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Glucide Factors of the Inflorescence Sap of Four Coconut (*Cocos nucifera* L.) Cultivars from Côte D'ivoire

Konan N'guessan Ysidor[1*,2], Assa Rebecca Rachel[1], Konan Konan Jean-Louis[2], Okoma Djeya Muriel[1,2], Alexia Prades[3], Allou Kouassi[2] and Biego Godi Henri Marius[1]

[1]Laboratory of Biochemistry and Food Sciences, UFR Biosciences, University Felix Houphouët Boigny, Abidjan, Côte d'Ivoire.
[2]Marc Delorme Research Station for coconut, National Centre of Agronomic Research (CNRA), Abidjan, Côte d'Ivoire.
[3]Centre of International Cooperation in Agronomic Research for Development (CIRAD), Department Persyst, France.

Authors' contributions

All authors collaborated to this work. Authors KNY and ARR designed the study and wrote the protocol. Author KNY managed literature search, performed some laboratory and the statistical analyses and wrote the first draft and the revised forms of the manuscript. Authors BGHM, KKJL and AK managed the research, provided the plant materials and laboratory reagents. Authors ARR, BGHM, ODM and KKJL took part on interpretation of the results and checked the first draft of the manuscript. Author AP performed the chromatographic analysis and took part in the revision of the manuscript. All authors read and approved the first draft, the revisions and the final form of the manuscript.

Original Research Article

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ABSTRACT

Aim: To assess physicochemical characters related to the glucide contents of the sap provided by four coconut cultivars.
Study Design: Thirty-six coconut saps from thirty-six healthy coconut trees inflorescences, replicated two times. Trees were randomly selected; cultivars were the most widespread coconut types in Côte d'Ivoire. The whole coconut saps consists of three

**Corresponding author: Email: haizykonan@yahoo.fr;*

batches of three samples per cultivar.
Place and Duration of the Study: Station Marc Delorme for the coconut Research at Port Bouet, National Centre of Agronomic Research (CNRA) of Côte d'Ivoire during 2012 and 2013.
Methodology: Inflorescences saps from four coconut cultivars namely Malayan Yellow Dwarf, West African Tall, and PB 121^+ and PB 113^+ hybrids were investigated according to their carbohydrate content. Nine coconut trees were randomly selected per cultivar on experimental fields and their unopened inflorescences (spathes) of rank 8 have undergone the production of sap. The sap was harvested twice a day and samples from both harvestings were stored at -20ºC. Even quantities of the daily samples were mixed and a slight volume was taken from this mixture for analysis. Five traits (pH, contents of total soluble solids, dry matter, total soluble sugars and reducing sugars) related to glucidic richness of the coconut sap were assessed. Then the main carbohydrates components (sucrose, glucose, fructose, mannose and glycerol) were elucidated using a high performance ionic chromatography and led to the evaluation of the sweet index.
Results: The effect of coconut cultivars on the pH and contents of total soluble solids, dry matter, total soluble sugars, sucrose, mannose, glycerol and sweet index was significant at P = .05. The sap of MYD recorded highest means of pH (7.32). This type of sap contained also highest contents of total soluble solids (16.31%), dry matter (16.47g/100ml), total soluble sugars (16.08g/100ml), mannose (0.019g/100ml) and glycerol (0.094g/100) contents and provided the greatest sweet index (16.00). Sucrose was the main carbohydrate of coconut sap. The MYD obtained higher sucrose content (12.24g/100ml) than the WAT (9.40g/100ml). Hundred (100ml) of saps from PB 121^+ and PB 113^+ provided respectively 10.31g and 10.38g of sucrose, which intermediate both means above. The contents of reducing sugars, glucose and fructose were respectively between 2.41 and 3.73g/100ml; 1.63 and 1.84g/100ml and from 1.24 to 1.52g/100ml, but didn't differentiate saps originating with MYD, WAT, PB 121^+ and PB 113^+ cultivars. Reducing sugars were significantly composed of glucose (r = 0.83) and fructose (r = 0.91).
Conclusion: The richness in glucides of coconut inflorescence sap is related to the contents of total soluble solids, dry matter and the whole carbohydrates. Thanks to their higher sucrose, glucose and fructose contents, the saps of the MYD, $PB121^+$ and $PB113^+$ cultivars could be suitable for the production of syrup, sugar and alcohol in order to improve benefits derived from the coconut.

