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Variability of Sensory Acceptance and Flavors of the Inflorescence Sap Deriving from Four Widespread Cultivars of Coconut (*Cocos nucifera* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author KNY designed the study, wrote the protocol, fitted the data performed the statistical analysis and wrote the first draft and the revision of the manuscript. Author ARR managed the literature and assisted author KNY for experiments implementation. Author KKJL valued the study design and supervised the data collection. Author BGHM expertized the results interpretations. All authors read and approved the submitted manuscript.

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ABSTRACT

Aims: The study focuses on the sensory properties of the coconut inflorescence sap for promoting its consumption by populations.
Study Design: Four widespread coconut cultivars sampled, namely Malaysian Yellow Dwarf (MYD), West African Tall (WAT), and the improved hybrids MYD x WAT (PB121$^+$) and Cameroon Red Dwarf x Rennel Island Tall (PB113$^+$). Sap collected from young unopened inflorescences. Acceptance and descriptive sensory flavors variability of the sap samples assessed using 75 and 15

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panelist tasters, respectively.
Place and Duration of Study: Marc Delorme Research Station for Coconut (MDRSC), from the National Centre of Agronomic Research, Abidjan, Côte d'Ivoire, between November 2014 and March 2015.
Methodology: Six healthy adult coconut trees (over nine years of age) randomly selected from experimental plots of the MDRSC. Unopened inflorescences (of rank 8) selected per palm to produce the coconut sap. Coconut sap harvested twice a day and sap volumes gathered per cultivar and kept fresh into a freezer till the sensory assessment. The analyzes targeted the acceptance of the coconut sap samples from the consumers, then the estimation of the sweet, salty and sour sap flavors degrees using a 7 points rating scale. Data were collected through written rating after tasting trials achieved according to standard directives at the Technology Laboratory of the MDRSC, using 75 tasters for the hedonic characterization and 15 tasters for the sensory profile.
Results: The tasting panelists enjoyed the coconut saps resulting from the 4 overall cultivars, but in various proportions ranging from 67.86% (WAT) to 92.86% (PB113$^+$). The samples from WAT and PB113$^+$ are more accepted, with full enjoyment mentioned by 48% and 62% panelists, respectively. The sweet flavor is felt with degrees ranging between 5.67/7 (PB113$^+$) and 6.39/7 (MYD). The salty and sour flavors are felt with lower indexes oscillating between means of 2.03 and 3.21 from the 7 points rating scale.
Conclusion: The MYD cultivar produces most sweetened sap whereas that of PB113$^+$ hybrid is more appreciated for consumption. Both WAT and PB113$^+$ cultivars could be promoted in coconut sap production for fresh drink. Besides, the sweeter sap of MYD and PB121$^+$ could be processed into other coconut by-products such as vinegar, alcohol, syrup or coconut sugar.

Keywords: Coconut sap; cultivars; hedonic acceptance; flavors descriptive profile.

ABBREVIATIONS

MDRSC :Marc Delorme research station for coconut
MYD :Malayan Yellow Dwarf coconut
WAT :West African Tall coconut
PB121$^+$:Improved coconut hybrid resulting from crossing MYD x selected WAT
PB113$^+$:Improved coconut hybrid resulting from crossing Cameroon Red Dwarf coconut (CRD) x selected Rennel Island Tall coconut (RIT)

1. INTRODUCTION

Cocos nucifera L. is a plant species belonging to the systematic family of *Palmaceae*. Commonly known as coconut, this culture is found in the inter-tropical and humid countries, from Asia, Latin America and Sub-Saharan Africa, accounting 12 million hectares of total acreage [1]. In Côte d'Ivoire, the coconut is spilled in the coastal region [2]. Since long, its usefulness has been about the fruits production for consumption as refreshing drink and the oil extraction for food, cosmetic and pharmaceutical uses. Supported by the research outcomes, these valorizations increased the coconut production in Côte d'Ivoire, reaching a mean yield of 65, 000 tons (T) copra/year, with a peak volume of 90, 000 T in 1994, from 50, 000 hectares (ha) of cultivated acreage [3,4]. However, the competition with other oil crops (soya, palm oil, etc.) impeded the coconut culture by inducing crashes in the prices of the coconut products from the smallholder farmers. Indeed, the mature fruits are sold between 10 and 25 CFA Francs (0.015 to 0.038 euros) while the kilogram of copra is bought from farmers below 200 CFA Francs (0.305 euros). Besides, the coconut plants are under the threat of many diseases, such as the Lethal Yellowing, generally caused by ants. The farms also face hard lacks of rainfall. Consequently, many householders neglect or abandon their coconut lands or even change them with the current more profitable plants such as rubber plants or cassava to insure significant livelihoods.

