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Multivariate and correlation network analyses in the selection of papaya cultivars in Mato Grosso, Brazil

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Abstract

Papaya (*Carica papaya* L.) is among the most widely grown fruit species in the world and have significant economic importance in Brazil. However, most of the Brazilian production is concentrated in the Northeast and Southeast regions, limiting the potential expansion of this production chain. The objective of this study was to evaluate the performance of papaya cultivars from the Solo and Formosa groups in the state of Mato Grosso, Brazil, focusing on the combination of high-yield traits, fruit quality, and consumer acceptance through canonical variable analysis. The research was conducted in Tangará da Serra, MT, Brazil, using 11 papaya cultivars (Golden, Golden-THB, Aliança, UC14, UC16, UC12, Bela-Nova, Calimosa, Rubi-Incaper-511, T2, and Tainung-1). The cultivars showed significantly different results. Overall, they met the standards required by both national and international markets in terms of fruit physical appearance. Golden-THB (Solo group) showed the highest yield, while Golden had the highest ascorbic acid and beta-carotene contents. Rubi-Incaper-511 and UC16 were the most preferred by consumers, according to the sensory analysis.

Keywords: *Carica papaya L.*, sensory analysis, canonical variables.

Introduction

Brazil is the fourth largest papaya-producing country in the world, and the production of this fruit is a significant source of income and employment in various regions of the country (FAO, 2024). Most Brazilian papaya production is concentrated in the Northeast and Southeast regions, which account for over 95% of the total national production (IBGE, 2024). The Mato Grosso, located in the Central-West region of Brazil, is a major producer of soybeans, maize, and cotton, using advanced technology. However, the state has limited fruit production, including papaya. Expanding papaya planting areas in Mato Grosso allows the country to increase its national fruit production.

Brazil is a large country, and consequently its regions exhibit high climate diversity, making genotype-environment interaction significant. Mato Grosso is characterized by high temperatures, which can reach 35 °C between June and September (INMET, 2023). Temperature and light intensity can have either beneficial or harmful effects on plant development (Santos et al., 2018). Papaya plants are affected by environmental factors, particularly temperature; exposure to high or low temperatures can result in floral abnormalities (Martelleto et al., 2011). The environmental factors that most limit crop production are temperature and water deficits (Campostrini et al., 2018).

The choice of adapted cultivars is another essential factor for expanding papaya planting areas. There are 63 papaya cultivars registered in Brazil (MAPA, 2024), but most crops in the country are based on the Sunrise Solo, THB, and Aliança cultivars, which belong to the Solo group (Silva et al., 2022), and the Tainung-1 and Calimosa hybrids from the Formosa group (Pereira et al., 2019).

Several characteristics are essential for evaluating

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papaya cultivars, including agronomic, physical, chemical, biochemical, and sensory attributes. These factors are important for decision-making by both growers and consumers. Multivariate methods can be used to study multiple traits simultaneously. Canonical correlation analysis is a potential method for identifying these joint multivariate relationships across different modalities. It is a statistical method that seeks linear combinations of two random variables to maximize the correlation between the combined variables (Hotelling, 1936).

The application of correlation network analysis in agriculture has been diverse, including studies on genetic divergence analysis in *Carica papaya* L. (Borbosa et al., 2011), the identification of differences in sensory attributes in tomato cultivars (Zushi & Matsuzoe, 2011), and the exploration of metabolic selection strategies to enhance fruit flavor (Colantonio et al., 2022). Therefore, the objective of this study was to evaluate agronomic, physical, chemical, biochemical, and sensory traits of fruits from different papaya cultivars (Solo and Formosa groups) in Mato Grosso using multivariate and correlation network analysis.

Material and Methods

The research was conducted at the experimental area of the Mato Grosso State University, in Tangará da Serra, Mato Grosso (MT), Brazil (14°37'55"S, 57°28'05"W, and 488 meters of altitude). The region's climate is tropical humid, with two well-defined seasons: a rainy season in the summer and a dry season in the winter (Alvares et al., 2013). The region exhibits a mean temperature of 24.9 °C, reaching 35 °C, and mean annual rainfall depth of 1,499 mm (INMET, 2023).

