Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.54822

Accessing the nutritional variability of *Butia odorata*: a food with identity

Julia Goetten WAGNER[1*], Jéssica Gonsalez CRUZ[1], Tatieli SILVEIRA[1], Nubia Marilin Lettnin FERRI[2], Vanessa Baptista RICHTER[3], Francielle Müller LIMA[3], Kathleen Uszacki FIGUEIRA[1], Claudete Clarice MISTURA[1], Márcia VIZZOTTO[2], Rosa Lía BARBIERI[2]

Abstract

Butia odorata (Arecaceae) is a palm species in southern Brazil and eastern Uruguay, which produces tasty fruits consumed by humans and animals. Despite the ecological and sociocultural relevance of the species, *B. odorata* is endangered by extinction. This study aimed to characterize physical aspects, chromatic parameters, chemical, and centesimal composition and determine the bioactive compounds and antioxidant activity of fruits of *B. odorata*. Fifteen accessions of *B. odorata* from Pelotas and Capão do Leão (RS-Brazil) were evaluated for bunches weight, fruit yield, fruit diameter and height, total soluble solids (TSS), pH, total titratable acidity (TTA), TSS/TST ratio, color parameters, total phenolic compounds, total carotenoids, antioxidant activity, percentage of moisture, dry matter, vitamin C, crude fiber, fat, ash, protein and pulp yield. There was genetic variability among the analyzed accessions for several parameters. Some of them influence consumer acceptance, such as coloration and sugar content, which highlights the possibility of selection for genetic improvement. The fruits showed a rich composition in fibers, vitamin C, total carotenoids, and total phenolic content, which contribute to health maintenance. With the growing demand for functional foods, *Butia* fruits represent a potential product for nutritional enrichment in diets.

Keywords: plant genetic resources; butia palm; physical-chemical evaluations; functional food; neglected and underutilized species.

Practical Application: *Butia odorata* can be an alternative for income generation and enrichment diets.

1 Introduction

Since the Global Food Conference of 1974, a new panorama has been built, where food security and food sovereignty are consolidated as goals, forming part of the Agenda 2030 and Sustainable Development Goals (SDGs) of ONU. Concomitant to the action plan to guarantee food in adequate quantity and quality proposed by the 2030 Agenda, globally, a change in the consumption profile is taking place, where the interest in nutritious, healthy, ecological, and fair foods is increasing (Barrientos, 2014; Canfield et al., 2021).

Promoting local food can be an ally to encourage the autonomy of the communities, the democratization of food, and the development of short commercialization circuits. In addition, the sustainable use of native plants, specially neglected and underutilized species, can help mitigate the threat of extinction that they are facing, as a strategy to achieve conservation (Barrientos, 2014).

Butia is a subtropical palm tree genus of the Arecaceae family, which produces tasty and succulent fruits called "butiás," consumed fresh or incorporated in recipes (Eslabão et al., 2016). In addition, there are potential and traditional ways of using several other parts of the plant, such as the leaves, endocarps, bracts, and fibers of fruit for handicrafts, consumption of the almond, and production for raw materials for various sectors of agribusiness. The plants are used in landscaping (Schwartz et al., 2010).

The *Butia* genus comprises 22 neglected and underutilized species that stand out for their great diversity, wide range of distribution, and cultural importance to the communities in its area of occurrence (Sant'Anna-Santos, 2021; Heiden & Sant'Anna-Santos, 2021).

Butia odorata occur in eastern Uruguay and southern Brazil, in Rio Grande do Sul state (Eslabão et al., 2016). Their populations are known as butiazais or palmares, and although they are now rare, they were once quite common in the landscapes of southern Brazil (Sosinski et al., 2019).

Given this scenario, the characterization of the available genetic variability is necessary to design conservation strategies, especially assuming the consumption trends and the possibility of exploring the marketing linked to a product with functional bias, such as butiá. Thus, this work aimed to characterize *Butia odorata* fruits from Pelotas and Capão do Leão (RS-Brazil) through physical-chemical evaluations, antioxidant activity, bioactive properties, composition, and chromatic parameters, to generate subsidies for the conservation of genetic resources through its use.

Received 26 May, 2022
Accepted 22 Aug., 2022
[1] *Universidade Federal de Pelotas – UFPel, Capão do Leão, RS, Brasil*
[2] *Embrapa Clima Temperado, Monte Bonito, Brasil*
[3] *Instituto Federal Sul-Rio-Grandense – IFSul, Pelotas, RS, Brasil*
*Corresponding autor: goettenj@hotmail.com

2 Materials and methods

2.1 Fruit samples and morphological attributes

Bunches of *Butia odorata* were collected in the municipalities of Pelotas and Capão do Leão, in the Rio Grande do Sul state (Brazil), between January and March 2019. Homeowners provided the bunches. Each bunch was collected in a backyard of a different house, totaling 15 bunches, each one considered a treatment.

The bunches were collected with a palm cutter and transported in bulk bags to the Food Science and Technology Laboratory of Embrapa Clima Temperado (Pelotas-RS). The bunches' weight, fruit number, and diameter were weighed, height and fruit weight was determined. The pulp and endocarps were separated to determine the percent pulp yield (pulp/endocarp ratio).

Sixty representative fruits from each sample were selected to measure height, diameter, and fruit weight using a digital caliper and analytical balance (Marte AY220). Then, the percent pulp yield was calculated through the formula: $\left[\left(weight\ of\ pulp\ \left(g\right)\ .\ 100\right)/\ weight\ of\ whole\ fruit\right]$.