Yet, facing the same concerns, the largest coconut areas countries (Indonesia, India, Philippines) targeted the effective diversification in the plant's valorizations since the overall parts of the coconut tree are usable [5]. Among these valorizations, the sap production using the unopened inflorescences remains the most important value added product that has sought the attention of all the stakeholders in the coconut path, because the coconut sap can be processed into other by-products as alcohol, vinegar, grain sugar and syrup [6].

The coconut sap belongs to the palms saps largely consumed by the populations as refreshing or alcoholic drink. These drinks record traditional local names of *"toddy"* in Asia, *"mimbo"* in Cameroon, *"nsafufuo"* in Ghana, *"emu"* in Nigeria [7] or *"bandji"* in Côte d'Ivoire and Guinea [8]. The palm sap is usually consumed by more than 10 million people in Western Africa [9], providing significant incomes for many farming or urban populations [10,11,12]. The sugar and syrup processed from the raw coconut sap are also low glycemic index dietary foods [13]. These are value-added products and their trading insures substantial incomes. Thus, the production and the processing of the coconut sap record a great boom in the Southeastern Asia and Latin American countries. Oppositely, in the African countries, especially in Côte d'Ivoire where the production of palm wine is otherwise traditionally known, the exploration of the coconut sap remains scarcely inexistent.

Nevertheless, some trials regarding the coconut sap production have been achieved at research station from the most widespread coconut cultivars of Côte d'Ivoire. The outcomes showed higher sap yields from the Dwarf x Tall hybrids coconuts than the Tall and the Dwarf individuals [14]. Considering chemical analyses, the sap produced from Dwarf coconuts seemed richer in carbohydrates, the main macromolecules of the sap's dry matter [15]. However, any research attempt has been implemented regarding the sensory characteristics of the coconut sap. Yet, the biochemical and nutritive importances of foods do not necessarily rely on great acceptance in consumers habits. The current investigation is performed to reveal the gustatory traits of the fresh sap produced from the four most widespread coconut cultivars of Côte d'Ivoire (MYD, WAT, PB121$^+$, and PB113$^+$) for resulting in their suitable uses.

2. METHODOLOGY

2.1 Sampling

Per cultivar, six healthy adult coconut trees (beyond 10 years of age) were randomly selected from the experimental plots of the Marc Delorme Research Station for Coconut (MDRSC). Then, the unopened inflorescences (or spathes) of rank 8 upon the leaves crown of each palm tree allowed the production of the coconut sap [14,16]. The sap was harvested twice the day (at 07 AM and 05 PM) and the overall sap volumes collected were gathered per coconut cultivar in plastic cans and kept fresh into a freezer at a temperature of –20℃ till the sensory analyzes. Thus, four main coconut sap samples were worked in this investigation.

The sensory analysis consisted in implementation of hedonic and descriptive tasting trials of the coconut saps. The hedonic analysis targeted the assessment of the acceptability of the coconut sap samples by the consumers, whereas the goal of the descriptive analysis was to draw the sensory profile of the coconut sap on flavors parameters basis. The data were collected through informations gathered from tasters on written questionnaires, according to standard suitable directives. The tasting essays were achieved in the Laboratory of Technology of the MDRSC using human persons in various individuals groups (panelists).

2.2 Designing of the Sensory Profile of the Coconut Saps

The sensory profile of the coconut sap samples was performed according to 3 flavor descriptors, specifically the sweet flavor (SweFla), the salty flavor (SalFla), and the sour (or acid) flavor (AciFla). Discerning the feeling degree of the sap flavors required panelists trained in the recognition of the four basic flavors (sour, bitter, salty and sweet) and their depth, using AFNOR process [17].

