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BRS Vitória grapes with natural surfactant pretreatment: evaluation of mineral composition, physical-chemical characteristics, and sensory characteristics after raisin production

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Abstract

Raisins have been gaining recognition for their nutrient and bioactive compound contents. Yet, pretreatments used for grape drying raise concerns regarding the economic viability and safety of the product. The objective of this proposal was to produce raisins from BRS Vitória grapes pretreated with a natural surfactant to accelerate the drying process. Subsequently, the influence of drying and pretreatment was evaluated for chemical composition (moisture, water activity (Aw), pH, total acidity (TA), reducing sugars (RS), and total sugars (TS)), total phenolic compounds (TPC), total anthocyanins, and qualitative and quantitative mineral composition. Finally, a sensory analysis of the raisins was conducted. By using the pretreatment, drying time decreased by approximately 38.5%. The raisins met the moisture requirements by the Brazilian and international regulations, and the pretreated raisins (PR) had a higher anthocyanin content, a high sugar concentration, acids, phenolic compounds (PC), and minerals (potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), and manganese (Mn)), and were well accepted by consumers, especially in terms of taste and appearance. Interestingly, the pretreatment also provided more brightness to the samples. In conclusion, BRS Vitória grapes yielded raisins with a complex composition, especially those that were subjected to the pretreatment, might be consumed as a healthier snack, adding PC and minerals to the diet.

Keywords: raisins; BRS Vitória; mineral composition; phenolic compounds.

Practical Application: Pretreated raisins with high content of minerals, phenolic compounds, and sensory acceptance.

1 INTRODUCTION

Among the non-alcoholic grape derivatives, raisins stand out because, besides being durable, they are easy to be transported and consumed. These attributes attend the growing market demands of convenience and practicality (Papadaki et al., 2021; Souza et al., 2015). They can be eaten directly, as healthy snacks, or incorporated as ingredients in a wide variety of food preparations (Khiari et al., 2019; Nikolidaki et al., 2017; Olivati et al., 2019, 2022). Studies describe the beneficial health effects of eating raisins (Jeszka-Skowron & Czarczyńska-Goślińska, 2020; Olmo-Cunillera et al., 2019), since they can provide micronutrients and compounds with bioactive properties, such as fibers, minerals, and phenolic compounds (PC) (Olivati et al., 2019, 2022; Olmo-Cunillera et al., 2019; Papadaki et al., 2021; Zhou et al., 2022). In addition, they are low in total fat, saturated fatty acids, and sodium (Jeszka-Skowron & Czarczyńska-Goślińska, 2020).

Although they have a higher sugar content when compared to fresh grapes, studies have shown that raisins have a low to moderate glycemic index, which in combination with the consumption of fibers and antioxidant compounds may aid in controlling and decreasing the risk of type 2 diabetes (Olmo-Cunillera et al., 2019). Studies have reported that even though PC degradation may occur during grape processing, raisins are still rich in these compounds due to the inherent concentration effect of dehydration. In addition, they have reported that using pretreatments with natural surfactants that speed up the process can improve the retention of PC in raisins (Olivati et al., 2019, 2022). Some authors also reported that the changes triggered in grape morphology during the drying process may promote greater bioavailability of phenolic and mineral compounds (e.g., Ozkan et al., 2022).

In view of the above, the prospection of grapes suitable for the production of raisins has been the object of study by several researchers. The Brazilian BRS Vitória grapes (CNPUV 681-29 x BRS Linda) (Caldeira et al., 2018; Freitas et al., 2013; Souza et al., 2015) stand out for their physical-chemical and sensory characteristics. Among their main characteristics are uniform

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bluish-black color, absence of seeds, pleasant raspberry flavor, high content of soluble solids (SS) (Maia et al., 2016), and PCs (anthocyanins, flavonols, flavan-3-ols, and proanthocyanidins) (Colombo et al., 2020; 2021). On the contrary, there are no reports describing their mineral composition and, in general, there is less scientific evidence on the effect of drying used as a pretreatment of the grape berries on the physical-chemical and sensory characteristics and mineral content of raisins. Among the existing techniques for qualitative and quantitative analyses of trace elements and minerals, inductively coupled plasma mass spectrometry (ICP-MS) stands out for its accuracy and speed, as well as its aptness when handling complex matrices, such as food with minimal interference in the matrix (Canizo et al., 2019; Shimizu et al., 2022).

