

Original Research Paper

Sensory acceptance and flavors variability of the inflorescence sap deriving from four widespread cultivars of coconut (*Cocos nucifera* L.)

ABSTRACT

Aims: The study aimed to assess the sensory properties of the coconut inflorescence sap for promoting its consumption from 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 unopened inflorescences. Acceptance and descriptive sensory flavor variability of the sap samples probed using 75 and 15 tasters, respectively.

Place and Duration of Study: Marc Delorme Research Station for Coconut (MDRSC), CNRA, Abidjan, Côte d'Ivoire, between November 2014 and March 2015.

Methodology: Six healthy adult coconut trees (more than 9 years of age) randomly selected from experimental plots of the MDRSC. Unopened inflorescences (of rank 8) chosen per palm for the production of the coconut sap. Coconut sap harvested twice a day and sap volumes gathered per cultivar for the sensory analyzes targeting the acceptance of the coconut sap samples from the consumers, and the estimation of feeling degrees for sweet, salty and sour flavors using a 7 points rating scale. Data were collected through written rating resulting from tasting trials 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 enjoy the coconut saps provided by the 4 cultivars, but in various proportions ranging from 67.86% (WAT) to 92.86% (PB113⁺). The samples from WAT and PB113⁺ are more accepted, with 48% and 62% of full enjoyment recorded, respectively. The sweet flavor is felt with degrees varying from 5.67/7 (PB113⁺) to 6.39/7 (MYD). The salty and sour flavors are discerned with lower indexes oscillating between 2.03/7 and 3.21/7.

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 drink. Besides, the sweetened sap providing from MYD and PB121⁺ could undergo technologies for coconut sugar or syrup production.

Keywords: Coconut sap, cultivars, hedonic acceptance, flavors descriptive profile

1. INTRODUCTION

The coconut (*Cocos nucifera* L.) culture is spilled in the coastal region of Côte d'Ivoire [1]. For long time, its usefulness was with the nuts production for the consumption as refreshing drink, or the extracting of oil for food, cosmetic and pharmaceutical uses. Supported by the research outcomes, these exploitations boosted the coconut production in Côte d'Ivoire which reached a mean yield of 65, 000 T copra/year with a peak volume of 90, 000 T in 1994, from 50, 000 ha of cultivated area [2, 3]. However, the competition with other oil crops (soya, palm oil, etc.) induced a crash in the coconut products prices from the smallholder farmers. The mature nuts are sold between 10 and 20 FCFA while the kilogram of copra is bought less than 120 FCFA. Besides, the coconuts are under the threat of many diseases, such as the Lethal Yellowing, generally caused by ants, and face the recurrent lacks of raining. Thus, many householders neglect their coconut lands or even replant them with the current more profitable plants such as hevea.

Yet, faced to the same stakes, the largest coconut areas countries (Indonesia, India, Philippines) targets on the diversification of the plant's valorizations because all its parts are usable [4]. Among the valorizations, the sap produced from unopened inflorescences remains the most important value added product that has sought the attention of all the stakeholders in coconut [5].

The sap is directly consumed by the populations as refreshing or alcoholic drink ("toddy" or "bandji"). It's also a raw material allowing production of coconut sugar or syrup, low glycemic index dietary foods [6] whose trading insures substantial incomes to the farmers. Thus, the production and the processing of the coconut sap records a great boom in the Southeastern Asian 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.

Trials of coconut sap production achieved in research station with the most widespread cultivars of Côte d'Ivoire showed higher yields from the Dwarf x Tall hybrids than the Tall and the Dwarf individuals [7]. Also, the sap derived from Dwarf coconuts is richer in carbohydrates, the main macromolecules of its dry matter [8]. However, the sensory characteristics of the coconut sap are still unknown. Yet, the biochemical and nutritive importances of foods do not necessarily rely on great acceptance in consumers habits. The current communication reveals the gustatory traits of the coconut sap produced from the four most widespread cultivars in Côte d'Ivoire (MYD, WAT, PB121⁺, and PB113⁺) for their suitable uses.

2. METHODOLOGY

2.1 Sampling

Per cultivar, six healthy adult coconut trees were randomly selected from experimental plots of the Marc Delorme Research Station for Coconut (MDRSC). Then, the unopened inflorescences (called spathes) of rank 8 of each palm allowed the production of the coconut sap. The sap was harvested twice a day (at 07 AM and 05 PM) and the volumes collected were gathered by cultivar in plastic cans and stored at - 20°C till the sensory analyzes. Thus, four samples of coconut sap were tasted in this investigation.

