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## Promising green banana and plantain genotypes for making flour

**Abstract** – The objective of this work was to characterize banana and plantain genotypes and to identify the most promising for flour production. Sixteen plantain genotypes and four banana cultivars were evaluated for dry matter content and flour yield. The obtained flours were characterized by color ( $L^*$ ,  $C^*$ , and  $h^*$ ) and by moisture, total and resistant starch, ash, protein, lipid, and fiber contents. A low genetic variability was observed among plantains for the evaluated physicochemical and nutritional characteristics. The Chifre de Vaca, Comprida, Terra Ponta Aparada, Trois Vert, Terrinha, and Terra Maranhão plantains showed the highest dry matter contents and flour yield. The Chifre de Vaca, Comprida, Curare Enano, Mongolo, Trois Vert, and Terra Maranhão plantains and the 'Pacovan', 'Prata Anã', 'BRS Platina', and 'BRS SCS Belluna' bananas had resistant starch levels above 60%. The flour from 'BRS SCS Belluna' presented the highest contents of ash, protein, and fiber, as well as the lowest caloric value. Considering dry matter content, flour yields, and resistant starch, the Chifre de Vaca, Comprida, Trois Vert, and Terra Maranhão plantains are the best options to produce flour. From a nutritional point of view, 'BRS SCS Belluna' is a good option for producing flour rich in resistant starch, mineral, protein, and fiber contents.

**Index terms:** *Musa*, nutrition, prebiotic, resistant starch, starch.

### Genótipos promissores de bananas e plátanos verdes para elaboração de farinha

**Resumo** – O objetivo deste trabalho foi caracterizar genótipos de bananas e plátanos e identificar os mais promissores para a fabricação de farinha. Dezesseis genótipos de plátanos e quatro cultivares de banana foram avaliados quanto ao teor de matéria seca e ao rendimento em farinha. As farinhas obtidas foram caracterizadas quanto à cor ( $L^*$ ,  $C^*$  e  $h^*$ ) e aos teores de umidade, amido total e resistente, cinzas, proteínas, lipídeos e fibras. Observou-se baixa variabilidade genética entre os plátanos para as características físico-químicas e nutricionais avaliadas. Os plátanos Chifre de Vaca, Comprida, Terra Ponta Aparada, Trois Vert, Terrinha e Terra Maranhão apresentaram maiores teores de matéria seca e melhor rendimento em farinha. Os plátanos Chifre de Vaca, Comprida, Curare Enano, Mongolo, Trois Vert e Terra Maranhão e as bananas 'Pacovan', 'Prata Anã', 'BRS Platina' e 'BRS SCS Belluna' apresentaram teores de amido resistente acima de 60%. A farinha de 'BRS SCS Belluna' apresentou maiores teores de cinzas, proteína e fibras, bem como menor valor calórico. Ao se considerar matéria seca, rendimento em farinha e teor de amido resistente, os plátanos Chifre de Vaca, Comprida, Trois Vert e Terra Maranhão são as melhores opções para produzir farinha. Do ponto de vista nutricional, a banana 'BRS SCS Belluna' é uma boa opção para produção de farinha com altos teores de amido resistente, minerais, proteínas e fibras.

**Termos para indexação:** *Musa*, nutrição, prebiótico, amido resistente, amido.

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## Introduction

Bananas and plantains belong to the genus *Musa* and result from the intra- and interspecific hybridizations of two species: *Musa acuminata* Colla (genome A) and *Musa balbisiana* Colla (genome B). Dessert bananas (AA, AAA, and AAB genomic groups) are consumed raw at several stages of maturity (Gibert et al., 2009), whereas plantains, which are part of the AAB group, are not palatable when raw, being consumed cooked, fried, or as a flour due to their high starch content even when ripe. In Brazil, plantains, known as “banana-da-terra”, differ from dessert bananas due to their larger and starchier fruits that are generally palatable only after cooking (Daniells, 2003). Although plantains are important in the country, only three varieties are available to farmers: Terra Maranhão, Terrinha, and D’Angola (Gonçalves et al., 2018).

Recently, green banana has been considered a new food ingredient, and several studies have suggested that its consumption has a beneficial effect on health, since it is the unprocessed food richest in resistant starch (RS) or in the fraction of starch that behaves physiologically as soluble fiber (Fuentes-Zaragoza et al., 2010).