It is also important to emphasize that besides the nutritional characteristics of raisins, their sensory characteristics are also influenced by the parameters of the drying process (Khiari et al., 2019). Thus, it is compelling that analyses on the nutritional quality of raisins are conducted concomitantly with a sensory analysis, aiming to obtain raisins that are not only nutritious, but also well accepted by consumers.

Hence, the objective of this study was to produce raisins from the BRS Vitória cultivar through conventional convective drying with and without the use of a natural surfactant (extra virgin olive oil – EVOO) as a pretreatment and then evaluate the influence of the drying process and pretreatment on their physical-chemical characteristics. These are moisture, water activity (Aw), pH, total acidity (TA), reducing sugars (RS), total sugars (TS), SS (only for fresh grapes), total phenolic compounds (TPC), and total monomeric anthocyanins (TMA). The qualitative and quantitative mineral composition of the grapes and the sensory acceptance of the raisins were also evaluated.

2 MATERIALS AND METHODS

2.1 BRS Vitória grapes and raisin production

BRS Vitória grapes were grown on the Paulsen 1103 rootstock by using the "Y" planting system, in Urania, São Paulo, Brazil. As for producing the raisins, the grapes that did not present any physical damage or rot were selected and sanitized with potable water and chlorinated water (200 $mg \cdot L^{-1}$ of active chlorine). Half of the selected grapes were directed to drying, while the other half was subjected to an EVOO pretreatment (acidity ≤ 0.50% and peroxide index ≤ 20.00 mEq kg^{-1}), according to the methodology presented by Olivati et al. (2019). Drying was carried out at 60°C in an oven with air circulation and renovation (Tecnal, Sao Paulo, Brazil), and drilled stainless-steel trays were used to ensure air indeed circulated. The trays were periodically weighed, and the process was concluded with the reduction of at least 75% of the initial mass of the grapes to ensure compliance to the existing national and international regulations regarding the final moisture of the product (Brasil, 2005; Codex Alimentarius, 2019). The drying process was carried out in duplicate for the grapes with (PR – pretreated raisins) and without (C – control) a pretreatment; both the pretreated and the control raisins were packed in polyethylene packaging with light and oxygen protection and kept under refrigeration (± 7°C) until the moment of the proposed analyses.

2.2 Physical-chemical characterization of the grapes and raisins

The grapes, PR, and C were characterized in triplicate according to the methodologies recommended by the Association of Official Analytical Chemists (AOAC, 2015) for moisture by the thermogravimetric method in a vacuum oven at 70°C. Aw, determined at 25°C using an electric hygrometer (Axair Ltd., Novasina, Aw Sprint, Switzerland); pH, by direct reading in a pH meter; TA, by potentiometric volumetry, with results expressed in grams of tartaric acid 100 g^{-1}; and RS and TS, by the Lane-Eynon method, with results expressed in g of glucose 100 g^{-1}. For fresh grapes, the content of SS was found by using refractometry and results were expressed in °Brix at 25°C. The contents of TPC, expressed in gallic acid equivalent (mg GAE 100 g^{-1}), and TMA, in malvidin-3,5-diglucoside kg^{-1}, were also determined according to the methodologies described by Singleton et al. (1999) and Ribéreau-Gayon and Stonestreet (1965), respectively.

2.3 Mineral composition of grapes and raisins

The qualitative and quantitative analyses of macro- and micro-elements of the BRS Vitória grape, PR, and C were conducted as follows: calcium (Ca), potassium (K), magnesium (Mg), phosphorus (P), iron (Fe), manganese (Mn), zinc (Zn), selenium (Se), aluminum (Al), and lead (Pb), according to the method recommended by the AOAC 2015.06 (Pacquette et al., 2018).