The sensory analysis consisted in implementation of hedonic and descriptive trials of the coconut saps. The hedonic tests target the assessment of the acceptability of the coconut sap samples from the consumers when the goal of the descriptive analysis is to draw their sensory profile. Data were collected through informations gathered from human subjects on written questionnaires, according to standard suitable directives. The tests were achieved in the Technology Laboratory at MDRSC, with groups of 75 tasters for the hedonic characterization and 15 tasters for the sensory profile.

2.2 Hedonic characterization

The hedonic tests were achieved with a panel of 75 usual volunteer persons. For each subject, the operation consisted in tasting slight quantities (about 30 mL) of sap samples distributed in glasses. Afterwards, he had to express his gustatory acceptance by writing out a numerical score within a 3 points rating scale [9]. Thus, the score 1 indicates the displeasure of the panelist; 2 shows its acceptance without real appreciation and 3 reveals the full enjoyment of the panelist for the tasted sap sample.

2.3 Sensory profile drawing

The sensory profile of the sap samples was performed according to 3 flavor descriptors, specifically sweet, salty, and sour flavors. The discerning of the perception degree from 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 (10) and flavor control solutions prepared beforehand (table 1). The controls consisted in 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 2) above the standard sensitive detection point was presented to panelists for tasting. Tasting trials were drawn in an intended place at the MDRSC. Thus, a 15 panelists group with efficient fitting of the flavors was constituted after casting trials, according to standards related to sensory analysis, stimulation of flavors sensitivity, and general directives for selecting, training and supervising qualified tasters [10].

The resulted panelists were then trained in discerning various concentrations from 3 selected standard flavors, namely sour, salty, and sweet. Thereafter, the sap samples were tasted against concentrations (table 1) of the selected control flavors whose maximal degrees were considered according to their

maximal mean contents recorded from physicochemical traits assessed therefore [9, 11]. For the sensory evaluation of the coconut sap, panelists were invited to taste samples anonymized with codes and presented in various orders, then to fit the rating scale by scoring the perceived degree with values from 1 (when the flavor is not found) to 7 (when it's extremely felt) as shown in table 2.

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

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

Table 2. Control solutions concentrations for tasting the coconut inflorescence saps

Rating scale of the concentrations	Concentrations of coconut sap flavors controls (g/100 mL)		
	Sour flavour ^α	Salty flavour ^β	Sweet flavour ^λ
1	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	0.4	0.33	16.83
Maximal concentrations ([11])	TTA (g/100 g)	TAC (g/100 g)	TCC (g/100 mL)
	0.4	0.33	16.83

^α Sour flavor control: monohydrate citric acid; ^β Salty flavor control: Sodium chloride; ^λ Sweet flavor control: Sucrose. TTA, total titrable acidity; TAC, total ash content; TCC, total carbohydrate content; [11]: values resulted from studies of Konan et al. (2015).

2.4 Statistical analysis

Data were statistically probed with SPSS software (SPSS 16.0 for windows, SPSS Inc.) at 5% significance level. For the hedonic characterization, a Xhi2 non parametric test comparing proportions was achieved against theoretic 33.33%-33.33%-33.33% distribution. About the sensory profile, the data were submitted to 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 sensory traits and sap samples.

3. RESULTS AND DISCUSSION

3.1 Hedonic characteristics

The coconut saps were generally accepted by consumers, with the agreement of 67.86% to 92.86% panelists. Otherwise, the three acceptance scores (1, 2 or 3) of the sap samples recorded statistically various proportions, from 7.14% to 61.90% panelists. The samples derived from WAT and PB113+ hybrid generated significantly different acceptance degrees ($P < 0.05$) whereas the samples provided from MYD and PB121+ hybrid recorded identical ($P > 0.05$) sizes for the 3 acceptance degrees (table 3).

The sap produced by WAT is generally accepted by the panelists (85.72%), with 47.62% of full enjoyment and a significantly lower rate (14.29%) of displeasure. From the PB113+ hybrid, the sap was agreed by 93% investigated persons. It enjoys the majority of the subjects (61.90%), whereas 30.91% tasters give mean acceptance, and a few rate of them (7.14%) rejects it. On the other hand, from the PB121+ hybrid and its female parental MYD, the 3 acceptance degrees of the coconut sap recorded statistically similar panelists proportions ($P > 0.05$), ranging between 29.76% and 32.14% and between 29.76% and 35.71% involved people, respectively (table 3).