The soil in the experimental area was classified as a Typic Hapludox (Latossolo Vermelho Distrófico), (Santos et al., 2018); analysis of the 0.0-20.0 cm soil layer showed the following characteristics: pH (water) = 5.8; P = 1.48 mg dm^{-3}; K = 0.10 cmolc dm^{-3}; Al = 0.1 cmolc dm^{-3}; Ca = 0. 8 cmolc dm^{-3}; Mg = 0.6 cmolc dm^{-3}; H + Al = 3.6 cmolc dm^{-3}, sum of bases = 1.5 cmolc dm^{-3}; cation exchange capacity at pH 7.0 = 5.10; base saturation = 29%; and organic matter (Walkley-Black) = 23 g dm^{-3}. Limestone filler was applied at a rate of 250 grams per planting hole, together with 45 grams of simple superphosphate, to increase the base saturation to 80%. Data on mean rainfall depths, temperatures, and relative humidity during the experimental period are shown in **Figure 1** (CETEGEO-SR, 2022).

Eleven papaya cultivars were evaluated in an experiment conducted in a randomized block design, with four replications and six plants per plot. The cultivars belong to two different groups: Solo group (Golden, Aliança, Golden-THB, UC14, and UC16) and Formosa group (Rubi-Incaper-511, Tainung-1, T2, Calimosa, Bela-Nova, and UC12).

Seeds were sown in 300-mL plastic bags containing a commercial substrate (Tropstrato HT), using three seeds per bag. Thinning was performed after emergence, leaving only one seedling per bag, with excess seedlings removed or transplanted to bags where seeds had not germinated.

Seedlings were transplanted to the field 59 days after sowing, with three seedlings planted per hole to ensure the presence of at least one hermaphrode plant per hole. The seedlings were planted in an area with micro-sprinkler irrigation system, with spacing of 4.0 m between rows and 2.0 m between plants. Cultural practices and plant health treatments were carried out as recommended for the crop, according to Martins & Costa (2003).

Physical, chemical, and biochemical characteristics of commercial fruits were evaluated throughout the crop cycle, using a 10-fruit sample per plot. Evaluations were carried out on individual fruits, and the resulting data were averaged per plot. Fruits were harvested at ripening stage 2 (up to 25% yellow skin) and evaluated at ripening stage 5 (completely yellow skin).

The characteristics evaluated were: fruit yield (Mg ha^{-1}), estimated by multiplying the number of commercial fruits per plant by the mean fruit weight per plant; fruit length (cm); fruit diameter (cm); fruit weight (g); soluble solids content (SS; °Brix), determined using a portable digital refractometer (Reichert R2 Mini); internal fruit cavity diameter (cm); pulp thickness (cm); titratable acidity (% of citric acid;), assessed by titration with NaOH 0.1 N; pH; and SS to TA ratio (SS/TA).

Vitamin C content was quantified in a 10-gram sample diluted in 50 mL of 1% oxalic acid. The mixture was titrated with a 0.2% sodium 2,6-dichlorophenolindophenol (DCPIP) solution until it turned pink. The results were expressed as milligrams of ascorbic acid equivalent per 100 g of fresh weight (mg AAE 100 g^{-1}) (Zenebon et al., 2008).

Lycopene and β-carotene contents (mg 100 g^{-1}) were quantified according to Nagata & Yamashita (1992). A 1-gram pulp sample was mixed with 4 mL of acetone and 6 mL of hexane, then shaken for 20 seconds. The supernatant was collected immediately after phase separation, and absorbances were read at 663 nm, 645 nm, 505 nm, and 453 nm using a spectrophotometer. Lycopene and β-carotene contents (μg 100 g^{-1}) were calculated using the following formulas:

$$C_{LYC} = -0.0458A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}$$
$$C_{CAR} = 0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453}$$

Total phenolic content was quantified in an aliquot (100µL) of methanolic extract (1 g mL^{-1}) mixed with 900µL of distilled water, 500µL of 10% Folin Ciocalteu, and 2.5 mL of 20% sodium carbonate. The mixture was vortexed and left to rest for 1 hour. Absorbance readings were taken at 760 nm using a spectrophotometer. Gallic acid (0-170µM) was used for calibration, and the results were expressed in milligrams of gallic acid equivalent per 100 g of fruit (mg GAE 100 g^{-1}) (Singleton & Rossi, 1965).