For each product (grape, PR, and C), representative samples were homogenized in a mixer (PMX-600, Philco, Brazil). Sample aliquots (0.25 g), in duplicate, were transferred to poly(tetrafluoroethylene-co-perfluoropropyl vinyl ether) – PFA (Teflon™) tubes, and the microwave digestion was carried out with a solution of 65% nitric acid (v/v) and 30% hydrogen peroxide (v/v), both from Merk, in a closed environment, using a Multiwave GO microwave oven (Anton Paar) until reaching the temperature of 190°C.

After the reaction period, the necessary time for thermal equilibrium of the tubes at room temperature was consented. Then, the tubes were opened in a hood with gas exhaustion and the extracts were filtered into 50-mL glass flasks, which had their volume completed with ultrapure standard water (Milli-Q element, 18 MΩ cm^{-1}). For the subsequent analyses, an ICP-MS Internal Standard solution (Perkin Elmer, Waltham, USA) was added as follows: Scandium to Fe, Ca, Mg, and K; Germanium to P, Mn, and Zn. Minerals were determined by using a NexION 1000 ICP-MS (Perkin Elmer, Waltham, USA). Analyses were conducted using the standard mode for the elements such as S, Mg, K, and Ca. For the other elements, the KED mode was used with He as the collision gas. The analyzed isotopes were ^{24}Mg, ^{39}K, ^{43}Ca, ^{31}P, ^{57}Fe, ^{27}Al, ^{208}Pb, ^{55}Mn, ^{66}Zn, and ^{82}Se. Calibration curves of standard elements were prepared using stock solutions from PerkinElmer and their contents in samples were calculated through a regression equation. For better comparison and discussion, the results were expressed on a wet (WB) and a dry basis (DB).

2.4 Sensory analysis of raisins with and without EVOO pretreatment

The sensory acceptance analysis of PR and C was previously submitted to the Research Ethics Committee of the Institute of Biosciences, Languages and Exact Sciences – IBILCE/ UNESP (report number 5.450.197) and carried out in the Sensory Analysis Laboratory of the Department of Food Sciences and Engineering of the same institute. There were 152 raisin consumers, between 18 and 62 years old, of whom 52.5% were women. Only the individuals who informed that they "liked it a lot", "liked it a little", or consumed raisins at least once a month were considered raisin consumers. The analysis was performed in individual booths, with temperature around 22 °C and white light. The samples were previously coded with a random sequence of three numbers and presented in a complete block in a monadic and balanced manner (Macfie et al., 1989).

PR and C were assessed for global acceptance using a structured 9-point hedonic scale, in which point 1 corresponded to "extremely disliked it" and 9 to "extremely liked it". Then, consumers were asked to say what they liked most and least about the sample through an open question.

2.5 Statistical analysis

The results obtained were expressed as mean ± standard deviation. The results of the physical-chemical and mineral analyses (DB and WB) were submitted to one-way analysis of variance (ANOVA), followed by the Tukey's test, considering α=0.05 to compare means obtained for grapes and raisins. From the sensory analysis, the global acceptance results were submitted to two-way ANOVA followed by the Tukey's test (α = 0.05), considering the sample and the consumer as factors. The software used to perform the statistical analysis was Statistica® 10.0 (Statsoft, Oklahoma, Tulsa, U.S.A.).

3 RESULTS AND DISCUSSION

3.1 Physical-chemical characterization of grapes and raisins

The results referring to the physical-chemical characterization of the BRS Vitória grapes, as well as the PR and C, are shown in Table 1. The fruit had SS content of 18.9 ± 0.1 ° Brix, which is suitable for harvesting grapes with a good balance between sugar and acidity. Aw and moisture were 0.98 ± 0.00 and 79.13 ± 0.00%, respectively. These values are consistent with the range of values (77–87%) described for other grape varieties and cultivars (Mascarenhas et al., 2012; Olivati et al., 2022), demonstrating their high perishability (Al-Tayyar et al., 2020; Khiari et al., 2019). Raisin production is an effective alternative to extend the shelf life of grapes (Khiari et al., 2019). Ways to minimize the degradation of nutrients and compounds with bioactive properties were sought through the association of pretreatment of the grapes with natural surfactants and conventional convective drying (Olivati et al., 2019, 2022).