2.2.1 Casting for panelists selection

For selecting quite flavor tasting panelists, training sessions were achieved. For this purpose, some flavors control solutions were previously prepared (Table 1). The controls consisted of monohydrate citric acid, quinine sulfate, sodium chloride and sucrose for respective sour, bitter, salty, and sweet flavors. Solutions were prepared with mineral water, and then the D5 concentration (Table 1) above the standard sensitive detection point was presented to panelists for tasting.

The casting sessions for tasters were achieved in an intended place at the MDRSC according to standards related to sensory analysis, stimulation of flavors sensitivity, and general directives for selecting, training and supervising qualified tasters [17]. The panelists were then trained in discerning various concentrations from 3 selected standard flavors, namely sour, salty, and sweet.

Table 1. Preparation of 1 L of control solutions for sour, bitter, salty, and sweet flavors

Dilution codes	Preparations (mL)		Concentration of control substances ($g.L^{-1}$)			
	RSV	WV	Citric acid (RS: 1 $g.L^{-1}$)	Quinine sulfate (RS: 0.3 $g.L^{-1}$)	Sodium chloride (RS : 6 $g.L^{-1}$)	Sucrose (RS: 32 $g.L^{-1}$)
D1	15	985	0.015	0.0045	0.09	0.48
D2	30	970	0.03	0.009	0.18	0.96
D3	60	940	0.06	0.018	0.36	1.92
D4	125	875	0.125	0.0375	0.75	4
D5	**250**	**750**	**0.250**	**0.075**	**1.50**	**8**
D6	500	500	0.5	0.15	3	16

RSV, volume of raw solution; WV, volume of water used; RS, raw solution concentration; Monohydrate citric acid, quinine sulfate, sodium chloride and sucrose are control solutions for respective sour (acid), bitter, salty, and sweet flavors. The bold line (D5) was considered for the standard flavors sensory trials

The casting resulted in the selection of 15 panelists with efficient fitting of the flavors analysis.

Thereafter, the sap samples were tasted against various concentrations (Table 2) of the selected control flavors of which maximal degrees were considered at their maximum contents recorded from physicochemical parameters assessed therefore [15,17].

2.2.2 Assessment of physicochemical parameters related to the flavors investigated

The physicochemical evaluation consisted in the determination of the acidity (pH and total titratable acidity), the total ash content (TAC), and the total carbohydrates content (TCC).

The pH was measured in the coconut saps using a pH-meter and the TTA was measured by acid-base titration of the sap samples using a 0.1 N sodium hydroxide solution [18]. The total carbohydrates content was determined with phenol and sulfuric acid method [19]. For the TAC, the analysis required an incineration of the coconut sap sample at 550℃ for 8 hours into an oven [20].

2.2.3 Tasting sessions for the description of the coconut saps flavors

For the evaluation of the coconut saps flavors, 100 mL of each sap sample were filled to each panelist in anonymous glasses (with codes A, B, C, and D), and presented in various orders. The control solutions were also filled into glasses and presented in rising concentrations of flavors, from 1 (''no obvious flavor'') to 7 (''the highest flavor concentration''). The panelists were invited to taste the sap samples against the control solutions of each flavor, and then to fit the rating scale by scoring the flavor's felt degree corresponding to one of the control concentrations. So, the tasters had to score ''1'' when the flavor is not felt, to ''7'' when it's extremely felt, as shown in Table 2.

2.3 Hedonic Characterization of the Coconut Saps

The hedonic tasting essays were achieved with a total of 75 panelists. The tasters were volunteer persons without any qualification requested. For each subject, 100 mL of each coconut sap sample were filled in various orders with anonymous coded glasses (A, B, C, and D). Thus, he had to taste the coconut sap, by putting about 30 mL of each sample into mouth, and then to translate his acceptance degree (agreement or disagreement) by writing out a numerical score within a 3 points rating scale [17]. Thus, the score ''1'' indicated the disagreement of the panelist; ''2'' showed its acceptance without real appreciation, and ''3'' revealed his agreement with full enjoyment from the tasted sap sample.