Keywords: Coconut Sap; inflorescences; cultivars; glucides characters; Côte d'Ivoire.

ABBREVIATIONS

CIS: coconut inflorescence sap; MYD: Malayan Yellow Dwarf; PB 121^+: improved PB 121 hybrid; PB 113^+: improved PB 113 hybrid; WAT: West African Tall.

1. INTRODUCTION

Coconut (*Cocos nucifera* L.) is a widespread perennial crop of the whole intertropical and humid zone. It's cultivated on more than 12 millions of ha [1] and represents the main livelihood of more than 10 millions of families [2]. All parts of the coconut are useful [3]. Nevertheless, the walnut is still being the most longstanding and widespread valorization of this plant. However, face to the decline of the profitability of the nuts products; the tapping of sap from inflorescences (or spathes) seemed to be an alternative under promoting. Such uses of the coconut spathes, which are opposite to the production of nuts are developed in many countries through South-Eastern Asia and in Latin America [4].

Previous studies compared the profitability of the coconut crop from the production of walnut to that involving the tapping of the sap. They mentioned the high incomes resulting from the production of coconut sap. According to Maravilla and Magat [5], the coconut sap could procure 3 to 16 times higher incomes to the farmers than the trading of walnuts or the copra. Indeed, the coconut inflorescence sap (CIS) is a natural raw material used for the production of by-products with substantial value, like syrup, sugar , wine and distillated alcohol. Indeed, the CIS is a nutritious liquid with a high content of glucides, which are mainly consisted of sucrose [6]. The coconut sugar has a low glycemic index of 35 to 42 [7]. Thus, it is one of the best carbohydrate foods that could improve the blood glucose of healthy people and patients suffering from the diabetes mellitus [8]. Thanks to this advantage, the CIS is processed to coconut syrup and sugar after partial or full water evaporation [9,3]. Besides, this quality promotes many changes of the CIS. It undergoes spontaneous and natural fermentation and leads prior to alcoholic beverage [10] then to acid raw material for vinegar production [11].

However, characterization of the coconut sap hasn't ever been achieved in Côte d'Ivoire, even though this country wishes the promoting of this raw material. Also, few works attempted on the compounds of CIS compare different coconut varieties. Moreover, many coconut types still present agronomic, morphological and genetic divergences [12]. In addition, the quality of such a substance could depend on the conditions surrounding with its production [3]. The present study investigates the glucides characters of the sap from the most widespread coconut cultivars in Côte d'Ivoire in order to promote other ways of their valorization.

2. MATERIALS AND METHODS

2.1 Plant Material

The plant material was sap collected from spathes of four coconut cultivars cultivated in Côte d'Ivoire, namely improved hybrids PB 113 (Cameroon Red Dwarf x improved Rennell Islands Tall) and PB 121 (Malayan Yellow Dwarf x improved West African Tall) and local dwarf (Malayan Yellow Dwarf) and tall (West African Tall) cultivars.