Table 1. Physical-chemical characteristics of BRS Vitória grapes and raisins with (PR) and without (C) EVOO.

Determinations*	Fresh grapes	C	PR
Moisture (%)	79.13 ± 0.00^a	7.55 ± 0.64^b	8.05 ± 1.06^b
Aw	0.98 ± 0.00^a	0.36 ± 0.01^b	0.39 ± 0.04^b
pH	3.89 ± 0.01^c	4.08 ± 0.03^b	4.17 ± 0.0^a
TA	0.86 ± 0.00^c	2.24 ± 0.07^a	2.06 ± 0.08^b
TS (%)	16.5 ± 0.0^b	66.0 ± 2.4^a	69.3 ± 1.6^a
RS (%)	15.3 ± 0.0^b	65.9 ± 2.3^a	69.1 ± 0.6^a
TPC	332.5 ± 6.6^b	599.4 ± 49.5^a	620.0 ± 52.2^a
TMA	650.2 ± 18.0^a	337.1 ± 39.3^c	560.7 ± 63.0^b

*Aw: water activity; TA: total acidity, expressed as grams of tartaric acid 100 g^{-1}; SS: soluble solids; TS: total sugars; RS: reducing sugars; TPC: total phenolic compounds, expressed as mg of gallic acid equivalent (GAE) 100 g^{-1}; TMA: total monomeric anthocyanin, expressed as mg of malvidin-3,5-diglucoside kg^{-1}. Different letters on the same line indicate significantly different means by Tukey's test (α = 0.05).

Drying time for C was approximately 66.0 ± 4.25 h, whereas for PR, it was 40.5 ± 0.71 h. Thus, the pretreatment decreased the drying time by an average of 38.5 ± 2.9%. Positive results were also reported when using the same pretreatment on BRS Morena (Olivati et al., 2019) and BRS Clara grapes (Olivati et al., 2022), in which there were reductions of 45% and 39% in the drying time, respectively.

As the water in grape berries is lost throughout the drying process, Aw and moisture are significantly reduced ($p < 0.05$). PR and C had Aw of 0.36 ± 0.01 and 0.39 ± 0.04, and moisture of 7.55 ± 0.64% and 8.05 ± 1.06%, respectively. The moisture values obtained were lower than the maximum limit of 25% moisture established by the Brazilian legislation for dried fruits (Brasil, 2005). They also comply with international regulations, according to which the water content for seedless raisins must be lower than 19% (Codex Alimentarius, 2019). Based on the available studies on raisins from different countries, it is noticeable how water content and Aw vary; however, the most common values reported are 14–18% and 0.50–0.65, respectively (Ghrairi et al., 2013; McCoy et al., 2015). It is reported that raisins with moisture values above 18% are more prone to contamination by molds and filamentous fungi, especially during handling, distribution, and at wholesale markets. These studies demonstrate that the Aw and moisture in the raisins are key factors to extend the shelf life and maintain the microbiological stability of the product throughout storage (McCoy et al., 2015).

From Table 1, it is possible to observe that due to the decrease in moisture, there is a significant concentration ($p<0.05$) of several compounds present in the grapes. TS and RS contents of 16.5 ± 0.00 and 15.3 ± 0.00 g of glucose 100 g^{-1}, found in the grapes, were significantly lower than those found in C (66.0 ± 2.4 and 65.9 ± 2.3 g of glucose 100 g^{-1}) and in PR (69.3 ± 1.6 and 69.1 ± 0.6 g of glucose 100 g^{-1}), respectively. Although the concentrated content of sugars in raisins has been a subject of debate, studies point to raisins as a good source of energy, with a lower glycemic index and promoting greater satiety when compared to other snacks (Restani et al., 2016; Jeszka-Skowron & Czarczyńska-Goślińska, 2020). In addition, their sugar content reveals their potential use in confectionery, adding nutritional value and flavor to different food products (Arshard et al., 2022; Soukoulis & Tzia, 2018).