To include green bananas in human diet, the best option is in the form of flour, which can be directly consumed or used in baked, dietetic, and baby food products (Vernaza et al., 2011). Its production technology is simple and increases banana shelf life and value, it is easy to transport and store, and it also creates opportunities for the rural agro-industries (Yani et al., 2013).

Compared with traditional fibers present in whole grains, bran and fruit, RS in green banana flour has better sensory attributes, such as appearance, texture and flavor of the end product, which is positive from a commercial perspective (Fuentes-Zaragoza et al., 2010). Green banana flour is also rich in proteins, fibers, and minerals, such as potassium, phosphorus, magnesium, copper, manganese, and zinc (Borges et al., 2009). When evaluating 23 cultivars from Colombia, Gibert et al. (2009) found contents of 2.10 to 4.88% protein, 1.8 to 5.0% total fiber, and 2.3 to 4.3% ash contents.

Some cultivars have already been used to obtain green banana flour and food products, including Prata Anã, Gros Michel (Daramola & Osanyinlusi, 2006), and different ones from the Cavendish subgroup

(Menezes et al., 2011; Segundo et al., 2017). Several studies have shown that the RS contents of these flours vary according to the banana genotype. Vatanasuchart et al. (2009), for example, reported values from 52.2 to 68.1% for RS contents of the flour from 11 cultivars from Thailand, whereas Thakorjal et al. (2010) observed 29.58 to 46.24% RS in the flour from five cultivars from Micronesia. Agama-Acevedo et al. (2012) found from 65.3 to 91.9% RS extracted from four cultivars from Mexico, while Mesquita et al. (2016) verified contents of 65.91 to 82.67% RS for five banana varieties cultivated in Brazil.

The results of these studies show that the genotype directly influences the nutritional quality and RS content of the obtained green banana flours; however, few works have explored the potential of plantains for flour production. The genetic variability of characteristics of interest is fundamental for genetic improvement programs, and the physicochemical and nutritional characterization of plantain germplasms can provide useful information to identify genotypes with different use potentials.

The objective of this work was to characterize banana and plantain genotypes and to identify the most promising for flour production.

## Materials and Methods

The following genotypes were evaluated: 12 plantain genotypes from the germplasm collection of Empresa Brasileira de Pesquisa Agropecuária, i.e., Chifre de Vaca, Comprida, Curare Enano, Mongolo, Pinha, Red Yade, Samura B., Terra Anã Branca, Terra Ponta Aparada, Terra Sem Nome, Tipo Velhaca, and Trois Vert; 3 commercial Brazilian plantains, Terra Maranhão, D’Angola, and Terrinha; and 5 commercial Brazilian dessert bananas, 'BRS SCS Belluna', 'BRS Platina', 'Grande Naine', 'Pacovan', and 'Prata Anã'. The study was conducted in the experimental field located in the municipality of Cruz das Almas, in the state of Bahia, Brazil (12°40'19"S, 39°06'22"W', at 220 m above sea level), between October 2013 and December 2015. The climate is classified as Aw to Am, tropical hot and humid, according to Köppen’s classification, with an average annual temperature of 24.5°C, relative humidity of 80%, and rainfall of 1,250 mm (Gonçalves et al., 2018).

The experiment was conducted in a completely randomized design with three experimental replicates, corresponding to the fruits of three different plants.

Bunches were harvested and processed in maturation stage 1, when the peel was completely green. Fruits were peeled and cut into 4-to-5-mm thick slices and immersed in an aqueous solution of 100 mg L<sup>-1</sup> citric acid and 300 mg L<sup>-1</sup> ascorbic acid for 10 to 15 min to prevent pulp darkening. The drying process was conducted with a convection dryer, at 50°C and an air velocity of 1.5 m s<sup>-1</sup>, until the moisture content was between 5 and 10% wet weight. The dehydrated slices were ground with a knife mill with 30-mesh sieves, packed in vacuum-sealed polyethylene bags, and stored frozen until analysis.

Yields were calculated based on the weight of fruits with peel (FYWP). For color evaluation, whiteness/darkness (L\*), chroma/color intensity (C\*), and hue angle (h\*) were determined with a colorimeter using illuminant D65 ( $z = 93.6$ ;  $x = 0.3133$ ;  $y = 0.3195$ ).