2.4 Statistical Analysis

The data were statistically treated with Statistical Program for Social Sciences software (SPSS 20.0 for windows, SPSS Inc.) at 5% significance level. For the sensory profile, the data were submitted to a one-way analysis of variance (ANOVA) with Newman Keuls test for means comparison. Then multivariate analysis consisting in principal components analysis (PCA) and hierarchical ascending clustering (HAC) was performed to highlight correlations between the sensory characteristics and the coconut sap samples. About the hedonic

Table 2. Control solutions concentrations for the tasting sessions of the coconut In florescence saps

Rating scale of the concentrations	Concentrations of coconut sap flavors controls (g/100 mL)		
	Sour flavour $^{\alpha}$	Salty flavour $^{\beta}$	Sweet flavour $^{\lambda}$
1 (No flavor felt)	0	0	0
2	0.066	0.055	2.805
3	0.133	0.11	5.61
4	0.198	0.165	8.415
5	0.266	0.22	11.22
6	0.332	0.275	14.026
7 (Flavor extremely felt)	0.38	0.33	16.83

$^{\alpha}$ Sour flavor control: monohydrate citric acid; $^{\beta}$ Salty flavor control: Sodium chloride; $^{\lambda}$ Sweet flavor control: Sucrose. TTA, Total titratable acidity; TAC, Total ash content; TCC, Total carbohydrate content

characterization, an Xhi^2 non parametric test comparing proportions was achieved against theoretic distribution of 33.33%-33.33%-33.33%.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Traits Related to the Flavors of the Coconut Saps

Regarding the acidity of the coconut saps, the samples showed pH mean values fluctuating between 6.97 and 7.32 while the means of the total titratable acidity ranged from 0.26 g/100 g to 0.31 g/100 g. The MYD coconut sap is with lower acid value than the three other coconuts studied. For the total carbohydrates, the MYD is also more provided (16.08 g/100 mL), whereas the saps of WAT, $PB121^+$ and $PB113^+$ recorded contents between 14.14 and 15.10 g/100 mL. The ashes were more concentrated in the saps deriving with $PB113^+$ (0.29 g/100 g) and also MYD (0.26 g/100 g), as shown in Table 3.

On the values recorded basis, the total titratable acidity and the total carbohydrates and the ashes contents display respective maximum amounts of 0.38 g/100 g, 16.83 g/100 mL, and 0.33 g/100 g (Table 3).

3.2 Sensory Profile

Whatever the coconut sap flavor, the feeling degrees are statistically different (P<.05) from the four cultivars, with means varying between 2.03 and 6.21 on the 7 points rating scale.

The sweet flavor is felt between 5.33/7 and 6.21/7 in the coconut sap samples. It's statistically more intensive in the samples of MYD (6.21/7) compared to WAT, $PB121^+$ and $PB113^+$ (5.67 to 5.91/7), as mentioned in Fig. 1.

The salty and acid (or sour) flavors are felt in respective degrees between 2.42/7 and 3.21/7 and between 2.03/7 and 2.45/7. The sap samples from WAT are found more salty than that of the $PB113^+$. But both sap samples do not show any obvious salty flavor difference with the MYD and $PB121^+$. From the acid flavor, the feeling degrees fluctuate from 2.03 and 2.45 without any significant divergence between the coconut cultivars (Fig. 1).

Table 3. Amounts of the physicochemical parameters in the inflorescence saps of Malayan Yellow Dwarf, West African Tall, $PB121^+$, and $PB113^+$ coconut cultivars

Parameters	Means (±standard deviation) per cultivar				F	P	Maximum value
	MYD	WAT	PB 121$^+$	PB 113$^+$			
pH	7.32±0.17^a	7.18±0.22^b	7.10 ± 0.2^b	6.97±0.15^c	16.26	<0.001	7.49
TTA (g acid eq/100g)	0.26±0.04^b	0.30±0.08^a	0.31±0.06^a	0.31±0.05^a	6.62	0.001	0.38
TCC (g/100 mL)	16.08±0.75^a	14.23±0.76^b	14.14±1.1^b	14.54±1.14^b	15.10	<0.001	16.83
TCE (g/100 g)	0.26±0.01^b	0.23±0.04^c	0.23±0.02^c	0.29±0.04^a	30.73	<0.001	0.33

pH, Potential of hydrogen; TTA, Total titratable acidity; TCC, Total carbohydrates content; TAC, Total ash content