Acid concentration was also significantly ($p < 0.05$) increased in grapes (Table 1) after dehydration. TA changed from 0.86 ± 0.00 g of tartaric acid 100 g^{-1} in grapes to 2.24 ± 0.07 and 2.06 ± 0.08 g of tartaric acid 100 g^{-1} in C and in PR, respectively.

It is noteworthy that, among raisins, TA was significantly higher for C. A similar behavior was observed for the pH, in which C presented a lower pH value (4.08 ± 0.03) when compared to the values determined in the PR (4.17 ± 0.0). The higher acidity of C may be the result of more intense PC hydrolysis due to longer exposure to drying conditions.

The TPC (mg of EAG 100 g^{-1}) found in the grapes was equivalent to 333 ± 6.6, whereas in C and PR, they were 599 ± 49.5 and 620 ± 52.2, respectively. Based on these results, values for the raisins were significantly higher than those for fresh grapes, which show their potential as a source of these compounds (Khiari et al., 2019). However, if the effect of concentration is excluded, when converting the results obtained on a DB, fresh grapes contained 1,728 mg EAG 100 g^{-1} of sample, while raisins (C and PR) had significantly lower concentrations ($p \leq 0.05$), equivalent to 751 and 800 EAG 100 g^{-1} of sample, respectively.

This possible degradation may also explain the TMA (mg malvidin-3,5-diglucoside kg^{-1}) values obtained for grapes (Table 1), with a significant decrease ($p \leq 0.05$) after the dehydration process, when C had significantly lower ($p \leq 0.05$) TMA concentrations (337) than those determined for PR (560). Olivati et al. (2019), after producing raisins from the BRS Morena red grapes cultivar with and without a pretreatment with EVOO, reported that TMA concentrations decreased with the drying process; it shows that during dehydration, these compounds undergo a degradation process, especially since they are sensitive to exposure to high temperatures for extended periods of time.

It is noticeable how the drying process resulted in the degradation of PC, particularly anthocyanins, yet the concentration effect indicates that raisins still had a considerable amount of these compounds. Some studies report that the application of drying methods on grapes favors the bioavailability of the PC found (Ozkan et al., 2022); in addition, the compounds present in raisins (100 g) seem to have similar bioavailability when compared to the ingestion of specific portions of wine (300 mL) and grapes (400 g) (Carughi et al., 2013; Murphy, 2012), which illustrates its potential as a source of PC.

3.2 Qualitative and quantitative composition of minerals found in grapes and produced raisins

The mineral content (mg 100 g^{-1}) obtained for BRS Vitória grapes and raisins (C and PR) are shown in Figure 1. It can be observed that K (mg 100 g^{-1}) was the most prevalent mineral found in BRS Vitória grapes (268). The mean value is within the range reported for Meili wine grapes (270–300) (Hao et al., 2021) and is higher than that reported by Bertoldi et al. (2011) for Chardonnay grapes (247).

P (49.6) was the second most prevalent mineral found in the grapes, and the values found were higher than those found for the Chardonnay grapes (19.19 mg 100 g^{-1}) (Bertoldi et al., 2011). The concentrations of the macro minerals Ca and Mg in BRS Vitória grapes (mg 100 g^{-1}, WB) were similar (20.5 and 13.5, respectively) to those reported for the Chardonnay grapes (29.9 and 13.4, respectively); on a DB, the results obtained (98.2 and 64.7) were higher than those reported by Ozkan et al. (2022) for the Isabella grapes (75.0 and 37.4).