2.2 Sampling

From each cultivar, three groups of three adult and healthy coconut trees were randomly selected at three experimental fields of the Marc Delorme Research Station of the National Center of Agronomic Research, Abidjan, Côte d'Ivoire. Thus, 36 coconut trees (3 coconut trees* 3 batches* 4 cultivars) were sampled. Then, the spathe of rank 8 of each tree was chosen for the coconut sap's production [12]. That led to the use of 36 spathes during this study. The sap production consisted at first in a training of the spathe to a drooping position by tying and slowly pulling it downward, avoiding breakage at its base, with a twine fastened to the nearby leaf below. Then, spathe was transversally severed with a slicing knife and 15-20 cm length was removed from its tip. Finally the bled part allowing the sap exudation was introduced into a polyethylene can previously sterilized with 100ºC boiling water. The can was fastened to the spathe and both were covered with a sterile muslin cloth in order to preserve the hygienic quality of the sap. The sap was harvested twice a day, at 7 AM and 5 PM [12]. From each harvesting, a volume of 150ml of sap by spathe was sampled into sterile pots. Samples were immediately placed into an isotherm cool bag, sent to laboratory and stored at -20ºC until analysis [6].

Before analysis, homogeneous mixture of the two daily sap harvests from each spathe was achieved. Then, 200ml was sampled from this mixture. So, 36 samples of sap were analyzed during a sap harvesting season. The study was performed along two seasons, in 2012 and 2013. Finally, 72 samples of CIS were investigated during these attempts.

2.3 Evaluation of Physical Characters Related to the Glucide Richness of the CIS

The potential of hydrogen (pH) was determined by using a pH-meter (HANNA Instruments). The total soluble solids contents were read with a manual refractometer (DIGIT 032, Brussels, Belgium) and expressed in percentage. The dry matter was valued by drying of the sap samples into an oven (Memmert, Berlin, Germany) at 104ºC [13] and with use of a two digits scale (METTLER BD 202, USA).

2.4 Analysis of Chemical Characters Related to the Glucide Richness of the CIS

Sugars contents were achieved with spectrophotometer methods. The contents of total soluble sugars were analyzed by phenol and sulfuric acid method [14]. Reducing sugars contents were determined with the use of 3, 5 - dinitrosallicylic acid [15]. The main components of soluble sugars were revealed by a DX600 High-Performance Ionic Chromatography (Dionex Corp., Sunnyvale, CA) coupled to a pulsed amperometric detector (Dionex ED50). Ten µl of CIS were diluted with 9,990 µl of deionized water, and then filtered on a Millipore (0.45 µm) nylon filter and injected on a column (Carbopac MA-1, Dionex, 4 x 250 mm). Sugars were eluted with 0.8 M NaOH using a gradient programme at 0.4 mL min^{-1}. External standard was a mixture of pure reagents from Sigma-Aldrich Corporation, USA. Sugar contents allowed evaluation of the sap's sweet index (SI):

$$SI\ (g/100\ ml) = Suc + 1.5*Fru + 0.8*Glu + 0.3*Man$$

With: SI, sweet index; Suc, sucrose content; Fru, fructose content; Glu, glucose content; Man, mannose content.

2.5 Statistical Analysis

The spathes from the groups of coconut trees were the replications for each cultivar. The statistical analysis evaluated differences between coconut cultivars using a One-way analysis of variance (ANOVA) and Newmann Keuls test for post hoc at P-value =.05. The correlations between all characters were assessed according to the Pearson index. Statistical analyses were performed with SPSS software (SPSS 16.0 for windows). All experiments were achieved at least in triplicate.

3. RESULTS

3.1 Physical Characters

Table 1 showed significant difference between the four coconut cultivars resulting from the physical characters assessed (*P* < .001).

The contents of total soluble solids varied statistically from 14.65% to 16.31%. Thus, the sap of MYD contained more total soluble solids (16.31g/100ml) than that of the three other cultivars which gave similar means of TSS (14.65 to 14.82g/100ml).

The pH of the sap of the coconut tree fluctuated between 6.97 and 7.32 and differed statistically within the studied cultivars. The MYD provided the highest pH (7.32), while the PB113$^+$ hybrid recorded the lowest value (6.97). The PB 121$^+$ hybrid and its male parent (WAT) gave the same value of pH (7.10 and 7.18, respectively).