Table 3. Acceptance scores of the coconut inflorescence saps tasted by panelists

Acceptance levels		Rates of acceptance degrees (%)			χ^2	P-value
		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

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

3.2 Sensory profile

Whatever the coconut sap flavor, the perception degrees are statistically different ($P < 0.05$), with means varying between 2.03 and 6.21 on the 7 points rating scale from the four cultivars.

The sweet flavor, felt between 5.33/7 and 6.21/7, is statistically more intensive in the coconut saps ($P < 0.001$) than the salty and sour flavors which were detected with similar degrees included between 2.03 and 3.21 (table 4). Moreover, the sweetness of the MYD coconut sap (6.39/7) is higher than that of the three other cultivars studied. The WAT, PB121+ and PB113+ cultivars recorded similar means (5.58 to 5.91) of this character (table 4).

The coconut sap samples did not display any obvious salty and sour flavors. Indeed, both characters are detected with 2.03 to 3.21 points out of 7. However, the salty flavor is relatively more intensive in the sap produced from the WAT cultivar (3.21) than that of the PB113+ hybrid (2.42) whereas the perception of the sour flavor recorded indexes oscillating between 2.03 and 2.45 without any divergence from the coconut cultivars studied (table 4).

Table 4. Degrees of sweet, salty and sour flavors felt in the inflorescence sap deriving from MYD, WAT, PB121⁺ and PB113⁺ coconut cultivars

Cultivars	Feeling degrees of flavors (means $\pm$ standard deviations)			F	P-value
	Sweet flavor	Salty flavor	Sour flavor		
MYD	6.39 $\pm$ 0.61 ^{aA}	2.91 $\pm$ 1.61 ^{abB}	2.45 $\pm$ 1.20 ^{aB}	91.00	<0.001
WAT	5.91 $\pm$ 0.98 ^{bA}	3.21 $\pm$ 1.39 ^{aB}	2.03 $\pm$ 1.47 ^{aC}	77.67	<0.001
PB121 ⁺	5.58 $\pm$ 1.23 ^{bA}	2.67 $\pm$ 0.92 ^{abB}	2.06 $\pm$ 1.22 ^{aB}	62.14	<0.001
PB113 ⁺	5.67 $\pm$ 0.96 ^{bA}	2.42 $\pm$ 1.25 ^{bB}	2.33 $\pm$ 0.85 ^{aB}	111.18	<0.001
F	4.73	3.60	1.79		
P-value	0.004	0.018	0.157		

Means ($\pm$ standard deviations) with the same lowercase/uppercase superscript per column/line are statistically similar.

F, Statistical Ficher value of the ANOVA; P-value, Value of the probability test of the ANOVA

3.3 Variability of the coconut saps sensory traits

The sweet, salty and sour flavors of the coconut saps are correlated to the F1 and F2 factors of the PCA (table 5). Thus, the sap samples projected in the F1-F2 factorial draw of the PCA correlate the MYD to the sweet and sour flavors, whereas the WAT is with more salty flavor, as strengthened by the dendrogramme built for the HAC (figure).

Table 5. Eigen values and correlation matrix resulting from the principal components analysis of the sensory parameters of the coconut inflorescences sap.

Factors	F1	F2	F3
Eigenvalues	1.65	1.34	0.01
Variance (%)	54.85	44.82	0.33
Cumulative variance (%)	54.85	99.67	100
Sweet flavor	-0.99	-0.15	0.06
Salty flavor	-0.38	-0.92	-0.05
Sour flavor	-0.72	0.69	-0.06

Bold values reveal significant correlation of the flavor to the factor.