2.2 Physical-chemical evaluations

The juice was extracted from the fruits using a centrifuge (Philips Walita) to quantify the pH, total soluble solids, titratable acidity, and vitamin C. The pH (peagameter Metrohm pH lab 827) and soluble solids (refractometer Atago Pocket PAL-3) were determined by following the methodologies 981.12 and 932.12 by AOAC (Association of Official Analytical Chemists, 1995).

Titratable acidity was quantified by Glass Electrode Method (Bürette Digital Brand Titrette), code number 942.15 of AOAC (Association of Official Analytical Chemists, 1995). The vitamin C was determined through ascorbic acid content by titrimetric method, using 2-6 dichlorophenolindophenol (method 967.21 from AOAC).

2.3 Centesimal composition

The moisture content was determined by method 934.06 of AOAC (Association of Official Analytical Chemists, 1995), through gravimetry, where the material was dried in a vacuum oven (Marconi MA 030) at a temperature of 70 °C. The gravimetric method was also used to determine the ash content, following guidelines of methodology 940.26 of AOAC (Association of Official Analytical Chemists, 1995), with a muffle furnace (Prolab) at a temperature of 600 °C.

The determination of lipids was performed by extraction through the Ankom device (Ankom XT 15), using Petroleum ether as solvent (Ankom Technology, 2009a). The protein content was determined by an elemental analyzer (FP-528 Protein/Nitrogen Analyzer Leco) by combustion, which used factor 6.25 to convert N into protein (Leco Corporation, 1999). In turn, the fiber content was quantified through the Ankom Fiber Analyser, with acid and alkaline digestion of the dry sample (Ankom Technology, 2009b). The analyses were performed in triplicate and followed the recommendations of the equipment manufacturers' manuals.

2.4 Total phenolic compounds, total carotenoids, and antioxidant activity

The methodology adapted from Swain & Hillis (1959) was employed to determine total phenolic compounds. An aliquot of 0.5 mL of methanolic extract was diluted in 0.4 mL of deionized water and 0.250 mL of the reagent Folin-Ciocalteau. After, 0.5 mL of sodium carbonate was added, and the solution was left to react for two hours. Then the reading in a spectrophotometer (Genesys 10UV) was made, where the absorbance was measured using a wavelength of 725 nm.

A methodology adapted from Talcott & Howard (1999) was employed to determine the carotenoid content. Out of direct light, 2 g of sample was added to 10 mL of the acetone/ethanol solution (1:1) containing 400 mg/L BHT (butylhydroxytoluene). The extract was homogenized in Ultra-Turrax (Marconi MA102). The extract was centrifugated (Eppendorf Centrifuge 5810 R) for 20 min, at 4000 RPM and 0 °C; the supernatant was separated and added to 50 mL of hexane. After the separating phases, 50 mL of deionized water was added, and then the reading was taken at a wavelength of 470 nm. The carotene content was expressed in mg of β-carotene per 100 g per sample.

The antioxidant activity was determined using a method adapted from Brand-Williams et al. (1995) through scavenging activity of radical 2,2-diphenyl-1-picrylhydrazyl-hydrate (DPPH). A 100 µL aliquot of methanolic extract was added to 1900 µL of diluted DPPH solution. The reaction proceeded in the dark for 24 hours at ambient temperature. Then the samples were read in a spectrophotometer at a wavelength of 515 nm. The antioxidant activity was expressed as µg of Trolox equivalent 100 mg $^{-1}$ in fresh weight (mmol Trolox 100 mg $^{-1}$ in fresh weight).

All analyses were performed in triplicate.

2.5 Instrumental color measurements

Ten representative fruits from the sample were used to estimate the coloration parameters. With a Minolta CR 300 colorimeter, two readings were taken at the equatorial region of the fruit. Using the CIELAB scale, it is possible to evaluate the luminosity through the "L" parameter, which varies from 0 (white) to 100 (black), and the color direction with the a* parameter, which indicates the coloration from green to red, and b*, from blue to yellow (McGuire, 1992). From these parameters were calculated the Hue angle (h^o = tan-1 b/a), which indicates the color direction, and the chroma ($C = (a^*2 + b^*2)½$), an indicator of color saturation.

2.6 Statistical analysis

The design used was entirely randomized (DIC), where each bunch was collected in a different plant at a different location and was considered a treatment, totaling 15 treatments. The data obtained were submitted to ANOVA and Scott Knott test ($p < 5$) for comparison of means, using the Genes computer program (Cruz, 2006).

3 Results and discussion

3.1 Morphological attributes

There were yield differences among the *B. odorata* accessions evaluated. The number of fruits per bunches ranged from 128 to 1325 fruits, with an average of 536. Bunch weight had a range variation between 1.3 kg and 15 kg, with an average of 6.06 kg. Statistical difference was observed for weight, where the values of unit fruit weight ranged from 3.63 g (accession B5LP) to 17.28 g (accession B1KP), with an average of 10.8 g.

The average pulp coefficient in this work was 79.13%, higher than 70.97% reported by Sganzerla (2010), but when the accessions are considered individually contrasts can be seen, with percentages ranging from 67% to 89%. Fruit height and diameter were highly variable, exhibiting statistical differences among the accessions. The average fruit diameter was 25.67 mm, and the average fruit height was 22.81 mm, demonstrating that the predominant fruit shape was depressed-globose (Mistura et al., 2015), with central flattening and greater diameter in relation to height. The accession B1KP stood out for its yield characteristics, higher fruit weight, higher bunch weight, and higher pulp yield, with a pulp coefficient of 85.33%.