The sensory evaluation of papaya fruits was conducted by 50 evaluators, each considered a replication. Evaluators were selected based on their regular consumption of papaya, availability, and interest in participating in the test. The participants included adults of both sexes, aged 18 to 50 years, which evaluated the samples using a subjective assessment method with a hedonic scale based on the methodology proposed by Meilgaard et al. (2006).

Samples for sensory were prepared one hour in advance: ripe, ready-to-eat fruits were peeled and sliced into 2 cm³ cubes, and sample portions were served in disposable cups with random three-digit alphanumeric codes.

A nine-point hedonic scale was used for each attribute, ranging from "extremely dislike" to "extremely like": (9) extremely like, (8) like very much, (7) like moderately, (6) like slightly, (5) neither like nor dislike, (4) dislike slightly, (3) dislike moderately, (2) dislike very much, and (1) dislike extremely. Purchase intention (market) was assessed using a 1-5 scale: (1) certainly would not purchase, (2) possibly would not purchase, (3) maybe/maybe would not purchase, (4) possibly would purchase, and (5) certainly would purchase. Evaluators were provided with detailed instructions regarding the origin of the samples and specific testing procedures prior to sensory evaluation. They were also offered crackers and room-temperature water to cleanse their palates.

The results were subjected to analysis of variance (ANOVA); when means were significant, they were subjected to the Scott Knott test ($P < 0.05$), using the R 3.1.2 software (TEAM, 2020). Canonical variable and correlation network analyses were performed using Rbio software (Bhering, 2017).

Results and Discussion

A mean fruit yield of 19 Mg ha-¹ was found for cultivars from the Solo group, with the Golden-THB cultivar showing the highest fruit yield (33.06 Mg ha^{-1}) and number of fruits (150). A mean fruit yield of 22 Mg ha^{-1} was found for The Formosa group, with no significant difference among cultivars; UC12 and Calimosa cultivars exhibited the highest number of fruits (90.5 and 79.8, respectively) within this group. These results indicate that, besides the number of fruits per plant, fruit weight is also a significant factor for determining the final yield.

Research conducted in Bahia and Espírito Santo found higher yields for both papaya groups (Dantas et al., 2015; Luz et al., 2015). The divergences found may be due to environmental factors, such as temperature. The predominant maximum temperature in the region from June 2021 to July 2022 was above 30°C, with occasional peaks exceeding 35°C (**Figure 1**). Papaya crops are susceptible to fluctuations in air temperature and humidity; temperatures exceeding 32 °C lead to sexual reversal of hermaphrodite flowers. This hinders the development of ovaries and male flowers, compromising fruit production (Awada, 1958; Nakasone & Paul, 1998).

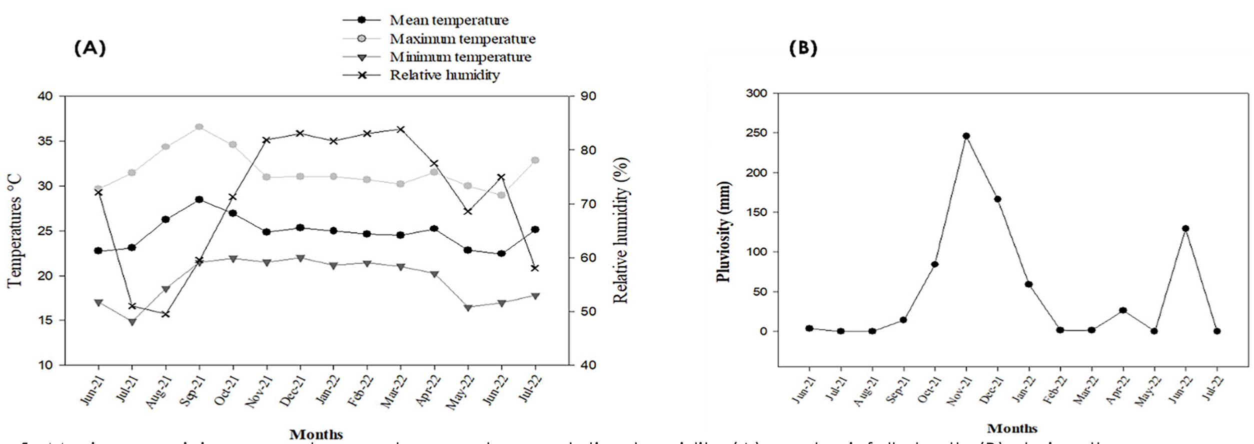


Figure 1. Maximum, minimum, and mean temperatures, relative humidity (A), and rainfall depth (B) during the papaya growing season, from June 2021 to July 2022, Tangará da Serra, MT, Brazil.