RS was obtained according to Goñi et al. (1996), and total starch was quantified based on the method of Rickard & Behn (1987). Moisture, ash, and protein contents were determined as proposed by Instituto Adolfo Lutz (Zenebon et al., 2008); dry matter, by the difference between 100 and moisture percentage; and lipid content, by the method of Bligh & Dyer (1959). The fiber content analysis was based on the AOAC 985.29 method (Latimer & George, 2012); for the obtained data, only one sample of each treatment was evaluated and no statistical analysis was performed. Carbohydrate content was determined by the difference between 100 and the sum (percentage) of moisture, ash, lipid, total protein, and nutritional fiber values. The total caloric value (TCV) was calculated based on flour composition, using the following conversion factors: 4 kcal g<sup>-1</sup> for proteins, 4 kcal g<sup>-1</sup> for carbohydrates, and 9 kcal g<sup>-1</sup> for lipids.

Data were subjected to the univariate analysis of variance, and averages were grouped by the Scott-Knott test, at 5% probability. The multivariate analysis was conducted using the unweighted pair-group average method from the Euclidean distance, and the principal component analysis using a correlation matrix. The statistical analyses were carried out with the Statistica software (TIBCO Software Inc., Palo Alto, CA, USA).

## Results and Discussion

The highest dry matter content was found for plantains, with an average of 40.40%, which did not differ among each other (Table 1). The 'BRS SCS Belluna', 'BRS Platina', and 'Grande Naine' dessert bananas had the lowest DM content, with an average of 26.36%. These results are in alignment with those of Gibert et al. (2009), who found values from 24.6% for dessert hybrids to 41.1% for plantains.

Dry matter content can directly influence flour yield and, therefore, is an important parameter that must be considered when choosing the raw material for flour production, directly reflecting in the producer's profit. The Chifre de Vaca, Comprida, Terra Ponta Aparada, and Trois Vert plantains have high FYWP values between 24.31 and 27.71%, similar to those of 27.19 and 25.17%, respectively, of the Terrinha and Terra Maranhão commercial plantains (Table 1).

The flour obtained from the 'Grande Naine' dessert banana had the lowest L\* values, and, therefore, was darker than the others (Table 1). This result is an indicative that the browning of green banana flours is due to genotype characteristics and maturity rate, as well as to the used processing methods (Yani et al., 2013). Since, in the present study, all genotypes were processed at the same maturity rate and with the same processing parameters, the difference in L\* values is due to genotype. Even at the green stage of maturity, the sugars in the fruits from 'Grande Naine' could react (Maillard reaction) with amino acids during the dehydration process, producing dark pigments (Yani et al., 2013). Flours obtained from the other genotypes presented more whiteness and had an average L\* of 81.76 (Table 1), higher to that of 78.12 observed by Vernaza et al. (2011) for the flour from a commercial banana. This characteristic can favor the use of these flours for the production of different products, since it does not greatly change their color, having little visual impact on consumer preference. These results corroborate those of Savlak et al. (2016), who evaluated green banana flours with different particle sizes, finding L\* between 80.18 (501–700 μm) and 85 (μm < 212). Anyasi et al. (2015) reported similar values between 79.39 and 85.29 for green banana flours.

No significant differences were found among h\* values, with an average was 90.65, showing that all the flours were yellow. Regarding C\*, the flours from the Comprida and Terra Ponta Aparada plantains

did not differ significantly from those from the Terrinha and Terra Maranhão commercial plantains, being characterized by a more intense yellow color (Table 1). This stronger color intensity is related to the pulp color of the genotypes, and an increase in C\* is directly associated with a greater concentration of pigments in food (Wrolstad & Smith, 2010). According to Borges et al. (2019), there is a positive correlation between the orange/yellow color of plantain pulp and carotenoid content, suggesting that genotypes with a high value of C\* in their pulp present a higher content of pro-vitamin compounds. Probably, the Comprida, Terra Ponta Aparada, Terrinha, and Terra Maranhão genotypes, which produced yellower flours, have more total carotenoids than the others, being interesting from a nutritional point of view.

There was no significant difference among genotypes for total starch contents, with an average of 83.98% (Table 2). Similar results of 80.02% were reported by Hoffmann Sardá et al. (2016) for green banana flour from a cultivar of the Cavendish subgroup; however, Menezes et al. (2011) obtained a lower value of 76.77% for flours from the same cultivar. Due to their high starch contents, green banana flours can also be used as alternative starch sources, replacing corn, rice, and wheat (Yani et al., 2013).

