.; Zhu, C.; Farré, G.; Serrano, J.C.E.; Portero-Otin, M.; Muñoz, P.; Sandmann, G.; Capell, T.; Christou, P. Biofortification of crops with nutrients: Factors affecting utilization and storage. *Curr. Opin. Biotech.* **2017**, *44*, 115–123. [CrossRef]
15. Alshaal, T.; El-Ramady, H. Foliar application: From plant nutrition to biofortification. *EBSS* **2017**, *1*, 71–83. [CrossRef]
16. Sen, F.; Karacali, I.; Irget, M.E.; Elmaci, O.L.; Tepecik, M. A new strategy to enrich calcium nutrition of fruit: Synergistic effects of postharvest foliar calcium and boron sprays. *J. Plant Nutr.* **2010**, *33*, 175–184. [CrossRef]
17. Elmer, P.A.G.; Spiers, T.M.; Wood, P.N. Effects of pre-harvest foliar calcium sprays on fruit calcium levels and brown rot of peaches. *Crop Prot.* **2007**, *26*, 11–18. [CrossRef]
18. McGuire, R.G.; Kelman, A. Calcium in potato tuber cell walls in relation to tissue maceration by Erwinia carotovora pv. atroseptica. *Phytopathology* **1986**, *76*, 401–406. [CrossRef]
19. D'Imperio, M.; Renna, M.; Cardinali, A.; Buttaro, D.; Serio, F.; Santamaria, P. Calcium biofortification and bioaccessibility in soilless "baby leaf" vegetable production. *Food Chem.* **2016**, *213*, 149–156. [CrossRef] [PubMed]
20. NIH (National Institutes of Health). Available online: https://pubchem.ncbi.nlm.nih.gov/compound/calcium (accessed on 4 November 2020).
21. Hocking, B.; Tyerman, S.; Burton, R.; Gilliham, M. Fruit calcium: Transport and physiology. *Front. Plant Sci.* **2016**, *7*, 569. [CrossRef]
22. Wei, S.; Qin, G.; Zhang, H.; Tao, S.; Wu, J.; Wang, S.; Zhang, S. Calcium treatments promote the aroma volatiles emission of pear (*Pyrus ussuriensis* 'Nanguoli') fruit during post-harvest ripening process. *Sci. Hortic-Amst.* **2017**, *215*, 102–111. [CrossRef]
23. Taiz, L.; Zeiger, E. *Plant Physiology*, 3rd ed.; Sinauer Associates, Inc.: Sunderland, UK, 2002; p. 665.
24. Peacock, M. Calcium metabolism in health and disease. *Clin. J. Am. Soc. Nephrol.* **2010**, *5* (Suppl. 1), S23–S30. [CrossRef]
25. IOM—Institute of Medicine. *Dietary Reference Intakes for Calcium and Vitamin D*; The National Academies Press: Washington, DC, USA, 2011; ISBN 978-0-309-16395-8.
26. Buchowski, M.S. Calcium in the context of dietary sources and metabolism. In *Calcium: Chemistry, Analysis, Function and Effects*; Preedy, V.R., Ed.; Food and Nutritional Components in Focus—Book Series; Royal Society of Chemistry: London, UK, 2015; Chapter 1; pp. 3–20. ISBN 978-1-78262-213-0.
27. Sharma, D.; Jamra, G.; Singh, U.; Sood, S.; Kumar, A. Calcium biofortification: Three pronged molecular approaches for dissecting complex trait of calcium nutrition in finger millet (*Eleusine coracana*) for devising strategies of enrichment of food crops. *Front. Plant Sci.* **2017**, *7*, 2028. [CrossRef] [PubMed]
28. AHDB—Agriculture and Horticulture Development Board. Available online: http://varieties.ahdb.org.uk/varieties/view/Agria (accessed on 4 November 2020).