According to Zinn et al. (2010), a single hot day or cold night near the time of fertilization can make reproduction unsuccessful.

The relationship between yield and the number of fruits has a direct impact on the commercialization of papayas. Cultivars from the Solo group, such as Golden-THB, produce a large quantity of fruits per plant, which is well-suited for markets that demand substantial volumes, such as supermarkets. Cultivars from the Formosa group, such as UC12, produce fewer but larger fruits, which is well-suited for markets that prioritize larger, high-quality fruits, allowing for higher prices per unit. This dynamic affects profit margins, production costs, and market segmentation, enabling producers to align their production with market demands. (**Table1**)

Fruit weights were significantly different between Solo and Formosa papaya cultivars. The highest fruit weights for the Solo Group were found for the following cultivars: UC14 (839.0 g), UC16 (728.3 g), Aliança (720.6 g), and Golden-THB (697.5 g). Fruit weights for the Formosa group ranged from 816.8 (Calimosa) to 1909.8 g (Bela-Nova). These results indicate the economic potential of this fruit, as these fruits could easily meet the standards of the domestic and international markets, which are 800 to 1500 g (Formosa group) and 300 to 650g (Solo group). Dantas & Lima (2001) found mean fruit weights of 0.28 to 0.85 kg for accessions from the Solo group and 0.71 to 2.2 kg for the Formosa group.

Fruit lengths ranged from 15.5 to 20.4 cm for the Solo group, with UC16 exhibiting the longest fruits. Formosa cultivars showed means from 21.6 to 26.7 cm, with Bela-Nova exhibiting the longest fruits. Papayas from Formosa cultivars are intended for the domestic market, as those from Solo cultivars are preferred by international markets (Dias et al., 2011). The largest fruit diameters (13.0 and 10.1 cm) were found for Bela-Nova (Formosa group) and UC16 (Solo group) and.

Internal cavity diameter (ICD) of papayas from the Formosa group exhibited a narrow range: 4.7 to 6.3 cm. The smallest ICD was found for Rubi-Incaper-511. This descriptor is related to fruit quality, as those with smaller ICD internal generally have more pulp. The central cavity length is a significant trait that contributes to maintain the fruit intact during transportation (Dantas et al., 2015).

Fruit pulp thickness and ICD are correlated; pulp thickness increases as ICD decreases. Fruits with thicker pulps tend to have higher pulp yields, which is of significant economic interest. The evaluated papaya cultivars exhibited mean pulp thicknesses exceeding 2.0 cm. According to Yamanishi et al. (2006), pulps thicker than 2.0 cm are considered optimal for commercialization.

Considering fruit physicochemical characteristics, significant differences were found only for ascorbic acid, β-carotene, and phenolic acid contents (**Table 2**).

The mean ascorbic acid content for Solo cultivars was 52.4 mg AAE 100 g^{-1}, with Golden-THB and Golden yielding the highest means (Table 2). The cultivars showed vitamin C contents similar to those found for

Table 1. Analysis of variance and means of agronomic characteristics related to fruit yield and physical attributes of papaya fruits. Tangará da Serra, MT, Brazil, 2021/2022.