The results of the morphological evaluations are presented in Table 1.

The differences observed are expected due the allogamous profile of *Butia* species, which results in significant genetic variability (Buttow et al., 2010). Besides genetic factors, yield parameters are also affected by plant age and edaphoclimatic conditions, as recorded by Nunes et al. (2010), who found statistical differences in fruit weight, fruit diameter, and number of fruits per bunch in genotypes of *B. odorata* cultivated in the same area, with the same age. Schwartz et al. (2010) observed fluctuations in the fruit yield in two seasons, which could be caused by alternate bearing, and cycle shortening linked with high temperatures and higher rainfall rates (resulting in low yield). Schlindwein et al. (2017) made associations between the high fertility of the soil, and the availability of calcium and magnesium with an increase in fruit yield of *B. odorata*.

These inferences could help to understand the heterogeneity found in yield parameters in this study, since, in addition to genetic divergence, the plants addressed differs in terms of age, management intensities, and environmental conditions.

3.2 Physical-chemical characterization

There was statistical difference among the accessions for the parameters of total soluble solids, titratable acidity, and vitamin C, but pH showed no difference (Table 2).

Although there is no specific pH delineation for *B. odorata,* the Brazilian regulation nº 37 of October 1º of 2018 (Brasil, 2018) establishes the minimum standard of quality of pH 2 for juice production with *Butia catarinenses*, *Butia eriospatha*, and *Butia capitata*. In this study, all accessions meet that quality standard, showing an average pH of 3.20. Schwartz et al. (2010) evaluating populations of *B. odorata* also found no differences in pH, obtaining an average of 3.05, a value close to this work. Ferrão et al. (2013) and Nunes et al. (2010) reported differences for this parameter in *B. odorata*, finding mean values of 3.50 and 3.38 respectively.

The average titratable acidity, expressed in citric acid, was 1.50. Acidity is an important attribute related to market acceptance, and fruits with lower acidity are preferred for fresh consumption. Nevertheless, higher acidity levels play a role by inhibiting microbial growth, allowing longer shelf life in fruits (Nunes et al., 2010). The minimum value to assure juice quality in *Butia* species (*B. catarinenses*, *B. eriospatha*, *B. capitata)* is 0.8 (Brasil, 2018). There

Table 1. Morphological evaluations of *Butia odorata* accessions from Pelotas and Capão do Leão (RS/Brazil) in 2019.

Accession	Fruit number	Bunch weight (kg)	Weight of 10 fruits	Pulp coefficient (%)	Fruit diameter (mm)	Height (mm)
B1KP	758	12.66	172.89 ± 19.51^{a}	85.33	33.72 ± 3.27^{a}	24.17 ± 1.30^{c}
B2LP	990	15.08	149.37 ± 8.23^{b}	71.78	30.76 ± 2.14^{c}	27.61 ± 5.50^{a}
B3KP	266	1.75	77.38 ± 3.34^{f}	75.56	25.72 ± 1.72^{e}	21.05 ± 2.01^{e}
B4JP	128	1.95	152.42 ± 5.81^{b}	82.29	30.89 ± 1.52^{c}	21.69 ± 1.25^{e}
B5LP	786	3.62	36.33 ± 2.64^{h}	67.22	18.25 ± 1.42^{g}	16.70 ± 1.23^{g}
B6FP	463	6.11	95.82 ± 5.48^{e}	78.84	25.48 ± 2.12^{e}	23.14 ± 2.10^{d}
B7MP	385	3.27	84.49 ± 3.64^{f}	81.37	18.25 ± 1.42^{g}	20.45 ± 1.14f
B8MP	1325	10.5	84.42 ± 7.18^{f}	75.32	25.28 ± 2.25^{e}	20.54 ± 1.29^{f}
B9JP	600	7.86	132.95 ± 6.23^{c}	82.13	29.33 ± 1.97^{d}	27.47 ± 1.75^{a}
B10LP	348	6.02	153.66 ± 3.54^{b}	81.75	31.84 ± 1.72^{b}	24.10 ± 1.81^{c}
B11VP	383	4.75	82.45 ± 9.24^{f}	89.76	24.73 ± 2.80^{e}	24.66 ± 2.33^{b}
B12LP	328	3.99	134.77 ± 6.45^{c}	80.16	30.37 ± 2.27^{c}	25.28 ± 1.54^{b}
B13MP	678	6.98	120.70 ± 2.44^{d}	85.13	29.32 ± 1.80^{d}	21.69 ± 1.17^{e}
B14MP	164	1.28	51.84 ± 2.59^{g}	76.23	18.28 ± 1.38^{g}	20.23 ± 1.64^{f}
B15MP	446	4.45	91.42 ± 5.47^{e}	74.20	22.90 ± 2.46^{f}	20.41 ± 1.67^{f}
Average	536	6.06	108.06	79.13	25.67	22.61

The accessions were numbered following the order of collection, identified by the initials of the owners and the geographical origin. Mean values with different superscripts within the same column are significant ($p < 0.05$) different.

Table 2. Results of physicochemical evaluations in *Butia odorata* accessions from Pelotas and Capão do Leão (RS/Brazil) in 2019.