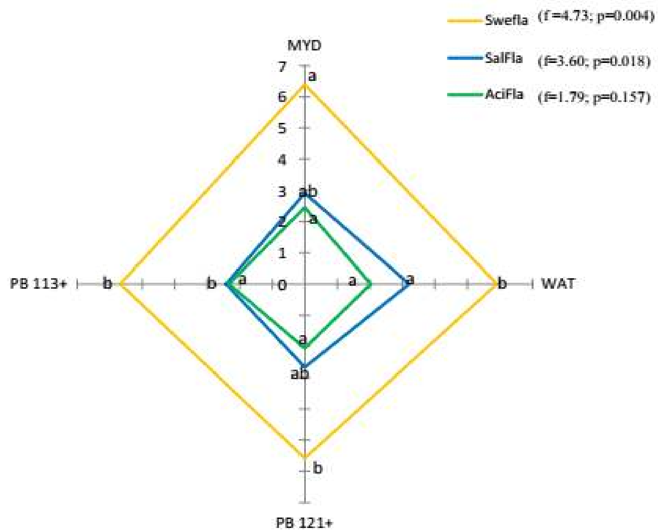

Fig 1. Radar chart of the sweet flavor *(SweFla)*, salty flavor *(SalFla)*, and sour or acid flavor *(AciFla)* felt in the inflorescence sap deriving from Malayan Yellow Dwarf (MYD), West African Tall (WAT), PB121$^+$, and PB113$^+$ coconut cultivars

Per flavor, the same lowerscripts are statistically identical at 5% significance.
F, Statistical Ficher value of the ANOVA; P, Statistical Probability value of the ANOVA

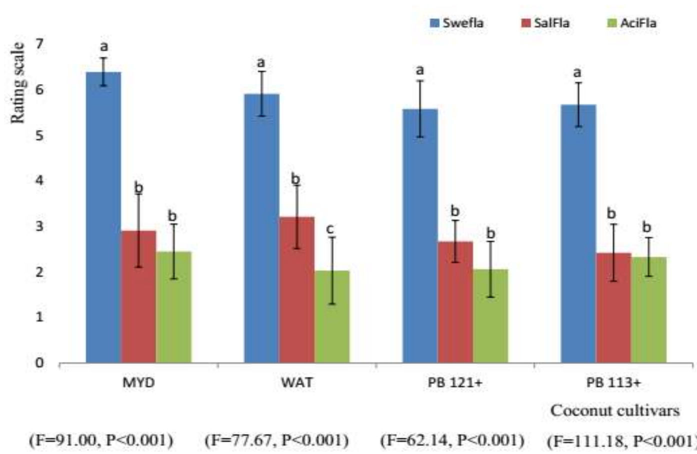

Fig 2. Diagram of rating scale comparing the sweet flavor *(SweFla)*, the salty flavor *(SalFla)*, and the acid flavor *(AciFla)* felt in the inflorescence sap of each coconut cultivar studied

Considering each coconut sap, the sweet flavor (5.58/7 to 6.39/7) is significantly more felt (P<.001) than the salty flavor (2.42/7 to 3.21/7) and the sour flavor (2.03/7 to 2.45/7). Both salty and sour flavors are felt in similar degrees from MYD, PB121$^+$, and PB113$^+$ cultivars with respective value of 2.91/7 and 2.45/7, 2.67/7 and 2.06/7, and 2.42/7 and 2.33/7. But from the WAT, the salty flavor (3.21/7) is more felt compared to the sour flavor (2.03/7) as shown in Fig. 2.

3.3 Variability of the Coconut Saps' Sensory and Related Traits

From the Principal Components Analysis (PCA), the sensory related parameters of the coconut saps (sweet flavor, salty flavor, acid flavor, pH, total titratable acidity, and total carbohydrates and total ashes contents) are correlated to 2 principal components (F1 and F2 factors) having respective eigenvalues of 4.17 and 2.52, and supporting 95.5% of the total variance (Table 4).

Thus, the F1-F2 factorial draw of the PCA correlates the sap sample of the MYD to the pH and the total carbohydrates values, and then to the sour flavor and specifically the sweet flavor, whereas the WAT records more salty flavor among overall samples, as strengthened by the dendrogramme built from the Hierarchical Ascending Clustering. The hybrids coconuts show the highest ash value (PB113$^+$) and total titratable acidity (PB121$^+$) but do not highlight any deeper sensory flavor value compared to WAT and MYD (Fig. 3).