Solo Group							
Cultivar	FY	NF	FW	FL	FD	ICD	PT
Golden-THB	33,062.3a	150.0a	697.5a	15.5d	8.9b	4.5a	2.6a
Aliança	22,233.3b	96.7b	720.6a	17.6c	9.2b	4.1a	2.6a
Golden	13,370.8b	88.7b	499.9b	15.9d	8.7b	4.2a	2.4a
UC16	15,255.7b	68.2c	728.3a	20.4a	10.1a	4.8a	2.7a
UC14	12,141.7b	46.7c	839.0a	18.7b	9.6a	4.2a	2.5a
QMTrat	300720780.4*	5990.7*	60556.7*	16.2*	1.2*	0.3^{ns}	0.0^{ns}
Overall mean	19,212.7	90.1	697.0	17.6	9.3	4.4	2.61
CV %	28.7	19.7	16.0	5.6	5.7	10.7	6.9
Formosa Group							
Cultivar	FY	NF	FW	FL	FD	ICD	PT
UC12	27,418.4a[1]	90.5a	974.4c	22.2b	11.0b	5.3a	2.9b
Calimosa	20,710.0a	79.7a	816.8c	22.1b	10.5b	5.4a	2.5b
Tainung-1	21,460.2a	54.2b	1262.2b	25.2a	10.9b	5.2a	2.7b
Rubi-Incaper-511	16,936.5a	53.0b	990.9c	21.6b	10.2b	4.7a	2.5b
Bela-Nova	29,679.6a	49.5b	1909.8a	26.7a	13.0a	6.3b	4.3a
T2	17,064.5a	42.7b	1289.8b	26.0a	10.5b	4.9a	2.8b
QMTrat	112016435.7^{ns}	1435.4*	605495.0*	20.8*	3.98*	1.1*	1.7*
Overall mean	22,211.5	61.6	1207.2	24.0	11.0	5.3	2.9
CV %	31.26	28.5	12.34	6.6	6.81	9.7	23.8

* and ^{ns} = significant at 5% and not significant, respectively, by the F-test. Means followed by the same letter in the columns are not significantly different by the Scott Knott grouping test at a 5% significance level. FY = fruit yield; NF = number of fruits; FW = fruit weight (cm); FL = fruit length (cm); FD = fruit diameter (cm); ICD = internal cavity diameter (cm); and PT = pulp thickness (cm).

Table 2. Means of physicochemical characteristics of papaya fruits grown in Tangará da Serra, MT, Brazil, 2021/2022.

Solo Group						
Cultivar	SS	TA	SS/TA	AA	β-Carotene	TP
Golden-THB	14.1a[1]	0.1a	120.7ª	70.6a	1238.2b	23.8a
Aliança	13.3a	0.1a	113.6ª	43.3b	1080.8b	24.2a
Golden	14.6a	0.1a	117.1ª	66.1a	1827.6a	30.6a
UC16	14.1a	0.1a	103.1ª	36.1b	1350.2b	21.9a
UC14	14.3a	0.1a	115.8ª	45.7b	1210.8b	20.7a
QM	0.8^{ns}	0.0^{ns}	177.2^{ns}	912.6*	332073.9*	59.32^{ns}
Overall mean	14.1	0.1	114.1	52.4	1341.5	24.3
CV %	5.5	14.6	8.1	30.4	23.0	23.4
Formosa Group						
Cultivar	SS	TA	SS/TA	AA	β-Carotene	TP
UC12	13.8a	0.1a	125.4ª	53.0a	1299.9a	25.2a
Calimosa	14.1a	0.1a	126.3ª	59.4a	1497.0a	25.7a
Tainung-1	13.3a	0.1a	120.1ª	43.9a	1013.5b	23.9a
Rubi-Incaper-511	13.5a	0.1a	128.2ª	40.4a	890.5b	21.9a
Bela-Nova	12.7a	0.1a	107.6ª	39.5a	1597.9a	25.4a
T2	13.7a	0.1a	114.1ª	53.2a	1466.3a	27.0a
QM	0.9^{ns}	0.0^{ns}	260.1^{ns}	262.9^{ns}	323827.8*	12.4^{ns}
Overall mean	13.5	0.1	120.3	48.2	1294.2	24.8
CV %	5.1	8.9	10.3	30.4	26.1	22.2

* and ^{ns} = significant at 5% and not significant, respectively, by the F-test. Means followed by the same letter in the columns are not significantly different by the Scott Knott grouping test at a 5% significance level. SS = soluble solids (°Brix), TA = titratable acidity (g 100 g^{-1}), SS/TA= SS to TA ratio, AA = ascorbic acid (mg 100 g^{-1}), β-Carotene (µg 100 g^{-1}), TP = total phenolic contents (mg GAE 100 g^{-1}).

other papaya cultivars (Wall, 2006; Farina et al., 2020). Variations in vitamin C content among cultivars are attributed to their genotypes. This is also true for other physical, physicochemical, and biochemical attributes. The recommended dietary intake of vitamin C is 75 and 90 mg per day for women and men, respectively (Vannucchi et al., 2018). Thus, each 100 g of Golden-THB papaya provides up to 90% of the recommended daily intake.