The dry matter was statistically more abundant into the sap of MYD (16.47g/100g). For this character, the contents provided by the sap of the cultivars WAT, PB 121$^+$ and PB 113$^+$ (14.86g/100g, 14.75g/100g and 14.64g/100g, respectively) were statistically identical (Table 1).

Table 1. Averages of three physical characters linked to the glucide richness of the sap produced by spathes of the four coconut cultivars: MYD, Malayan Yellow Dwarf; WAT, West African Tall; PB121$^+$ and PB113$^+$ hybrids

Characters	Means ± SD						
	MYD	**WAT**	**PB 121$^+$**	**PB 113$^+$**	**F**	**P**	**RSD** (%)
TSS (%)	16.31±1.09^a	14.69 ± 0.81^b	14.82 ± 0.89^b	14.65 ± 0.83^b	16.76	<0.001	7.49
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	3.15
DM (g/100g)	16.47±1.46^a	14.86±0.96^b	14.75±1.12^b	14.64±1.07^b	14.79	<0.001	9.01

F- statistical value; P- value of probability test; RSD- Relative Standard Deviation. Per row, means ± SD (standard deviation) with the same superscript are statistically identical. TSS- total soluble solids; pH- potential of hydrogen; DM- dry matter content.

3.2 Chemical Characters

Soluble carbohydrates were the main macromolecules dissolved into the coconut sap. They consisted of 14.14% to 16.08% of the sap, and represented 91.39% to 94.63% of the dry matter. Statistically, the total sugars content differentiated the MYD from the other coconut cultivars (P< .001). Indeed, the sap produced by MYD provided the highest total soluble sugars content (16.08g/100ml). The PB 121$^+$, PB 113$^+$ and WAT cultivars recorded statistically the same total soluble sugars contents in their sap (14.23g/100ml, 14.14g/100ml and 14.54g/100ml, respectively).

Concerning the reducing sugars content, it consisted of 2.41% to 3.73% of the CIS. But this character didn't discriminate (P = .11) the four coconut cultivars (Table 2).

3.3 Main Components of the Soluble Sugars

Chromatographic analysis revealed different proportions of fructose, glucose, glycerol, mannose and sucrose from carbohydrates of CIS (Table 3). Sucrose was the major sugar component of CIS of the four cultivars. Sucrose contents varied from 9.40g/100ml to 12.24g/100ml. This di-saccharide was statistically more abundant in the sap produced from MYD (12.24g/100ml) than that of WAT (9.40g/100ml). The hybrids PB 121^+ (10.31g/100ml) and PB 113^+ (10.38g/100ml) provided statistically similar sucrose contents, intermediate of the MYD and WAT cultivars.

Glucose and fructose were minor components. Glucose content fluctuated between 1.63 and 1.84g/100ml, while fructose constituted 1.24g to 1.52g from 100ml of sap. Nevertheless, the CIS from all the cultivars showed statistically the same contents of glucose and fructose.

Furthermore, slight contents of glycerol and mannose where noticed in CIS. The highest glycerol content was provided by MYD (0.094g/100ml). The sap resulted from the three other cultivars contained statistically identical amounts of glycerol, between 0.05 and 0.058 g/100ml. The CIS of MYD was also statistically higher in mannose content (0.019g/100ml) than those of WAT (0.011g/100ml), PB 121^+ (0.008g/100ml) and PB113^+ (0.014g/100ml).

The sweet index, estimated according to the carbohydrate components, discriminated the sap collected from MYD from those of the three other coconut types. Indeed, sweet index recorded for the sap produced by the Dwarf coconuts (16) was statistically superior to those resulted from hybrids PB 121^+ (13.68), PB 113^+ (13.56) and the Tall WAT (13.03). These last three cultivars provided statistically similar sweet index (Table 3).