29. Pelica, J.; Barbosa, S.; Lidon, F.; Pessoa, M.F.; Reboredo, F.; Calvão, T. The paradigm of high concentration of metals of natural or anthropogenic origin in soils—The case of Neves-Corvo mine area (Southern Portugal). *J. Geochem. Explor.* **2018**, *186*, 12–23. [CrossRef]
30. Ramalho, J.C.; Pais, I.P.; Leitão, A.E.; Guerra, M.; Reboredo, F.H.; Máguas, C.M.; Carvalho, M.L.; Scotti-Campos, P.; Ribeiro-Barros, A.I.; Lidon, F.J.C.; et al. Can elevated air [CO_2] conditions mitigate the predicted warming impact on the quality of coffee bean? *Front. Plant Sci.* **2018**, *9*, 287. [CrossRef]
31. Subramanian, N.K.; White, P.J.; Broadley, M.R.; Ramsay, G. The three-dimensional distribution of minerals in potato tubers. *Ann Bot.* **2011**, *107*, 681–691. [CrossRef]
32. Weinl, S.; Held, K.; Schlücking, K.; Steinhorst, L.; Kuhlgert, S.; Hippler, M.; Kudla, J. A plastid protein crucial for Ca^{2+}-regulated stomatal responses. *New Phytol.* **2008**, *179*, 675–686. [CrossRef] [PubMed]
33. Dayod, M.; Tyerman, S.; Leigh, R.; Gilliham, M. Calcium storage in plants and the implications for calcium biofortification. *Protoplasma* **2010**, *247*, 215–231. [CrossRef]
34. El-Yazied, A.; Ragab, M.E.; Ibrahim, R.E.; El-Wafa, A. Effect of nitrogen fertigation levels and chelated Calcium foliar application on the productivity of sweet corn. *AJS* **2007**, *15*, 131–139. [CrossRef]
35. Rasouli-Sadaghiani, M.; Moghaddas Gerani, M.; Ashrafi Saeidlou, S.; Sepehr, E. Effect of Different Calcium Sources Application on Antioxidant, Enzymatic Activity and Qualitative Characteristics of Apple (Malus domestic). *JCPP* **2017**, *7*, 73–87. [CrossRef]
36. Alonso, T.A.; Barreto, R.; Prado, R.; Souza, J.; Carvalho, R. Silicon spraying alleviates calcium deficiency in tomato plants, but Ca-EDTA is toxic. *J. Plant. Nutr. Soil Sci.* **2020**, *183*, 659–664. [CrossRef]
37. Navarre, D.A.; Goyer, A.; Shakya, R. Nutritional value of potatoes. *Adv. Potato Chem. Technol.* **2009**, *4*, 395–424. [CrossRef]
38. Rusinovci, I.; Aliu, S.; Fetahu, S.H.; Kaçiu, S.; Salihu, S.; Zeka, D.; Berisha, D. Contents of mineral substances in the potato (*Solanum tuberosum* L.) tubers depending on cultivar and locality in the agro-ecological conditions of Kosovo. *Acta Hortic.* **2012**, *960*, 289–292. [CrossRef]
39. Aulakh, M.S.; Dev, G. Interaction effect of calcium and sulphur on the growth and nutrient composition of alfalfa (*Medicago sativa* L. pers.), using ^{35}S. *Plant Soil* **1978**, *50*, 125–134. [CrossRef]

40. Braun, H.; Fontes, P.; Finger, F.; Busato, C.; Cecon, P. Carboidratos e matéria seca de tubérculos de cultivares de batata influenciados por doses de nitrogênio. *Ciência Agrotecnologia* **2010**, *34*, 285–293. [CrossRef]
41. Murayama, D.; Sakashita, Y.; Yamazawa; Nakata, K.; Shinbayashi, Y.; Palta, J.; Tani, M.; Yamuchi, H.; Koaze, H. Effect of calcium fertilization on processing properties and storability of frozen French fries. *Food Sci. Technol. Res.* **2016**, *22*, 451–459. [CrossRef]
42. Romano, A.; D'Amelia, V.; Gallo, V.; Palomba, S.; Carputo, D.; Masi, P. Relationships between composition, microstructure and cooking performances of six potato cultivars. *Food Res. Int.* **2018**, *114*, 10–19. [CrossRef] [PubMed]
43. Arvanitoyannis, I.; Mavromatis, A.; Vaitsi, O.; Korkovelos, A.; Golia, E. Effect of genotype and geographical origin on potato properties (physical and sensory) for authenticity purposes. *J. Agric. Sci.* **2012**, *4*, 1916–1960. [CrossRef]
44. *Portaria n.º 587/87 de 9 de Julho. Diário da República n.o 155/1987, Série, I. Ao abrigo do disposto no n.o1 do artigo 4.o do Decreto-Lei n.o 512/85, de 31 de Dezembro*; Ministérios da Agricultura, Pescas e Alimentação e da Indústria e Comércio: Lisboa, Portugal, 2021.