β-carotene contents of cultivars significantly varied, ranging from 890.05µg 100 g^{-1} to 1827.6µg 100 g^{-1} between both groups (Table 2). Golden, Bela-Nova, Calimosa, T2, and UC12 cultivars exhibited the highest carotenoid contents. Carotenoids are important for human health and nutrition, and are known as potent antioxidants. Several in-vitro and in-vivo studies have shown that carotenoids can prevent cardiovascular diseases and influence cell signaling pathways while providing protection against certain types of cancer (Bufka et al., 2024).

Despite the absence of statistically significant difference ($p > 0.05$) in soluble solids content (SS), titratable acidity (TA), SS to TA ratio (SS/TA), and total phenolic content between both cultivar groups, these attributes are associated with fruit quality and often described as essential for the marketing of papayas. SS in papayas should exceed 12 °Brix for export (Dantas et al., 2015); the evaluated cultivars had SS, on average, higher than 12 °Brix.

According to the results of the sensory evaluation of papayas from the evaluated cultivars (**Figure 2**), the overall impression scores assigned by the evaluators ranged from 7.3 to 5.8. Tainung-1 was the only cultivar rated as "neither like nor dislike," while the others were rated as "like moderately". UC16 and Rubi-Incaper-511 were highly acceptable in terms of aroma and flavor due to their high SS (Table 2). Although there were no significant differences in TA, SS, or SS/TA among cultivars, these differences in fruit quality may be attributed to genetic factors.

The correlation between physicochemical parameters, such as TA and SS, affects the organoleptic properties of fruits (Scarano et al., 2020). The extant literature indicates that consumers tend to prefer sweeter papayas (Del Carmen et al., 2013; Sulistyaningrum, 2021).

Papayas from UC16 and most of Formosa cultivars, overall, were rated with a score 7.0 ("like moderately") for pulp texture. The reports of evaluators indicated that samples of firmer pulp fruits were the most acceptable. Therefore, fruit pulps from cultivars of Formosa cultivars and UC16 (Solo group) were notably firm, resulting in higher mean scores in the sensory evaluation.

Regarding purchase intention, UC16, Aliança, and Rubi-Incaper-511 stood out, suggesting that these cultivars are highly appreciated by consumers and that the papaya cultivars produced in the study region have satisfactory quality.

Correlation analysis should be interpreted from three perspectives: magnitude, direction, and significance. A positive correlation coefficient indicates

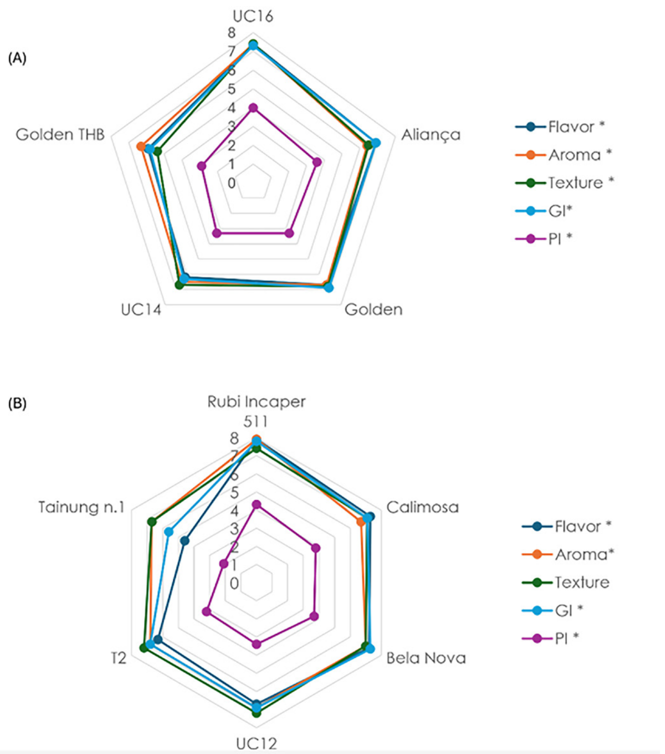
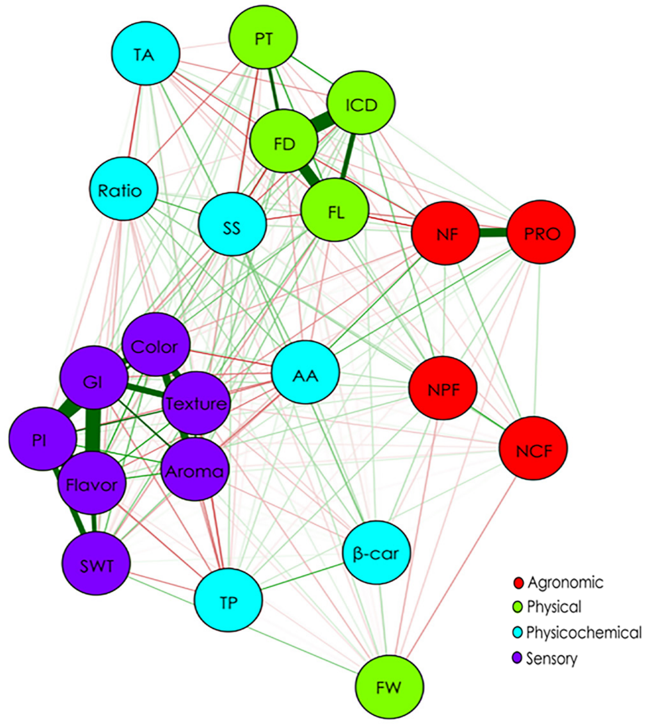