Table 2. Total soluble sugars and reducing sugars contents of the CIS derived from the four cultivars: MYD, Malayan Yellow Dwarf; WAT, West African Tall; PB121+ and PB113+ hybrids

Characters	Means ± SD				F	P	RSD (%)
	MYD	WAT	PB 121+	PB 113+			
TS(g/100 ml)	16.08±0.7[a]	14.23±0.76[b]	14.14±1.10[b]	14.54±1.14[b]	15.10	<0.001	8.29
(g/100g dm)	92.56±4.32	91.40±4.88	91.40±7.11	94.63±7.42			
RS (g/100 ml)	3.21±2.02[a]	3.28±1.64[a]	2.41±1.30[a]	3.73±2.87[a]	2.13	0.11	65.13
(g/100 dm)	19.96±12.56	23.05±11.52	1704±7.62	25.65±19.73			

F- statistical value; P- value of probability test; RSD- Relative Standard Deviation. Per row, means ± SD (standard deviation) with the same superscript are statistically identical. TAC- total titrable acidity; TS- total soluble sugars content; RS- reducing sugars content; DM- dry matter.

Table 3. Carbohydrates composition and contents of the sap produced by spathes of the four coconut: MYD, Malayan Yellow Dwarf; WAT, West African Tall; PB121+ and PB113+ hybrids

Glucide components	Means ± SD						RSD (%)
	MYD	WAT	PB121+	PB113+	F	P	
Sucrose (g/100ml)	12.24±2.82[a]	9.40±2.26[b]	10.31±3.04[ab]	10.38±2.73[ab]	2.66	0.048	27.07
Glucose(g/100ml)	1.84±0.24[a]	1.72±0.36[a]	1.63±0.22[a]	1.64±0.27[a]	2.22	0.10	16.79
Fructose(g/100ml)	1.52±0.37[a]	1.50±0.31[a]	1.38±0.42[a]	1.24±0.33[a]	2.55	0.07	26.28
Mannose(g/100ml)	0.019±0.007[a]	0.011±0.003[b]	0.008±0.002[c]	0.014±0.004[b]	25.51	<0.001	46.99
Glycerol(g/100ml)	0.094±0.037[a]	0.058±0.014[b]	0.058±0.008[b]	0.048±0.013[b]	32.94	<0.001	42.35
Sweet Index	16.00±2.64[a]	13.03±2.26[b]	13.68±3.03[b]	13.56±2.64[b]	3.41	0.025	20.21

F- statistical value; P- value of probability test; RSD- Relative Standard Deviation. Per row, means ± SD (standard deviation) with the same superscript are statistically identical.

3.4 Correlations between the Assessed Characters

Values of Pearson indexes (r) showed positive significant links between several physicochemical characters (Table 4). Logically the total soluble solids content was correlated to the dry matter content (r = 0.88). This latter depended on the amount of total soluble sugars of the CIS (r = 0.77). As a consequence, the contents of total soluble solids and total soluble sugars were hardly closed (r = 0.83). The reducing sugars content were reasonably correlated to the levels of glucose (r = 0.85) and fructose (r = 0.91) contents. Mean significant correlations engaged glycerol and mannose contents (r = 0.56), then glucose and fructose contents (r = 0.56). In addition, a high amount of sucrose ensured a high sweet index (r = 0.90).

Table 4. Matrix of correlations between physicochemical characters related to the richness in glucides of the CIS of the four coconut cultivars: MYD, Malayan Yellow Dwarf; WAT, West African Tall; PB121$^+$ and PB113$^+$ hybrids

Characters	pH	DM	TSS	Gly	Man	Glu	Fru	Suc	RS	TS	SI
pH	**1**										
DM	0,48	**1**									
TSS	0,47	**0,88**	**1**								
Gly	0,23	0,18	0,24	**1**							
Man	0,14	0,22	0,17	**0,56**	**1**						
Glu	0,20	0,12	0,11	0,18	0,13	**1**					
Fru	0,09	0,09	0,08	0,12	-0,03	**0,56**	**1**				
Suc	0,26	0,12	0,19	0,34	0,33	-0,21	-0,42	**1**			
RS	0,17	0,13	0,12	0,22	0,08	**0,85**	**0,91**	-0,35	**1**		
TS	0,45	**0,77**	**0,83**	0,25	0,29	0,02	0,00	0,31	0,03	**1**	
SI	0,35	0,19	0,26	0,44	0,38	0,13	0,01	**0,90**	0,09	0,34	**1**