Accession	TSS	pH	Vitamin C[1]	TTA	TSS/TTA
B1KP	9.26 ± 0.11[b]	3.24 ± 0.02[a]	60.67 ± 2.44[d]	1.4 ± 0.04[g]	6.61
B2LP	11.03 ± 0.11[a]	3.49 ± 0.01[a]	67.72 ± 4.85[d]	1.19 ± 0.05[i]	9.26
B3KP	12.73 ± 0.05[a]	3.40 ± 0.01[a]	51.85 ± 1.06[e]	1.07 ± 0.01[j]	11.89
B4JP	12.46 ± 0.05[a]	3.05 ± 0.03[a]	167.55 ± 1.61[a]	2.23 ± 0.01[a]	5.58
B5LP	3.43 ± 0.40[b]	3.11 ± 0.01[a]	37.84 ± 3.45[f]	1.57 ± 0.02[f]	2.18
B6FP	8.10 ± 0.17[b]	3.00 ± 0.01[a]	33.77 ± 1.2[f]	1.78 ± 0.01[c]	4.55
B7MP	9.2 ± 0.1[b]	3.36 ± 0.01[a]	40.52 ± 1.30[f]	1.2 ± 0.02[i]	7.66
B8MP	11.5 ± 0[a]	3.36 ± 0.01[a]	49.53 ± 3.89[e]	1.28 ± 0.03[h]	8.98
B9JP	14.93 ± 0.11[a]	2.88 ± 0[a]	49.31 ± 5.52[e]	1.70 ± 0.03[d]	8.78
B10LP	14.8 ± 0.26[a]	3.13 ± 0[a]	22.36 ± 1.49[g]	1.80 ± 0.12[c]	8.2
B11VP	13.93 ± 0.30[a]	3.36 ± 0[a]	63.29 ± 1.09[d]	1.08 ± 0.03[j]	12.89
B12LP	12.73 ± 0.05[a]	3.10 ± 0.01[a]	105.06 ± 3.80[b]	1.64 ± 0.01[e]	7.76
B13MP	13.36 ± 0.23[a]	3.03 ± 0.01[a]	68.35 ± 1.26[d]	1.47 ± 0.02[g]	9.08
B14MP	15.96 ± 0.15[a]	3.42 ± 0.03[a]	77.21 ± 2.73[c]	1.19 ± 0.02[i]	13.41
B15MP	14.5 ± 0.1[a]	3.12 ± 0.01[a]	71.72 ± 0.73 c	2.0 ± 0.01[b]	7.25
Average	11.83	3.20	64.05	1.50	8.27

[1]mg of ascorbic acid in 100 mL. TSS: Total soluble solids in degrees Brix; TTA: Total titratable acidity expressed in g of citric acid/100 mL-1. The accessions were numbered following the order of collection, identified by the initials of the owners and the geographical origin. Mean values with different superscripts within the same column are significant ($p < 0.05$) different.

are no regulations for *B. odorata* titratable acidity, but the range obtained (between 1.07 and 2.0) are in consonance with standard for juice quality in related species. Variation in titratable acidity has also been recorded by Ferrão et al. (2013) and Schwartz et al. (2010).

The TSS content varied from 3.43 to 15.96º Brix, with an average of 11.83º Brix. Among all samples, only the accession B5LP with 3.43º did not meet the quality standard for *Butia* juice, whose minimum value is 6º Brix. The soluble solids content is a good indicator of the fruit maturity point, and the low value of TSS obtained in B5LP accession may suggest an incipient ripening stage. Ferrão et al. (2013) also registered differences among populations of *B. odorata* for TSS content, with values ranging from 9.50 up to 15.50, and by it turn Schwartz et al. (2010) evaluating two populations did not find differences for this parameter.

Although TSS is widely used to indicate fruit quality, the ratio (TSS/ATT) is a parameter more representative of fruit flavor. Flavor is also highly affected by the acidity, and the ratio coefficient considers the influences of soluble solids and acidity to point out the taste impression (Nunes et al., 2010). The values for ratio ranged from 2.18 up to 13.45, similar wide range was observed by Ferrão et al. (2013): between 4.42 up to 13.63.

The range for vitamin C varied widely, from 22.36 mg of acid ascorbic in 100 mL of juice (accession B10LP) up to 167.55 in the accession B4JP. The Anvisa (National Health Surveillance Agency) recommendation for daily consumption of vitamin C is 60 mg (Brasil, 1998), resulting that among the genotypes evaluated the amount of juice needed to meet the established daily intake can vary from 268.33 mL (accession B10LP) to 35.81 mL (accession B4JP).

3.3 Centesimal composition

The percentage of moisture and dry matter variables showed no difference between the accessions. However, there was a difference in the percentage of protein, fiber, and fat, as shown in Table 3. The percentage of protein on a wet basis ranged from 0.37% to 1.56% in the sample with the highest concentration. The protein value range in this work was higher than that found by Ferrão et al. (2013), which covered percentages between 0.56% and 0.93%.

The average percentage of crude fiber on a wet basis was 1.51%, similar to 1.67% found by Ferrão et al. (2013). The lipid content had an average of 0.59%, ranging from 0.25% to 2.47%. This difference is in agreement with the range of variation found by Ferrão et al. (2013) and Sganzerla (2010), smaller, however, than the variation from 1.40 to 2.41% found by Fonseca (2012).