A great variability in RS content, varying from 21.15 to 70.06%, was observed among the assessed green banana flours (Table 2). The RS content of most of the genotypes evaluated in the present study is similar to that of 50.7 to 68.1% obtained by Vatanasuchart et al. (2009), who analyzed flours from 11 banana cultivars. The flours from the Curare Enano and Mongolo

**Table 1.** Dry matter, flour yields based on the weight of fruits with peel (FYWP) on a dry basis percentage, and color attributes of green banana and plantain (*Musa* spp.) flours<sup>(1)</sup>.

Group	Genotype	Dry matter	FYWP	L*	C*	h*
Plantains from germplasm collection	Chifre de Vaca	44.67a	24.31a	82.25a	15.80b	92.01
	Comprida	39.20a	27.71a	82.15a	21.43a	89.90
	Curare Enano	42.08a	18.48b	81.82a	12.34c	90.59
	Mongolo	42.06a	20.85b	81.02a	12.82c	90.90
	Pinha	39.75a	20.89b	81.82a	13.41c	92.35
	Red Yade	40.32a	20.60b	82.21a	15.11b	91.26
	Samura B.	35.94a	19.69b	81.23a	12.35c	90.10
	Terra Anã Branca	41.94a	20.10b	81.51a	13.12c	90.44
	Terra Ponta Aparada	40.00a	27.08a	81.69a	21.87a	89.80
	Terra Sem Nome	40.52a	18.05b	82.33a	11.25c	90.96
Commercial Brazilian plantains	Tipo Velhaca	42.33a	19.29b	81.58a	12.66c	90.24
	Trois Vert	37.60a	25.32a	82.00a	16.77b	91.82
	Terra Maranhão	37.60a	25.17a	82.84a	19.64a	92.32
Commercial Brazilian dessert bananas	D'Angola	41.56a	19.65b	81.58a	12.72c	90.91
	Terrinha	40.43a	27.19a	81.92a	20.24a	92.00
	BRS SCS Belluna	28.06c	17.76b	80.56a	16.17b	89.51
	BRS Platina	24.84c	14.67b	81.90a	13.88c	88.83
	Grande Naine	26.18c	17.23b	77.13b	12.42c	87.84
Commercial Brazilian dessert bananas	Pacovan	31.92b	18.70b	82.30a	13.36c	90.43
	Prata Anã	31.32b	20.28b	80.76a	12.94c	90.87
F-value		12.80**	7.03**	7.87**	7.67**	1.08 <sup>ns</sup>
CV (%)		7.51	11.42	0.89	13.75	2.14

<sup>(1)</sup>Means followed by equal letters, in the columns, belong to the same group based on the Scott & Knott test, at 5% probability. L\*, whiteness/darkness; C\*, chroma/color intensity; and h\*, hue angle. \*\*Significant by the F-test, at 1% probability. <sup>ns</sup>Nonsignificant by the F-test, at 5% probability.

plantains and of the 'Pacovan' and 'BRS Platina' dessert bananas did not differ and had RS values above 65%. The Chifre de Vaca, Comprida, Trois Vert, and Terra Maranhão plantains and the 'BRS SCS Belluna' and 'Prata Anã' dessert bananas had an average of 60.34%. The RS content of these genotypes was greater than the values from 45.70 to 47.25% observed by Sarawong et al. (2014) and Vernaza et al. (2011) for commercial green banana flours. The differences between these results and those of the present study are explained by variations in the RS content of flours due to genotype,

**Table 2.** Total starch (TS), resistant starch (RS), and nonresistant starch (NRS) contents of flours obtained from bananas and plantains (*Musa* spp.) on a dry basis percentage<sup>(1)</sup>.