***Bold** values are significant at P-value = .05. pH, potential of hydrogen; DM, dry matter content; TSS, total soluble solids content; Gly, glycerol content; Man, mannose content; Glu, glucose content; Fru, fructose content; Suc, sucrose content; RS, reducing sugars content; TS, total soluble sugars content; SI, sweet index.*

4. DISCUSSION

The differentiation among the physicochemical characters could be originated with the divergence between the four coconut genotypes. The higher contents of total soluble solids and dry matter of the sap collected from MYD could be a specificity of the dwarf coconut cultivars. Indeed, a part of the sap may directly result from both hydric and mineral absorption by plant's roots from soil. The other part is synthesized during photosynthesis and water transpiration involved by leaves [16,17]. So, the sap transports and procures the main nutrients to all the plant organs, including the inflorescences [12]. The latter produce the fruits, nuts and ensure their development, thanks to the coconut water that may have been resulted from the sap. Indeed, in the Dwarf cultivars, the coconut water of the walnut is generally higher in dry matter and total soluble solids contents than those of the Tall cultivars and their hybrids [18]. This may have involved highest contents of TSS and DM in the sap of the dwarf coconut trees (MYD). However, the TSS and DM contents of the sap were clearly superior to those provided by the coconut water [19,20]. All soluble compounds of the CIS may not be engaged into the coconut water. Significant ratio of the nutrients could contribute to the nuts bearing and development of the other parts of the nuts (husk and shell).

Besides, the dry matter is especially composed of the nonvolatile macromolecules of the CIS. This could explain the significant positive correlation between DM and TSS, which often specify the fruit juices. The total soluble solids content of the CIS is close to that recorded from the sap of *Borassus flabellifer* which fluctuated between 11 and 17% [21]. Also, the dry matter content of the sap of the coconut cultivars studied didn't differ from the statement of Karamoko et al. [22] with the sap produced by Elaeis guineensis.

The pH values confirmed the CIS as a nearly neutral raw material. This was previously indicated by Nakamura et al. [6] on the same palm plant. However, differences appeared between the coconut cultivars. The PB 113$^+$ and PB 121$^+$ hybrids and the WAT could have produced saps with more hydronium ions (H_3O^+) amount than the sap of MYD. These results exceed the pH value (4.5) mentioned by Umerie [23] from the sap of the oil palm. Different palm species would not provide the same pH value from their sap.

The total sugars content of the sap could also depend on the coconut ecotypes. The MYD recorded the highest total soluble sugar content which could reveal a more intensive activity of sugar synthesis by the dwarf coconut types than by the others. The dwarf coconuts have thinner stipes than the talls and the dwarf x tall hybrids. Logically they have weak root system that might not enable good hydric and mineral intake. Consequently, for their survival, the dwarf coconut could achieve an intensive photosynthesis leading to a high production of carbohydrates. Besides, sugars remained the main components of the dry matter; that led to hard correlation between both characters. The saps we have studied were richer in total soluble sugars than that investigated by Debmalya and Mazumdar [24] from the same palm plant. The difference may have involved with not only the ecotypes of coconut cultivars, but also the method used for the analysis and the environmental effects. From these authors, sap was filtered on a Watman paper whereas this step was achieved with a muslin cloth in our study. Watman paper could have removed sugars residues from the sap and led to the misestimating of the real sugars content of the CIS. In addition, the coconut plants of our study were selected from experimental research coconut plots of the coastline of Côte d'Ivoire. The climate and the soil of this region and the planting of these plots according to agronomical technical's, could have improved the performance in sap components synthesis of such coconut trees. Indeed, the soil and the climate conditions can influence the hydric and mineral absorption and the system of photosynthesis that lead to production of the carbohydrates by the plant. Also, the planting of the coconut seeds following right agronomic rules, such as the distance between plants, can help the development of the plants that involves the production of sap. Our results are however comparable to those of Xia et al. [11], stated about a TS content of 14%.