The ash content is representative of the total of minerals, being considered an important attribute of food quality since these substances are fundamental for the body's functioning. In this study, there was no difference in the percentage of ash, whose average for the 15 accessions was 0.68%, lower than 0.99% obtained by Fonseca (2012). The evaluation of moisture also did not show difference, with a range between 80 and 88%. Moisture ranged between 80.4% and 85.38% (Table 3), a result similar to the observations of Fonseca (2012): between 79.93 to 83.61%.

3.4 Total phenolic compounds, total carotenoids, and antioxidant activity

There was significant variation for the parameters evaluated. For total phenolic compounds, the concentration range varied among the accessions from 304.34 mg (chlorogenic acid equivalent/100 g of sample) up to 906.06 mg (Figure 1). The range of phenolic compounds were higher in this study than in the findings of Beskow et al. (2015) and Vinholes et al. (2017), who obtained values between 280.50 up to 398.50, and 454.5 up to 535.9 chlorogenic acid equivalent/100 g of sample, respectively. These compounds are secondary metabolites from the defense system of plants, and their expression is related to responses

Table 3. Centesimal composition in *Butia odorata* accessions in Pelotas and Capão do Leão/RS, 2019.

Accession	Moisture (%)	Dry matter (%)	Ash (%)	Proteins (%)	Crude fiber (%)	Lipids (%)
B1KP	88.01 ± 0.27[a]	11.98 ± 0.27[a]	0.71 ± 0.01[a]	0.62 ± 0.02[d]	-	0.25 ± 0.01[h]
B2LP	84.57 ± 0.16[a]	15.42 ± 0.16[a]	0.85 ± 0.01[a]	0.49 ± 0.01[e]	1.35 ± 0.01[e]	0.35 ± 0.01[g]
B3KP	83.10 ± 0.40[a]	16.89 ± 0.40[a]	0.77 ± 0.02[a]	0.85 ± 0.03[c]	1.18 ± 0.02[g]	0.34 ± 0.03[g]
B4JP	84.00 ± 0.19[a]	15.99 ± 0.19[a]	0.73 ± 0.01[a]	0.38 ± 0.01[e]	0.89 ± 0.03[h]	0.43 ± 0.01[f]
B5LP	83.1 ± 0.33[a]	16.39 ± 0.33[a]	0.17 ± 0.01[a]	1.21 ± 0.01[b]	1.96 ± 0.01[c]	0.51 ± 0.02[e]
B6FP	84.16 ± 0.18[a]	15.83 ± 0.18[a]	0.86 ± 0.01[a]	0.66 ± 0[d]	1.56 ± 0.04[d]	0.44 ± 0.02[f]
B7MP	83.16 ± 0.30[a]	16.83 ± 0.30[a]	0.10 ± 0.01[a]	0.37 ± 0.02[e]	1.18 ± 0.01[g]	0.51 ± 0.02[e]
B8MP	85.38 ± 0.35[a]	14.62 ± 0.35[a]	0.12 ± 0.01[a]	0.61 ± 0.01[d]	0.81 ± 0.03[i]	0.67 ± 0.02[c]
B9JP	80.4 ± 0.15[a]	19.55 ± 0.15[a]	0.53 ± 0.02[a]	0.45 ± 0.01[e]	2.34 ± 0.02[a]	0.33 ± 0.01[g]
B10LP	81.82 ± 0.46[a]	18.18 ± 0.46[a]	0.59 ± 0.01[a]	0.62 ± 0.01[d]	1.50 ± 0.02[d]	0.59 ± 0.03[d]
B11VP	80.66 ± 0.49[a]	19.34 ± 0.49[a]	0.77 ± 0.01[a]	1.56 ± 0.03[a]	1.96 ± 0.02[c]	2.47 ± 0.05[a]
B12LP	81.65 ± 0.33[a]	18.34 ± 0.33[a]	0.69 ± 0.01[a]	1.14 ± 0.04[b]	2.15 ± 0.04[b]	0.34 ± 0.01[g]
B13MP	83.15 ± 0.43[a]	16.85 ± 0.43[a]	0.52 ± 0.01[a]	0.77 ± 0.01[c]	-	0.29 ± 0.02[h]
B14MP	83.21 ± 0.37[a]	16.78 ± 0.37[a]	0.54 ± 0.01[a]	-	-	0.60 ± 0.04[d]
B15MP	82.53 ± 0.28[a]	17.47 ± 0.28[a]	0.68 ± 0.02[a]	0.61 ± 0.01[d]	1.35 ± 0.04[e]	0.86 ± 0.02[b]
Average	83.29	16.71	0.68	0.73	1.51	0.59

Samples that did not have enough material to perform the analysis are identified with a dash (-). The accessions were numbered following the order of collection, identified by the initials of the owners and the geographical origin. Mean values with different superscripts within the same column are significant ($p < 0.05$) different.

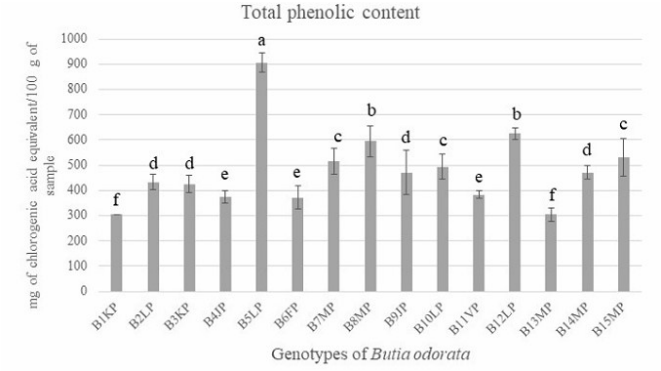

Figure 1. Total phenolic content in *Butia odorata* genotypes from Pelotas and Capão do Leão (RS/Brazil) expressed in mg of chlorogenic acid equivalents in 100 g of sample. The different letters in the bars indicate statistical differences by Scott-Knott test ($p < 5$).