Table 4. Eigen values and correlation matrix resulting from the principal components analysis of the sensory parameters of the coconut inflorescences sap

Components (or factors)	**F1**	**F2**	**F3**
Eigenvalues	4.17	2.52	0.31
Variance (%)	59.54	35.96	4.49
Cumulative variance (%)	59.54	95.51	100.00
pH	0.78	-0.62	0.10
TTA	-0.96	-0.10	-0.26
TCC	0.99	0.13	0.04
TCE	0.25	0.92	-0.31
SweFla	0.95	-0.25	-0.18
SalFla	0.23	-0.92	-0.33
AciFla	0.79	0.61	-0.06

From parameters assessed, bold values reveal significant correlation of the flavor with the factor

3.4 Hedonic Characteristics

The coconut saps are generally accepted by consumers, with agreements ranging from 67.86% to 92.86% panelists. Otherwise, the three scores (1, 2 or 3) for the saps samples acceptance recorded statistically different proportions varying between 7.14% to 61.90% panelists from the overall coconut cultivars.

The sap samples deriving from WAT and PB113$^+$ hybrid generate significantly different acceptance degrees ($P < 0.05$) whereas the samples provided from MYD and PB121$^+$ hybrid record similar ($P > 0.05$) sizes for the 3 acceptance levels (Table 5).

A percentage of 85.72% panelists accept the sap produced from WAT, with 47.62% for full enjoyment and a lower rate (14.29%) of displeasure. From the PB113$^+$ hybrid, the sap is agreed by 93% investigated persons. It enjoys the majority of the subjects (61.90%), whereas 30.91% tasters give mean acceptance, and a lower rate of them (7.14%) rejects it. Regarding the PB121$^+$ hybrid and its gene parental MYD, the 3 acceptance degrees of the coconut sap record statistically similar panelists proportions ($P > 0.05$), ranged between 29.76% and 32.14% and between 29.76% and 35.71% panelists, respectively (Table 3).

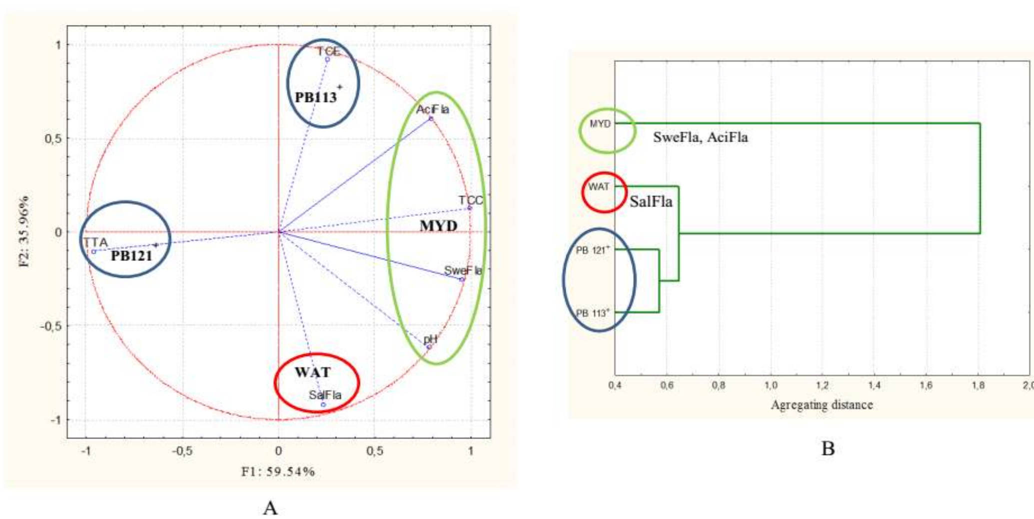

Fig 3. Correlations between the studied coconut sap samples and their sensory and related physicochemical parameters in the F1-F2 factorial draw of the PCA (A) and clustering dendrogramme of the coconut sap samples (B)

Swe Fla, sweet flavor; Sou Fla, sour flavor; Sal Fla, salty flavor

Table 5. Acceptance scores of the coconut inflorescence saps tasted by panelists

Acceptance levels		Percentages of acceptance degrees (%)			x^2	P
		1	2	3		
Theoretical distribution		33.33	33.33	33.33		
Coconut cultivars	MYD	29.76	34.52	35.71	0.5	0.78
	WAT	14.29	38.1	47.62	14.86	**0.001**
	PB121$^+$	32.14	38.1	29.76	0.93	0.63
	PB113$^+$	7.14	30.95	61.9	38	**<0.001**

x^2, value of the chi square non parametric test; P, Probability value of the statistical test
1, do not accept; 2, accepts without obvious enjoyment; 3, enjoys
For bold P-values, recorded data and theoretical distribution are statistically different