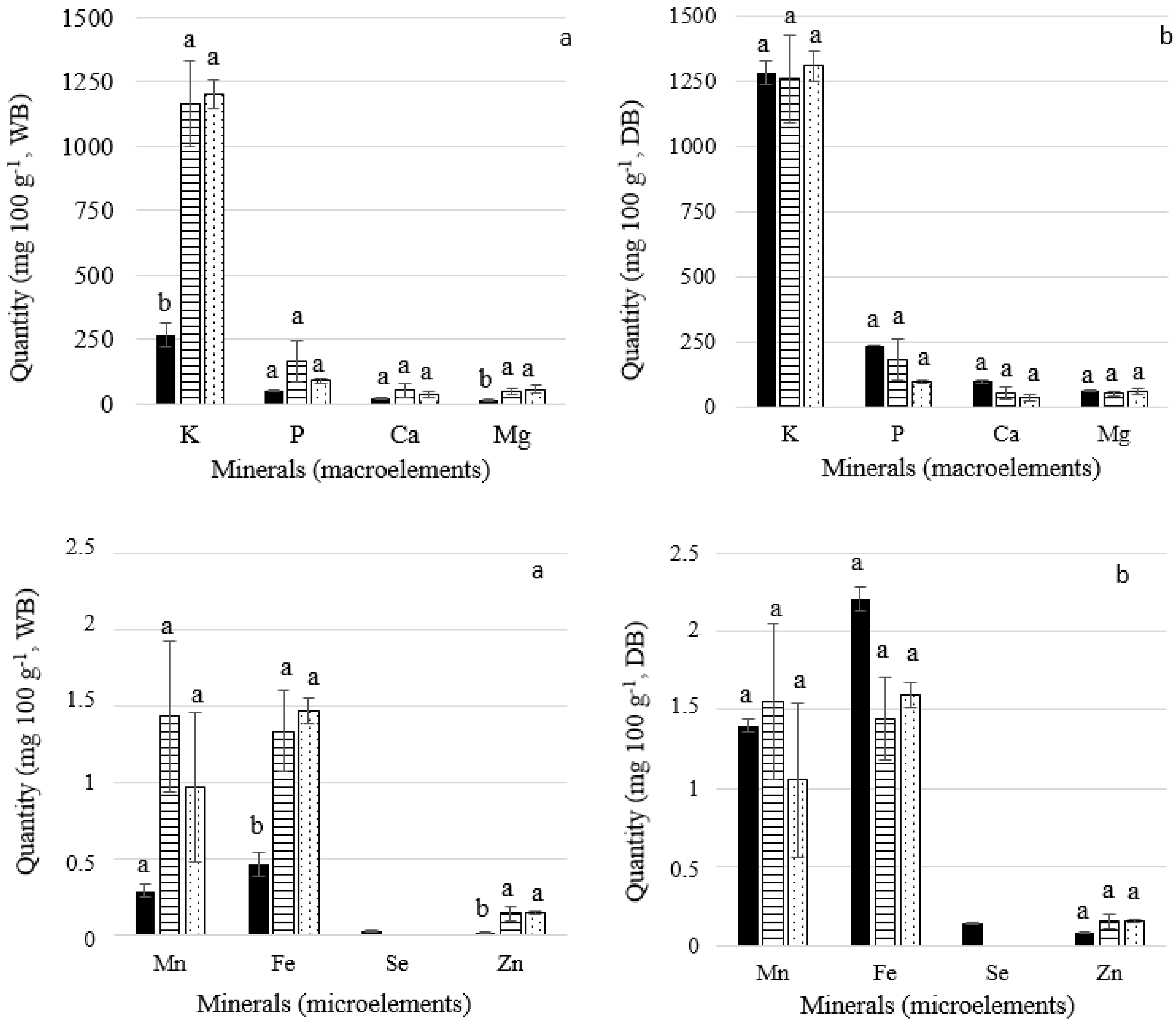
As for the micro minerals Mn, Fe, Se, and Zn, concentrations varied from 0.02 to 0.46 mg 100 g^{-1}, on a WB. The most prevalent micro mineral in the studied grapes, Fe, had lower concentrations than those reported in the literature for the Cabernet Sauvignon (0.83 mg 100 g^{-1}), Merlot (1.96 mg 100 g^{-1}), Black Borgoña (1.57 mg 100 g^{-1}) (Panceri et al., 2013), and Meili (0.52–0.69 mg 100 g^{-1}) grapes (Hao et al., 2021).