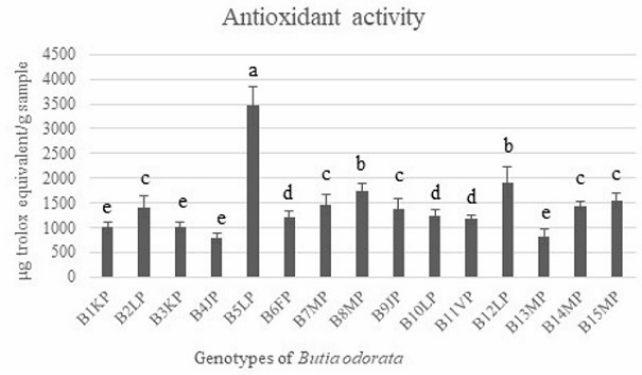

Figure 3. Antioxidant activity in *Butia odorata* genotypes from Pelotas and Capão do Leão (RS/Brazil) by DPPH method, expressed in µg Trolox equivalent 100 mg^{-1}. The different letters in the bars indicate statistical difference by Scott-Knott test ($p < 5$).

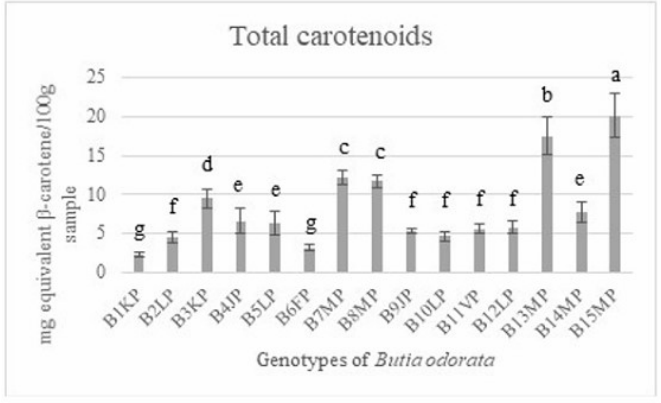

Figure 2. Total carotenoids in *Butia odorata* genotypes from Pelotas and Capão do Leão (RS/Brazil) expressed in mg equivalents of β-carotene in 100 g of sample. The different letters in the bars indicate statistical difference by Scott-Knott test ($p < 5$).

to the external pressure such as UV radiation, pathogens, and exposure to heavy metals (Ferreres et al., 2013).

The concentration of total carotenoids ranged from 2.28 to 20.15 mg of β-carotene in 100 g of sample (Figure 2). Lower concentrations of β-carotene were found by Vinholes et al. (2017) and by Beskow et al. (2015): from 1.71 up to 2.86 mg/100 g of sample, and 2.80 to 4.08, respectively. The carotene content may vary according to the level of ripeness, climate, soil characteristics, geographical area, and even within the harvest conditions (Sganzerla, 2010).

The antioxidant activity ranged from 785.05 µg of Trolox per g of sample to 3459.82 µg in the B5LP accession (Figure 3), the same accession that showed the highest concentration of total phenolic compounds. Employing the same method for antioxidant activity quantification Vinholes et al. (2017) obtained a lower scavenging range: between 160.4 to 610.9 µg of Trolox per g of sample.