3.5 Discussion

From the PB121$^+$ hybrid and its gene parental MYD, the sap was enjoyed, fairly accepted and rejected by similar percentage of consumers. Yet, the MYD recorded the greatest sweet flavor. Therefore, the sweetness of the coconut sap could not be a sufficient parameter for its appreciation. Other rheological traits, such as the viscosity, could rely in significant contribution for the sensory appreciation. Indeed, according to some panelists, the sap samples from PB121$^+$ and MYD cultivars are with a relative viscosity that impedes their pleasance.

Oppositely, the saps produced from PB113$^+$ and WAT cultivars are more fluid and therefore pleasant for drinking, as expressed by the major acceptance percentage (>85%) from panelists. Thanks to this aspect, the saps produced from both cultivars are very desired by the consumers, with a full enjoyment of 47.62% and 62% people investigated for respective WAT and PB113$^+$ samples.

Otherwise, the saps provided by WAT and PB121$^+$ hybrid contain total polyphenols amount superior to that of the MYD [21]. Still, according to Lugasi et al. [22], the polyphenols compounds such as tannins are involved in the flavor quality, specifically the astringency of many plant foods. Thus, the sap of the WAT and PB113$^+$ could present a relative astringency that would have improved their taste.

The coconut sap is really with sweet flavor than the sourness and saltiness. This characteristic is an important sensory appreciation trait for the fruits juices as the coconut water, the orange juice, the apple juice, etc. In fact, many consumers often desire the sweet flavor since it could result in a delicious taste. In our study, the sweetness of the control solutions was prepared referring to the total carbohydrates contents evidenced from laboratory analyses. By this way, the highest sweet degree felt corresponded to the maximal total carbohydrates contents of the coconut saps. Thus, the sweet flavor is discerned with a score closely to the total carbohydrates contents of the studied sap samples. Therefore, the tasting panels could be efficient means for the assessment of the carbohydrates amounts in the coconut saps as forecasted by Assa et al. [23] for the coconut water.

The sucrose was the reference sugar for the tasting trials. According to Konan et al. [15], the sap deriving from MYD is richer in sucrose than that provided by the three other cultivars investigated. So, it seems logical that the sweet flavor is more felt in the sap of dwarf coconut (as the MYD) than from the WAT, PB121$^+$ and PB113$^+$ cultivars.

On the other hand, the salty flavor and sour flavor were detected with scores reflecting lower concentrations of total titratable acidity and ash, respectively, than the maximal values of both characteristics in the coconut saps. Such an observance suggests that the minerals (which are the major ash components) and also the acid molecules of the coconut sap could have been not deeply discerned by panelists. Indeed, the sensory traits are not always correlated to the physicochemical parameters, as reported by Vickers [24] after assessment of correlations between the sensory parameters of cookies and experimental measures of their crispness. Thus, a considerable part of the minerals could be trapped by molecules in the intrinsic structure of the coconut sap, so that they would not be soundly felt by the human's tongue. Regarding the acid flavor, it's supported by acid molecules that are known to be representative in the volatile organic components of the coconut sap. However, all of the acid components would not account for the coconut sap's aroma because the aroma highly results from esters [25]. This could explain the similar appreciation degrees of the sour flavor from the four cultivars, although they generated various titratable acidity values.

The sensory outcomes resulting from this assessment therefore strengthen the specific valorization of the coconut sap produced from each of the widespread coconut cultivars.

4. CONCLUSION

This tasting study was achieved to assess the sensory parameters of the coconut sap. The coconut sap records sweeter flavor than the sour flavor and the salty flavor. Among the investigated coconuts, the $PB113^+$ hybrid and the WAT which inflorescences saps are more appreciated by the consumers could be used in sap production for fresh drink. The sap produced from MYD and $PB121^+$ could be processed into coconut by-products as vinegar, alcohol, syrup, or coconut sugar in order to fit quite value addition valorizing this culture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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