The main CIS sugars were sucrose, a non-reducing di-saccharide. This statement is true for every plant from the arecaceae family. The sucrose is the major carbohydrate reserve into the sap conducting organs (xylem and phloem) of the coconut tree [25]. The sucrose contents of the PB 121$^+$ and PB 113$^+$ hybrids were still close to those of MYD and WAT cultivars. Accounting on this, such character may have been inherited, with co-dominance effect, from both Dwarf and Tall coconut genotypes. Our results corroborate the attempts of Nakamura et al. [6] whose sucrose content of CIS was 11.6g/100ml. Otherwise, sucrose is more abundant in the sap than the whole coconut products, such as coconut water and kernel, whatever their development stages [20]. During formation of the coconut water, the sucrose coming from the sap would not be entirely in taken.

Even contents of fructose and glucose were revealed in the CIS of the four coconut cultivars. The contents of both monosaccharides enhance the final reducing sugars content of the

CIS, because they could probably be the main reducing sugars of CIS. Their presence in the plant may have resulted from two biochemical processes. The first source might be the enzymatic hydrolysis of sucrose, during fermentation stages. Indeed, the sap exudate undergoes a spontaneous fermentation by microorganisms occurring from the environment [26] using the inner sucrose. This phenomenon provides glucose and fructose into the sap, which are thereafter also metabolized, leading to alcohol and acid compounds. The second origin of reducing sugars would be a physiological synthesis by the plant. Thanks to their photosynthesis system, the coconut tree can perform molecules with higher atoms of carbon (C6) from C3 molecules [27]. This endogenous biological process may have produced other hexoses, like mannose, among the reducing sugars of the coconut sap. The reducing sugars are substrate for enzymatic browning and Maillard reactions which could happen during production of coco syrup and coco sugar from coconut sap [21]. The four coconut cultivars provided reducing sugars contents of their saps equivalent to the sap of the oil palm [22].

The presence of glycerol could be explained by the glycopyruvic fermentation of the reducing sugars (glucose, fructose and mannose) due to yeasts. Simultaneously, this oxidization could lead to other volatile organic compounds, such as acids, aldehyds, ketones and esters, which contribute to the astringency and aroma of the coconut sap [28,3].

The highest sweet index of the sap produced by the MYD may have resulted from its substantial sucrose content. The sweet index and sucrose content are hardly correlated. Thanks to this value of sweet index, the sap of the Dwarf coconut could be more delicious than that produced from the spathes of Tall and hybrids coconuts. However, whatever the coconut cultivar, the sweet index of the sap overcomes that recorded from the coconut water whose highest value was 7.5 g/100ml [29].

5. CONCLUSION

This study showed a neutral pH for the sap of the four coconut cultivars: MYD, WAT, PB121$^+$, and PB113$^+$. The dry matter of CIS contained mainly carbohydrates components. These macromolecules were more abundant in the sap of the MYD cultivar. However, sucrose was the main carbohydrate, and its content differentiated MYD from WAT whereas PB 121$^+$ and PB 113$^+$ hybrids exhibited intermediate values. Furthermore, the similar contents of glucose and fructose revealed the same stage of synthesis of these monosaccharides into the sap of the four coconut cultivars. Thus, the sap produced by MYD, PB 121$^+$ and PB 113$^+$ could provide the same yield of productions of alcohol, syrup and sugar, thanks to their highest sucrose content. Nevertheless, the sap of the MYD could be more delicious for drinking.

COMPETING INTERESTS

All authors declared no competing interest with any information of this manuscript.

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