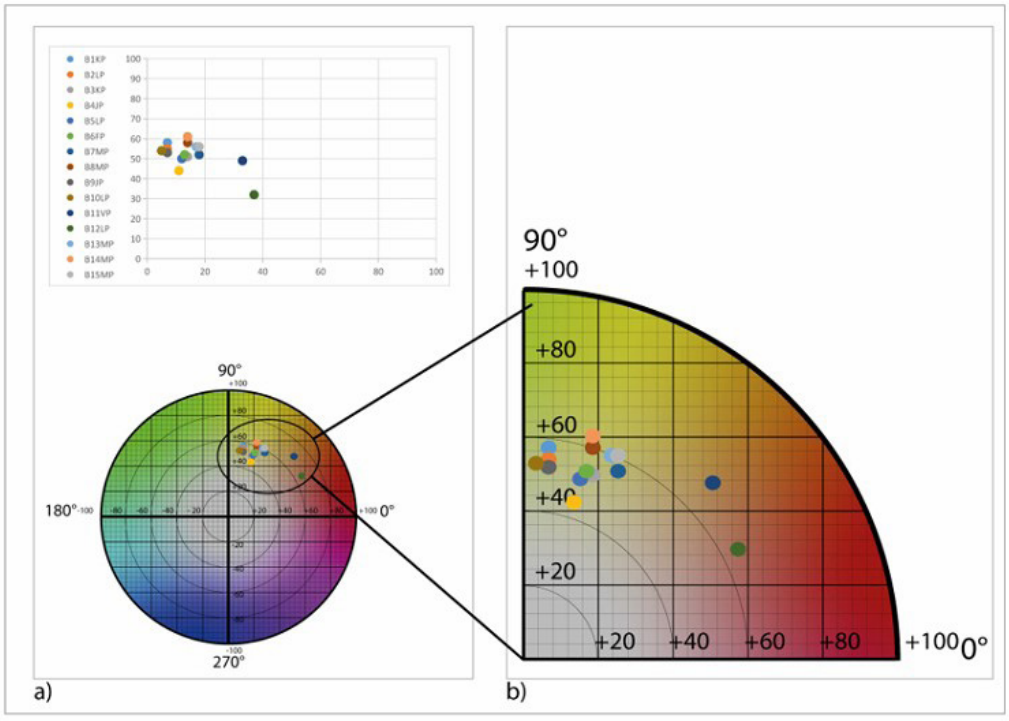

Figure 4. a) Representation of the *Butia odorata* genotypes distribution inside the chromatic circle, using the CIELAB color space in Adobe Photoshop software. The x-axis is relative to the a* parameter, and indicate the hue between green and red. The y-axis refers to b* parameter and specify the hue between blue and yellow. b) Zoom in the first quadrant where all genotypes are distributed. Each genotype was identified by a different color dot.

3.5 Instrumental color measurements

There was a difference among the accessions in all chromatic parameters. The values of a* and b* parameters were positive, so all samples were classified within the first quadrant, demonstrating yellowish and reddish coloration (Figure 4; Table S1).

The average of a* was 15.55, and b* was 48.58, similar to the averages found by Schwartz et al. (2010) in Santa Vitória do Palmar (RS), of 11.65 for a* and 43.94 for b*, and higher than a* 8.09 and b* 35.42 found by Ferrão et al. (2013) in accessions of the municipalities of Santa Maria and Santa Rosa (RS).

The color direction, indicated by the Hue angle, had a range of 40.98º in the B12LP accession, up to 84.74º in the B10LP accession. Values close to 0 indicate a predominance of reddish coloration, in contrast, values close to 90 indicate yellowish tones. Thus, the B12LP accession with the smallest color angle showed greater intensity of reddish coloration, and the B10LP accession stood out with the greatest intensity of yellow.

The average Hue angle among the accessions was 73.19º, which shows the predominance of yellowish coloration. This pattern was also reported by Schwartz et al. (2010) in two seasons (74.49º and 73.39º) and Ferrão et al. (2013) which obtained the Hue of 87.55º.

The luminosity reading showed a variation between 41.0 and 72.24, and the color saturation ranged between 45.55 and 62.92 (Figure S1). Once coloration is one of the most critical visual attributes that affect consumer acceptability, these parameters are good quality indicators (McGuire, 1992).

4 Conclusion

There was genetic variability among *Butia odorata* fruit accessions from Pelotas and Capão do Leão (RS-Brazil) for diameter, height, weight, total soluble solids, total titratable acidity, vitamin C, total phenolic compounds, antioxidant activity, total carotenoids, chromatic parameters (L, a*, b*, C and hº), percentage of crude fiber, protein and lipids. The accessions showed expressive concentrations of fibers, vitamin C, total carotenoids, and phenolic compounds. The variability identified in *B. odorata* favors the conservation through use scenario since these genetic resources could be employed in the context of selection for breeding and the use for nutritional enrichment in diets.

References

Ankom Technology. (2009a). *Operator's manual XT15 – Ankom. Ankom Technology method 2*. Macedon: Ankom Technology.

Ankom Technology. (2009b). *Operator's manual: Fiber Analyzer A2000. AOCS method Ba 6a-05*. Macedon: Ankom Technology.

Association of Official Analytical Chemists – AOAC. (1995). *Official methods of analysis of AOAC International* (16th ed.). Arlington: AOAC.

Barrientos, M. (2014). Introducción. In C. Ayres, J. Crosa, M. Rivas & E. Dellacassa. *Valorización de frutos nativos como forma de promover el desarrollo local: aprovechamiento agroalimentario del butiá en Rocha* (Serie FPTA-INIA, Vol. 57, cap. 1, pp. 11-13). Montevideo: Instituto Nacional de Investigación Agropecuaria.

Beskow, G. T., Hoffmann, J. F., Teixeira, A. M., Fachinello, J. C., Chaves, F. C., & Rombaldi, C. V. (2015). Bioactive and yield potential of jelly

palms (*Butia odorata* Barb. Rodr.). *Food Chemistry*, 172, 699-704. http://dx.doi.org/10.1016/j.foodchem.2014.09.111. PMid:25442610.

Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *Lebensmittel-Wissenschaft + Technologie*, 28(1), 25-30. http://dx.doi.org/10.1016/S0023-6438(95)80008-5.

Brasil, Agência Nacional de Vigilância Sanitária. (1998, January 13). Regulamento técnico referente à informação nutricional complementar (Portaria nº 27 de 13 de Janeiro de 1998). *Diário Oficial da República Federativa do Brasil*.

Brasil, Ministério da Agricultura, Pecuária e Abastecimento. (2018, October 8). Instrução Normativa nº 37 de 1 de outubro de 2018. *Diário Oficial da República Federativa do Brasil*, seção 1.

Buttow, M. V., Castro, C. C., Schwartz, E., Tonietto, A., & Barbieri, R. L. (2010). Caracterização molecular de populações de *Butia capitata* (Arecaceae) do sul do Brasil através de marcadores AFLP. *Revista Brasileira de Fruticultura*, 32(1), 230-239. http://dx.doi.org/10.1590/S0100-29452010005000001.

Canfield, M., Anderson, M. D., & McMichael, P. (2021). UN food systems summit 2021: dismantling democracy and resetting corporate control of food systems. *Frontiers in Sustainable Food Systems*, 5, 661552. http://dx.doi.org/10.3389/fsufs.2021.661552.