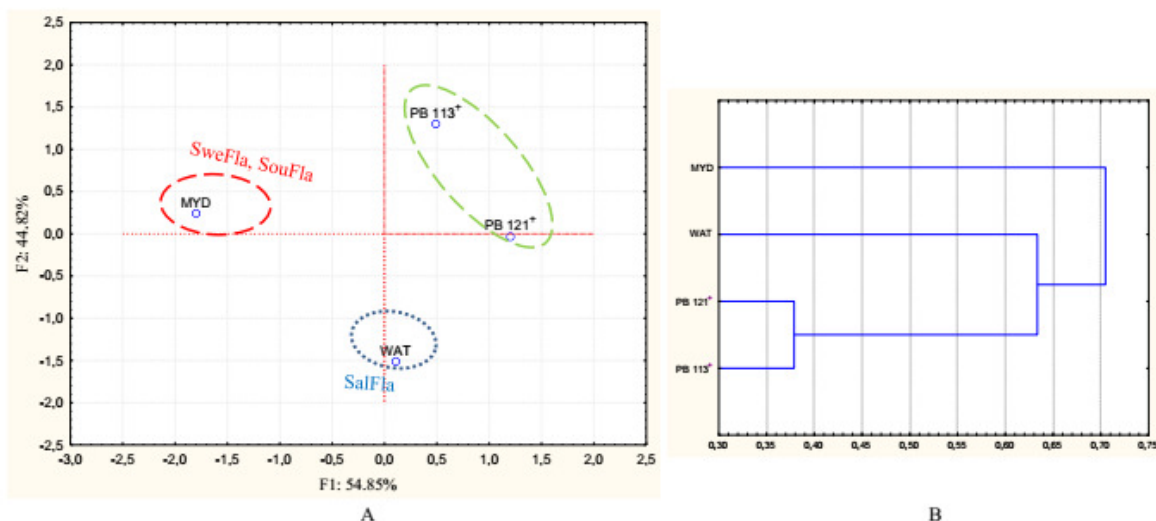


Fig. Correlations between sensory parameters of the studied coconut sap samples in the PCA F1-F2 factorial draw (A) and clustering dendrogramme of the coconut sap samples (B).

SweFla, sweet flavor; *SouFla*, sour flavor; *SalFla*, salty flavor

3.4 Discussion

From the PB121⁺ hybrid and its genetic parental MYD, the sap was enjoyed, fairly accepted and rejected by similar percentage of consumers. Yet, the MYD recorded the greatest sweet flavor. The sweetness could be therefore not the sole appreciation factor of the coconut sap. Indeed, in the opinion of some panelists, the sap samples from PB121⁺ and MYD cultivars would be with a relative viscosity which impedes its pleasance. Oppositely, the saps produced from PB113⁺ and WAT cultivars are more fluid and therefore pleasant for drinking. Thanks to this aspect, both cultivars are very desired by the consumers, with a full enjoyment of 62% people investigated for the PB113⁺ samples. Otherwise, the saps provided by WAT and PB121⁺ hybrid contain total polyphenols contents superior to that of the MYD [11]. Still, according to Lugasi *et al.* [12], the polyphenols compounds such as tannins are involved with the flavor quality, specifically the astringency of many plant foods. Thus, the sap of the WAT and PB113⁺ could present a relative astringency which would have improved their taste.

The coconut sap is really with sweet flavor than the sourness and saltiness. This characteristic is an important appreciation trait for the fruits juices as the coconut water, the orange juice, the apple juice, etc. In fact, consumers generally like the sweet flavor which could be basis of 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 felt sweet degree corresponded to the maximal total carbohydrates contents of the coconut saps highlighted by Konan *et al.* [11]. Thus, the sweet flavor is detected with a score expressing closely the total carbohydrates contents of the studied sap samples. Therefore, the tasting panel could be efficient means in assessing the coconut sap's carbohydrates content.

The sucrose was the reference sugar for the tasting trials. According to Konan *et al.* [11], the sap deriving from MYD is richer in sucrose than that provided by the three other cultivars investigated. So, it's logical for the sweet flavor to be more felt out in the dwarf coconuts sap than with the WAT, PB121⁺ and PB113⁺ cultivars.

On the other hand, the salty and sour flavors were detected with lower scores than those reflecting the maximal titrable acidity and ash contents of the coconut saps, respectively. This suggests that the minerals, major ash components, and the acid molecules of the sap could have been not fully discerned by panelists. A part of the minerals could be trapped by molecules and would not be soundly felt by the human's tongue. Concerning the acid molecules, they represent the main volatile organic compounds of the coconut sap. However, all of them would not account for its aroma which highly results from esters

[13]. This could explain the similar appreciation degrees of the sour flavor from the four cultivars, although they generated diverse titrable acidity values [11].

4. CONCLUSION

This tasting study was conducted to highlight the sensory parameters of the coconut sap. Its outcomes show that the coconut sap is with more sweet flavor than sour and salty flavors. Among the investigated coconuts, the PB113⁺ hybrid and the WAT produce sap accounting more appreciation from the consumers. Therefore, the production of coconut sap as common drink could provide quite value added for valorization of this culture.

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ABBREVIATIONS

MDRSC: Marc Delorme research station for coconut

246 **MYD**: Malayan Yellow Dwarf coconut
247 **WAT**: West African Tall coconut
248 **PB121***: Improved coconut hybrid resulting from crossing MYD x selected WAT
249 **PB113***: Improved coconut hybrid resulting from crossing Cameroon Red Dwarf coconut (CRD) x
250 selected Rennel Island Tall coconut (RIT)
251