The mineral composition of the grapes reflects the geochemistry in which the grapevines are grown, and, as a consequence, the grapes and raisins are influenced by the soil composition, cultural practices, and nutritional management strategies, as well as the soil and climatic conditions during the production cycle (Hopfer et al., 2015; Likar et al., 2015). Also, grape cultivar, cup and rootstock genotypes, age, and root depth must be considered (Hopfer et al., 2015). It justifies, therefore, such variability in the concentrations of minerals among the various existing grapes.

After dehydrating the grapes and analyzing the results expressed on a WB (Figure 1A), it is observed that among the macro minerals, grapes had significantly lower ($p < 0.05$) concentrations for K and Mg if compared to raisins; as for the micro minerals, the same behavior was observed for Fe and Zn. These results were expected once these compounds were concentrated in the raisins as a result of the dehydration process of the grapes (Khiari et al., 2019), even though such an increase did not happen for the minerals P, Ca, or Mg.

To understand the effect of drying and pretreatment on the mineral content of the BRS Vitória grapes excluding the effect of the concentration of these compounds, the obtained results were also expressed on a DB (Figure 1B). It must be emphasized that minerals, unlike other organic nutrients, are not degraded by exposure to heat, light, oxidizing agents, or extreme pHs (Miller, 2010). Nevertheless, they are involved in several chemical reactions that may be triggered during processing. Maillard reaction products, organic acids, and PC, for example, are able to chelate minerals and interfere with their solubility. Organic acids may also be neutralized by K and Ca ions, forming salts, while other minerals, such as Mg, act as a cofactor in the activity of certain enzymes, such as oxidoreductases. There was no significant difference ($p > 0.05$) in mineral contents between C and PR, which shows that some reactions were probably triggered, yet the drying and pretreatment processes were not sufficiently strong to make a significant difference in the contents of these compounds.

Similar to grapes, K (mg 100 g^{-1}) was also the most prevalent mineral in raisins (C – 1,203 and PR – 1,165). On a DB, values obtained for K (mg 100 g^{-1}) were higher (1,267–1,301) than those reported by Carranza-Concha et al. (2012) in raisins produced from Imperial seedless (500–602) and Thompson seedless (687–702) wine grapes and by Zemni et al. (2017) in raisins produced from Italia Muscat (208–348) grapes, which evidences the desirable nutritional aspect of the raisins produced from the BRS Vitória grapes. In a recent study, it was suggested that the different microstructures resulting from the drying and breakdown of the natural matrix would influence the release, transformation, and subsequent absorption of minerals in a simulated digestion model and that K is the most



*Different letters for the same compound indicate significantly different means by Tukey's test ($\alpha = 0.05$).

Figure 1. Mineral composition of BRS Vitória fresh grapes (■) and raisins without (⊟ – C) and with (⊡ – PR) EVOO, expressed in mg 100 g^{-1} on a (A) wet basis (WB) and a (B) dry basis (DB), with separate results on the following macro elements: potassium (K), phosphorus (P), calcium (Ca), and magnesium (Mg), and microelements: manganese (Mn), iron (Fe), selenium (Se), and zinc (Zn).

bioaccessible mineral in grapes after the dehydration process (Ozkan et al., 2022).

After K, the most abundant minerals in raisins, in descending order, were P, Ca, Mg, and Mn. In turn, C and PR had content values (mg 100 g^{-1}, DB) of Mg (52.62 and 60.43), Ca (37.72 and 55.94), and Zn (0.16), respectively, in accordance with those reported in the literature (Carranza-Concha et al., 2012; Khiari et al., 2019). Although the results did not present statistically significant differences, with the effect of concentration, a mere 30 g portion of raisins provides a substantial concentration of Mn. There is a significant ($p < 0.05$) concentration effect (four-fold) for raisins when compared to the grapes. This information is particularly important, considering how concerned several international organizations are about the consumption of this mineral (NIH, 2022).