Group	Genotype	TS	RS	NRS <sup>(2)</sup>
Plantains from germplasm collection	Chifre de Vaca	82.37	61.05b	21.97c
	Comprida	91.40	60.79b	30.61c
	Curare Enano	85.19	68.50a	16.69d
	Mongolo	91.82	65.92a	25.80c
	Pinha	84.61	53.12d	31.35c
	Red Yade	86.47	43.44f	43.76b
	Samura B.	85.05	52.33d	32.71c
	Terra Ana Branca	84.76	46.26e	40.26b
	Terra Ponta Aparada	80.66	56.13c	24.53c
	Terra Sem Nome	86.97	21.15g	65.94a
Commercial Brazilian plantains	Tipo Velhaca	88.60	55.91c	32.69c
	Trois Vert	84.71	60.59b	22.19c
	Terra Maranhão	82.10	62.19b	19.91d
Commercial Brazilian dessert bananas	D'Angola	90.09	46.35e	43.74b
	Terrinha	83.52	40.14f	45.68b
	BRS SCS Belluna	74.56	59.14b	14.39d
	BRS Platina	78.53	67.43a	11.11d
	Grande Naine	73.84	51.37d	22.46c
	Pacovan	84.46	70.06a	9.30d
	Prata Anã	79.84	58.30b	23.43c
F-value		1.85 <sup>ns</sup>	49.28 <sup>**</sup>	11.59 <sup>**</sup>
CV (%)		7.59	5.39	24.19

<sup>(1)</sup>Means followed by equal letters, in the columns, belong to the same group based on the Scott & Knott test, at 5% probability. <sup>(2)</sup>Calculated as the difference between total starch and resistant starch. <sup>\*\*</sup>Significant by the F-test, at 1% probability. <sup>ns</sup>Nonsignificant by the F-test, at 5% probability.

fruit maturation stage, presence or absence of peel, production technique, and processing parameters. Regarding ash content, there were significant differences among the flours from the commercial dessert bananas, with the highest value found for 'BRS SCS Belluna' and 'Grande Naine', with an average of 3.26% (Table 3). Both of these cultivars are part of the AAA genomic group, whereas BRS SCS Belluna, from Thailand, has no defined subgroup and Grande Naine belongs to the Cavendish subgroup. Mota et al. (2000) reported similar values of 3.5 and 3.0% for flours from the Nanica and Nanicão cultivars, respectively, and Menezes et al. (2011), of 3.14% from Nanicão; these cultivars are also part of the Cavendish subgroup. The flours from 'Prata Anã', 'Pacovan', and 'BRS Platina', which have the B genome and belong to the Prata subgroup, did not differ among themselves for ash content, with an average of 2.44%, similar to that of 2.59% observed by Borges et al. (2009) for 'Prata'. Although plantains have also the B genome, they differed from the others and were characterized by the lowest ash contents, with an average of 1.65% (Table 3). This result is in alignment with that of Gibert et al. (2009), who found that plantains had lower ash and mineral contents than dessert bananas.

Since the ash and mineral contents of food are directly related, it can be inferred that 'BRS SCS Belluna' and 'Grande Naine' are richer in minerals and, therefore, would be more interesting from a nutritional point of view to bring minerals into the diet. In the present study, considering that all genotypes were cultivated under the same soil and climate conditions, the differences in mineral contents are due to the intrinsic characteristics of each banana genotype.

'BRS SCS Belluna' and 'Grande Naine' had the highest protein contents, with an average of 4.26% (Table 3), and are good options for producing flour as a source of this nutrient. The flours from 'BRS Platina', 'Prata Anã', and Terra Ponta Aparada presented an average of 3.59% protein, and the remaining genotypes, an average of 2.96%. These results are similar to those of: 3.54–5.24% reported by Segundo et al. (2017) for flours from 'Nanica'; 3.60% by Menezes et al. (2011) for 'Nanicão'; and 4.50% by Borges et al. (2009) for 'Prata'.

The green banana flours had low lipid contents, from 0.47 to 1.15%, and a fiber content from 4.18% for Terra Ponta Aparada to 18.79% for 'BRS SCS Belluna'

(Table 3). According to Resolução RDC n° 54, de 12 de novembro de 2012 (Anvisa, 2012), considering a portion of 50 g, food products with a fiber content above 2.5 g per portion are considered “sources of fiber” and those with a content above 5.0 g have a “high fiber content.” Based on this legislation, the flours from Terrinha and 'BRS SCS Belluna' stand out and can be considered foods with a “high fiber content”, while the other flours (except those from the Terra Ponta Aparada and Terra Maranhão plantains) are “sources of fiber”.