Figure 2. Sensory profile of papayas from 11 cultivars evaluated by a trained panel. (A) cultivars from the Solo group and (B) cultivars from the Formosa group. OI = overall impression; PI = purchase intention. * = significantly different among cultivars.



Red and green lines represent, respectively, negative and positive correlations; the thickness of the line is proportional to the magnitude of the correlation; highlighted lines have a correlation coefficient greater than 0.6 in absolute value.

FY = fruit yield; NF = number of fruits; NPF = number of pentandric fruits; NCF = number of carpelloid fruits; FW = fruit weight; FL = fruit length; FD = fruit diameter; PT = pulp thickness; ICD = internal cavity diameter; SS = soluble solids; TA = titratable acidity; Ratio = SS to Ta ratio; AA = ascorbic acid; β-Car = β-carotene; TP = total phenolic contents; SWT = sweetness; OI = overall impression; PI = purchase intention.

Figure 3. Correlation network analysis for agronomic, physical, physicochemical, and sensory variables of papaya fruits.

a tendency for one variable to increase as the other increases, whereas a negative correlation coefficient indicates a tendency for one variable to increase as the other decreases (Epskamp et al., 2012).

Small clusters can be visually discerned within the correlation network. The correlation between clusters was exclusively discernible within the respective analyzed sets (**Figure 3**). Moreover, fruit weight appeared somewhat isolated, exhibiting only a slight correlation with other properties within the network.

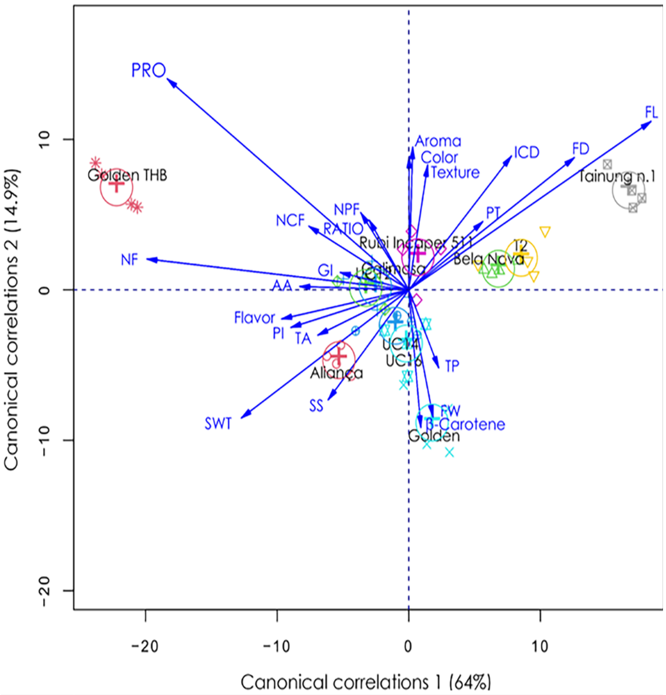
The correlation graph highlighted the interaction between the analyzed characteristics, showing a strong correlation between fruit yield and the number of fruits, which were relatively isolated from the other variables. Additionally, it evidenced a strong correlation among fruit length, fruit diameter, internal cavity diameter, and pulp thickness, forming a complex network of interrelationships.