45. Amaral, A.; Militão, J. Efeito de Doses e Modo de Fraccionamento de Potássio na Batata de Indústria "VR0808". *Rev. Unidade Investig. Inst. Politécnico St.* **2015**, *3*, 118–130. Available online: http://hdl.handle.net/10400.15/1569 (accessed on 5 November 2020).
46. Ahangarnezhad, N.; Najafi, G.; Jahanbakhshi, A. Determination of the physical and mechanical properties of a potato (the Agria variety) in order to mechanise the harvesting and post-harvesting operations. *Res. Agric. Eng.* **2019**, *65*, 33–39. [CrossRef]
47. Mesías, M.; Holgado, F.; Márquez-Ruiz, G.; Morales, F.J. Impact of the characteristics of fresh potatoes available in-retail on exposure to acrylamide: Case study for French fries. *Food Control* **2017**, *73*, 1407–1414. [CrossRef]
48. Bicho, N.C.; Leitao, A.E.; Ramalho, J.C.; Lidon, F.C. Application of colour parameters for assessing the quality of Arabica and Robusta green coffee. *Emir. J. Food Agric.* **2014**, *26*, 9–17. [CrossRef]
49. Hernández-Herrero, J.A.; Frutos, M.J. Colour and antioxidant capacity stability in grape, strawberry and plum peel model juices at different pHs and temperatures. *Food Chem.* **2014**, *154*, 199–204. [CrossRef]
50. Cevallos-Casals, B.A.; Cisneros-Zevallos, L. Stability of anthocyanin-based aqueous extracts of Andean purple corn and red-fleshed sweet potato compared to synthetic and natural colorants. *Food Chem.* **2004**, *86*, 69–77. [CrossRef]
51. Kus, Z.A.; Demir, B.; Eski, I.; Gurbuz, F.; Ercisli, S. Estimation of the colour properties of apples varieties using neural network. *Erwerbs-Obstbau* **2017**, *59*, 291–299. [CrossRef]
52. Kumar, N.; Sarnagat, V.S. A Study on Colour and Dimensional Assessment of Different Apple cultivars present in Domestic Fruit Market of NCR Region. *J. Trop. Agric.* **2017**, *35*, 849–856.
53. Coleman, W. Comparative performance of the L* a* b* colour space and North American colour charts for determining chipping quality in tubers of potato (*Solanum tuberosum* L.). *Can. J. Plant Sci.* **2004**, *84*, 291–298. [CrossRef]
54. Cantos, E.; Tudela, J.A.; Gil, M.I.; Espín, J.C. Phenolic compounds and related enzymes are not rate-limiting in browning development of fresh-cut potatoes. *J. Agric. Food Chem.* **2002**, *50*, 3015–3023. [CrossRef] [PubMed]
55. Cabezas-Serrano, A.B.; Amodio, M.L.; Cornacchia, R.; Rinaldi, R.; Colelli, G. Suitability of five different potato cultivars (*Solanum tuberosum* L.) to be processed as fresh-cut products. *Postharvest Biol. Technol.* **2009**, *53*, 138–144. [CrossRef]
56. Picouet, P.A.; Gou, P.; Pruneri, V.; Diaz, I.; Castellari, M. Implementation of a quality by design approach in the potato chips frying process. *J. Food Eng.* **2019**, *260*, 22–29. [CrossRef]