The evaluated flours differed significantly regarding carbohydrate content and TCV (Table 3). The flours from the Chifre de Vaca, Curare Enano, D'angola, Terra Ponta Aparada, Tipo Velhaca, Trois Vert, and Terra Maranhão plantains are notable for their highest carbohydrate contents, with an average of 83.55%. Green banana flour is rich in unavailable

carbohydrates with a high in vitro fermentability, which makes it a food with potential to promote intestinal health (Menezes et al., 2011). Similar results of 83 to 88% were obtained by Yani et al. (2013) for flours from different cultivars, of 82.58% by Vernaza et al. (2011) for commercial flours, and of 81.19 to 82.61% by Segundo et al. (2017) for flour from 'Nanica'. The flours from the 'BRS SCS Belluna' banana had a lower TCV of 296.51 kcal 100g<sup>-1</sup>, whereas those from the Terra Maranhão and Terra Ponta Aparada plantains had the highest values of 356.58 and 360.17 kcal 100 g<sup>-1</sup>, respectively.

According to Silva et al. (2015), the chemical composition of green banana flours varies with genotype characteristics, maturation stage, processing techniques, and parts of the fruit (peel and pulp) used in the process. In the present study, since all genotypes

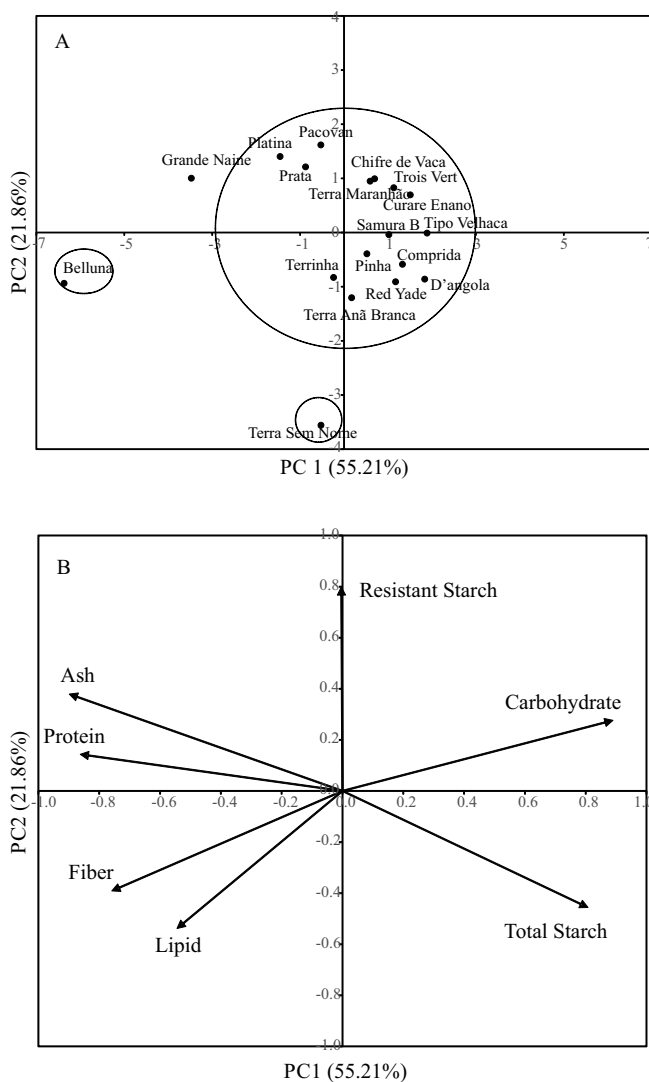
**Table 3.** Nutritional composition and total caloric value (TCV) of green banana and plantain flours (*Musa* spp.) on a wet basis<sup>(1)</sup>.