Sensory attributes were interrelated, with a high positive correlation among INTC, SAB, and IMPG (0.93 and 0.88, respectively) (Figure 3). Correlation among OI, Flavor and PI, this correlation demonstrates that flavor is closely associated with the evaluators' sense of satisfaction, which is reflected by their overall impression of the samples. Consumers have demonstrated a preference for fruits with a more pleasant taste (Morzelle et al., 2012).

A negative correlation was found between TA and Ratio, with a magnitude of 0.51. According to Magwaza & Opara (2015), SS in fruits tend to increase, while TA tends to decrease during the ripening process. Consequently, Ratio is directly proportional to SS and inversely proportional to TA.

According to PCA (Principal Component Analysis), Golden-THB (Solo group) was the cultivar most strongly associated with production aspects (**Figure 4**). Therefore, it is in PC2+, accounting for 14.9%, and production attributes contributed the most to PC2. However, this cultivar has smaller fruit compared to the Formosa cultivars, mainly Tainung-1, T2, and Bela-Nova, which exhibited the most favorable physical fruit characteristics and, therefore, were grouped in PC1+, accounting for 64% of the data.

These differences can be attributed to the distinct heterotic groups to which the cultivars belong, as they exhibit different fruit patterns. Formosa-group cultivars stand out for their larger fruit size, whereas Golden-THB belongs to another group (Solo), characterized by smaller fruits. Production characteristics are the most valued by growers because they represent the potential for higher profit and the ability to consistently meet market



Yield-related variables: fruit yield (FY); number of fruits (NF); number of pentandric fruits (NPF); number of carpelloid fruits (NCF). Physical variables: fruit weight (FW); fruit length (FL); fruit diameter (FD); pulp thickness (PT); and internal cavity diameter (ICD). Physicochemical variables: soluble solids (SS); titratable acidity (TA), SS to TA ratio (RATIO), ascorbic acid (AA); β-carotene, and total phenolic content (TP). Sensory variables: taste, aroma, color, texture, sweetness (SWT), purchase intention (PI), and overall impression (OI)

Figure 4. Two-dimensional projection of the score for fruit characteristics of papaya cultivars (Golden, Golden-THB, Aliança, UC16, UC14, Bela-Nova, T2, Calimosa, Rubi-Incaper-511, UC12 and Tainung-1).

demands. Nevertheless, physical characteristics also directly affect fruit pricing.

Fruits from Rubi-Incaper-511 were preferred by evaluators. However, this cultivar was not grouped with the other Formosa cultivars, as it produces fruits with smaller lengths and diameters (Table 1). The highest contents of biochemical compounds were found for the Golden cultivar, which was therefore grouped in PC1+.

The findings of the present study have significant practical implications for papaya production in the state of Mato Grosso, Brazil. The data were similar to those found for fruits produced in other regions of the country, indicating that the production potential of the evaluated cultivars is robust and competitive. Nevertheless, further studies should investigate the implications of the region's climate conditions and their impact on crop performance, focusing on the effects of high temperatures on fruit yield. Based on the results, selecting suitable cultivars can optimize production and increase the competitiveness for papaya crops in Mato Grosso.

Conclusion

This comparative study of papaya cultivars from the Solo and Formosa groups grown in Tangará da Serra, Mato Grosso, Brazil, revealed that Golden-THB, Bela-Nova, and UC12 are promising cultivars in terms of fruit yield and quality. Golden-THB (Solo group) exhibited high fruit yield and vitamin C content in the pulp. Bela-Nova (Formosa group) produced larger, heavier fruits rich in β-carotene. These cultivars are viable options for growers in the state seeking to compete in the market, as they combine high fruit production with desirable consumer characteristics while contributing to the strengthening of regional agricultural production.

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