Cruz, C. D. (2006). *Programa Genes: biometria*. Viçosa: Editora UFV.

Eslabão M. P, Pereira, P. E. E., Barbieri, R. L., & Heiden, G. (2016). *Mapeamento da distribuição geográfica de butiá como subsídio para a conservação de recursos genéticos* (Boletim de Pesquisa e Desenvolvimento, No. 252). Pelotas: Embrapa Clima Temperado.

Ferrão, T. S., Ferreira, D. F., Flores, D. W., Bernardi, G., Link, D., Barin, J. S., & Wagner, R. (2013). Evaluation of composition and quality parameters of jelly palm (*Butia odorata*) fruits from different region of Southern Brazil. *Food Research International*, 54(1), 57-62. http://dx.doi.org/10.1016/j.foodres.2013.06.002.

Ferreres, F., Vinholes, J., Gil-Izquierdo, A., Valentão, P., Gonçalves, R. F., & Andrade, P. B. (2013). In vitro studies of α-glucosidase inhibitors and antiradical constituents of *Glandora diffusa* (Lag.) D.C Thomas infusion. Food Chemistry, 136(3-4), 1390-1398. http://dx.doi.org/10.1016/j.foodchem.2012.09.089.

Fonseca, L. X. (2012). *Caracterização de frutos de butiazeiro (Butia odorata Barb. Rodr.) Noblick & Lorenzi e estabilidade de seus compostos bioativos na elaboração e armazenamento de geleias* (Master's thesis). Universidade Federal de Pelotas, Pelotas.

Heiden, G., & Sant'Anna-Santos, B. F. (2021). *Butia (Becc.) Becc.*. Retrieved from http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB15703

Leco Corporation. (1999). *Operator's manual: FP-528 Protein/Nitrogen Analyzer*. Saint Joseph: Leco Corporation.

McGuire, R. G. (1992). Reporting of objective color measurements. *HortScience*, 27(12), 1254-1255. http://dx.doi.org/10.21273/HORTSCI.27.12.1254.

Mistura, C. C., Barbieri, R. L., Castro, C. M., Paulosi, S., & Alercia, A. (2015). *Descriptors for butiá [Butia odorata (Barb. Rodr.) Noblick]*. Rome: Biodiversity International/Embrapa Clima Temperado.

Nunes, A. M., Fachinello, J. C., Radmann, E. B., Bianchi, V. J., & Schwartz, E. (2010). Caracteres morfológicos e físico-químicos de butiazeiros (*Butia capitata*) na região de Pelotas, Brasil. *Interciência*, 35(7), 500-505.

Sant'Anna-Santos, B. F. (2021). A new endemic and critically endangered species of Butia (Arecaceae) with comments on morpho-anatomical novelties in the genus. *Plant Systematics and Evolution*, 307(1), 4. http://dx.doi.org/10.1007/s00606-020-01729-w.

Schlindwein, G., Tonietto, A., Abichequer, A. D., Azambuja, A. C., Lisboa, B. B., & Vargas, L. K. (2017). Pindo palm fruit yield and its relationship with edaphic factors in natural populations in Rio Grande do Sul. *Ciência Rural*, 47(2), e20151371. http://dx.doi.org/10.1590/0103-8478cr20151371.

Schwartz, E., Fachinello, J. C., Barbieri, R. L., & Silva, J. B. (2010). Avaliação de populações de *Butia capitata* de Santa Vitória do Palmar. *Revista Brasileira de Fruticultura*, 32(3), 736-745. http://dx.doi.org/10.1590/S0100-29452010005000089.

Sganzerla, M. (2010). *Caracterização físico-química e capacidade antioxidante do butiá* (Master's thesis). Universidade Federal de Pelotas, Pelotas.

Sosinski, E. E. Jr., Urruth, L. M., Barbieri, R. L., Marchi, M. M., & Martens, S. G. (2019). On the ecological recognition of *Butia* palm groves as integral ecosystems: why do we need to widen the legal protection and the in situ/on-farm conservation approaches? *Land Use Policy*, 81, 124-130. http://dx.doi.org/10.1016/j.landusepol.2018.10.041.

Swain, T., & Hillis, W. E. (1959). The phenolic constituents of *Prunus domestica* I – the quantitative analysis of phenolic constituents. *Journal of the Science of Food and Agriculture*, 10(1), 63-68. http://dx.doi.org/10.1002/jsfa.2740100110.

Talcott, S. T., & Howard, L. R. (1999). Phenolic autoxidation is responsible for color degradation in processed carrot puree. *Journal of Agricultural and Food Chemistry*, 47(5), 2109-2115. http://dx.doi.org/10.1021/jf981134n. PMid:10552504.

Vinholes, J., Lemos, G., Barbieri, R. L., Franzon, R. C., & Vizzotto, M. (2017). *In vitro* assessment of the antihyperglicemic and antioxidant properties of aracá, butiá and pitanga. *Food Bioscience*, 19, 92-100. http://dx.doi.org/10.1016/j.fbio.2017.06.005.

Supplementary Material

Supplementary material accompanies this paper.

Table S1. Chromatic characterization (L, a*, b*, C and h°) of Butia odorata accessions from Pelotas and Capão do Leão/RS, 2019.

Figure S1.

This material is available as part of the online article from https://doi.org/10.1590/fst.54822