Group	Genotype	Nutritional composition (%)					TCV (kcal 100g <sup>-1</sup> )
		Ash	Protein	Lipids	Fiber <sup>(2)</sup>	Carbs	
Plantains from germplasm collection	Chifre de Vaca	2.05c	2.96c	0.67b	5.36	82.85a	349.28b
	Comprida	1.50c	2.94c	0.80b	7.36	82.25b	347.95b
	Curare Enano	1.50c	2.73c	0.72b	5.85	83.74a	352.62b
	Mongolo	1.75c	2.69c	0.80b	8.36	80.90b	341.52c
	Pinha	1.65c	3.04c	0.80b	7.24	81.76b	345.79b
	Red Yade	1.31c	3.15c	0.72b	6.44	82.31b	348.33b
	Samura B.	1.71c	2.80c	0.64b	7.29	81.67b	343.60c
	Terra Anã Branca	1.59c	2.97c	0.78b	9.32	79.58c	337.22c
	Terra Ponta Aparada	1.84c	3.52b	0.70b	4.18	84.80a	360.17a
	Terra Sem Nome	1.52c	3.30c	1.15a	8.53	78.70c	337.86c
Tipo Velhaca	1.51c	2.71c	0.62b	6.38	83.41a	349.38b	
Trois Vert	1.68c	3.03c	0.61b	6.17	82.93a	349.31b	
Commercial Brazilian plantains	Terra Maranhão	1.86c	3.30c	0.78b	4.22	84.08a	356.58a
	D'Angola	1.51c	2.72c	0.69b	6.36	83.01a	349.17b
	Terrinha	1.82c	3.15c	0.47b	11.84	78.19c	329.63d
Commercial Brazilian dessert bananas	BRS SCS Belluna	3.34a	4.18a	1.11a	18.79	67.46e	296.51e
	BRS Platina	2.40b	3.53b	0.71b	7.65	76.66d	327.11d
	Grande Naine	3.19a	4.33a	0.83b	8.37	77.62d	334.34c
	Pacovan	2.38b	2.84c	0.62b	8.07	77.35d	326.32d
	Prata Anã	2.53b	3.74b	0.71b	5.46	81.38b	346.85b
F-value		7.53**	6.62**	2.35**	-	52.05**	39.20**
CV (%)		18.33	9.99	23.63	-	1.17	1.14

<sup>(1)</sup>Means followed by equal letters belong to the same group based on the Scott & Knott test, at 5% probability. <sup>(2)</sup>Data from a composite sample, with no statistical analysis. \*\*Significant by the F-test, at 1% probability.

were processed at the same maturity stage and with the same parameters, the chemical composition of the assessed flours is due to genetic characteristics.

The principal component analysis was used to evaluate the differences among genotypes considering chemical characteristics. The two first principal components (PC1 and PC2, respectively) explained 77.07% of the observed variation and, therefore, were selected to differentiate genotypes (Figure 1 A). Three



**Figure 1.** Principal component analysis of the flours produced from different banana and plantain genotypes, showing: A, the spatial distribution of the 20 evaluated flour samples in relation to the two first components; and B, correlations (“loadings”) between the chemical characteristics of the flours and the two first components.

groups were identified by the cluster analysis, and most of the plantains and dessert bananas formed one group with very similar chemical characteristics. The 'BRS SCS Belluna' dessert banana, located in the negative PC1 area, and the Terra Sem Nome plantain, located in the negative PC2 area, differed from each other and from the others.

PC1 was represented by carbohydrates (0.889), total starch (0.807), ash (-0.898), proteins (-0.862), and fibers (-0.759) (Figure 1 B), which differentiate genotypes in relation to the first principal component. The plantains, located in the positive PC1 area, were mainly characterized by high contents of carbohydrates and total starch. The 'BRS SCS Belluna' dessert banana, located in the negative PC1, was characterized by elevated ash, protein, and fiber contents, which differentiated this genotype from the others.

PC2 was represented by RS (0.799), and the plantain and dessert banana located in the positive PC2 area showed the highest contents. The Terra Sem Nome plantain, located in negative PC2 area, differed from the others and was characterized by a lower RS content (Table 2). Lipid content had a low correlation with PC1 (-0.544) and PC2 (-0.539), and, therefore, was not considered relevant to differentiate the evaluated genotypes. In a research conducted by Hoffmann Sardá et al. (2016), the following characteristics were considered relevant to distinguish green banana flours: RS (-0.746), dietary fiber (0.979), ash (0.949), and lipids (0.939); except for lipids, the remaining three characteristics were also important to differentiate genotypes in the present study. Gibert et al. (2009), in the component analysis, also concluded that the contents of starch, dry matter, and ash were relevant to differentiate bananas from plantains.

## Conclusions

1. The Chifre de Vaca, Comprida, Trois Vert, and Terra Maranhão plantains are the best options to produce flour, considering flour yield, dry matter, and resistant starch contents.

2. The BRS SCS Belluna cultivar is a good option for producing flour richer in resistant starch, minerals, proteins and fibers, being interesting from a nutritional point of view.

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