It must be emphasized that grapes, as well as the raisins produced, despite not being considered a source of minerals by Brazilian regulations (Brasil, 2020), contains a broad array of these inorganic compounds with vital physiological functions for the human organism. Among these important functions are involvement of K, P, Ca, and Mg in the hydroelectrolytic balance, maintenance of normal blood pressure, glucose metabolism, muscle contraction, bone and tooth formation, nerve impulse transmission, certain enzyme regulations, protein synthesis, cell growth, and reproduction, among other functions (Groper et al., 2005). Fe plays a crucial role in the production of blood cells, whereas Zn is imperative for the immune system (Mitić et al., 2012; Sousa et al., 2014). Since minerals cannot be synthesized by the human body, it is of paramount importance the ingestion of such compounds from dietary sources on a daily basis and in sufficient quantity to fulfill their functions. Thus, the intake of grapes and raisins, along with other food products containing minerals, may contribute to the daily consumption of these mineral elements (Soetan et al., 2010).

3.3 Sensory analysis

The results of the sensory acceptance analysis of raisins produced from the BRS Vitória grapes (C and PR) showed that there was no significant difference ($p > 0.05$) between the acceptance of PR (mean 7.05 ± 1.51) and C (mean 6.75 ± 1.63), both being close to the score equivalent to “I liked it moderately” on the 9-point structured hedonic scale.

When the evaluator was asked about what they liked most about the sample, 59 and 56% of consumers, respectively, for PR and C, mentioned terms related to the taste. Among the flavor terms mentioned, 60% (PR) and 59% (C) referred to sweetness, acidity, or the balance between those two. Following that, the most mentioned terms were related to the appearance, corresponding to 19% (PR) and 16% (C) of the mentioned terms. These were probably the characteristics that contributed the most to the acceptance of the studied raisins. Interestingly, among the terms related to the appearance, for PR “brightness” was the most cited term (24%), while for C, terms referring to the size of the raisins were mentioned the most (25%). These results indicate that the EVOO may have positively influenced the brightness of the raisins, without leading to changes in flavor.

Flavor was also the class of the most mentioned terms in relation to the characteristics that consumers liked least about the sample, corresponding to 32 and 38% of the mentioned terms for PR and C, respectively. Among the flavor terms, the most mentioned one referred to the acidity of the sample (47% for PR and 41% for C). Texture was the second most mentioned class of terms (31% for PR and 29% for C), and among the cited terms, those referring to the hardness/dryness of the sample were prevalent (32% for PR and 27% for C).

Thus, the samples were well accepted by consumers and the results obtained demonstrate the importance of flavor (especially regarding the balance in acidity), texture (softness/hardness of the samples), and appearance (including brightness and size) of the samples. It is important to consider the subjectivity of the sensory analysis while contemplating what was consistent for the majority of the evaluators; aiming at improving the raisins produced, further tests could be conducted using grapes with higher ripeness, consequently, higher sugar content and lower acidity, and shorter drying time, producing raisins with higher moisture.

4 CONCLUSION

It was possible to produce raisins from the Brazilian BRS Vitória grapes with and without pretreatment with EVOO in accordance with the standards required by Brazilian and international regulations. Products had higher sugar concentrations, acids, PC, and minerals, in particular K, P, Ca, Mg, and Mn. Drying time decreased by approximately 38.5% with the use of the pretreatment. Lower exposure time during dehydration yielded raisins with a higher anthocyanin content, if compared to those without EVOO pretreatment. Raisins with and without pretreatment were well accepted by consumers, especially for their taste and appearance attributes; moreover, the pretreatment promoted more brightness to the samples. Therefore, raisins obtained from the BRS Vitória grapes had a complex composition and might be consumed as a healthier snack, adding PC and minerals to the diet.

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