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Sensory evaluation and sugars contents of coconut (*Cocos nucifera* l.) water during nuts ripening

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Sensory characteristics of coconut water from four coconut cultivars (*Cocos nucifera* L.) were investigated during nuts ripening. The study was carried out on the West African Tall, the Malaysian Yellow Dwarf, the Equatorial Guinea Green Dwarf and the improved hybrid PB121. Tested parameters were tastes (sweet, salty and sour), gustatory preferences and sugars contents. Obtained results showed significant interactions between cultivars and maturity stages for analyzed parameters. So, during the ripening of nuts, the sweet taste of coconut water predominated according to the maturity stages. It was maximal at the rank 21 of dwarf cultivars with perception equivalent from 5.80 to 6.10% sugars contents. At full maturity, the coconut water sweet taste lowers because its sugars enhance the formation of the kernel. The results of hedonic tests led to the preference of the coconut water according to its sweet taste. So, the water of dwarf cultivars immature nuts, more sweetened, was the most appreciated. Sugars contents are specific for cultivars and maturity stages. Their values were maximal at ranks 19 and 21 of dwarf cultivars. Moreover, gustative data were closed to those of the sweet taste perception. This study allowed to determinate the sensory characteristics of the coconut water in order to give indicators for its efficient technological promotion.

Key words: Coconut water, sensory tests, sugars contents, cultivars, ripening.

INTRODUCTION

The coconut tree (*Cocos nucifera* L.) is a permanent culture of tropical countries. It is also called 'life's tree' due to its numerous uses (Manisha and Shyamapada, 2011). The coconut tree plays a socio economic primordial role in all humid inter tropical zones. Indeed, about 10 millions families, draw their resources with coconuts speculations (Moore and Batugal, 2004). So, in Ivory Coast, the coconuts farms cover 50000 ha among which more than 90% are located along the coastal region (Amrizal, 2003). In this region, the coconut tree represents the main source of incomes for most peasants (Konan et al., 2008). Indeed, the water and the kernel are edible and economically profitable parts of the coconut. However, technologies transformation is not fully

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Table 1. Concentrations (%) of the coconut water tasting witnesses substances.

Witnesses solutions codes	Sweet (sucrose)	Salty (sodium chloride)	Acid (citric acid)
1	0	0	0
2	1.75	0.05	0.01
3	3.5	0.1	0.02
4	4.375	0.15	0.03
5	6.125	0.2	0.04

developed there. They are limited to the manufacture of the copra (dried kernel at 6% of humidity) and oil extraction, at small scale, with mature nuts kernels. Besides, an accomplished inquiry into coastal region of Ivory Coast showed that 90% of populations use the coconut water to quench thirst or for its therapeutic virtues (Assa et al., 2006). Moreover, the physic-chemical characteristics of the coconut water were previously studied. So, the immature coconuts water is a delicious and nutritious drink (Jackson et al., 2004). It can be used also for the manufacture of syrups or fermented drinks (Enonuya, 1988). At maturity, coconut water loses its delicious taste to the advantage of the kernel (Jayalekshmy et al., 1986). However, in spite of coconut water, incentive prices, therapeutic virtues and high consumption, its sensory characteristics are not much studied, with few exceptions (Lapitan and Mabesa, 1983). Besides, these previous studies do not always treat cultivars intra and inter variations.

Also, they are generally centered on hedonic characteristics of fruits, without indications on their sensory profiles. Thus, sensory methods have an important place among analytical techniques because they use human as instrument measure (Raoux, 1998). Moreover, in Ivory Coast, sensory data of coconuts are non existent. So, the present document studies the sensory precisely gustatory parameters of coconuts water during nuts ripening. Values will be compared to sugars contents in order to characterize specifically coconut water and give indicators for their efficient promotion. Then, this work is interesting for the field because it will permit a consensus about analytical and sensorial methods for coconuts characterization.

MATERIALS AND METHODS

The biological material was constituted of coconut cultivars mostly used by their actors. It was about the West African Tall (WAT), the Malaysian Yellow Dwarf (MYD), the Equatorial Guinea Green Dwarf (EGD) and the improved hybrid PB121 (PB121+); obtained by a crossing between MYD and WAT (Bourdeix et al., 1992). Fruits were harvested on healthy grown-up coconut trees plots located on the station Marc Delorme of the National Centre of Agronomical Research (CNRA) in Abidjan, Ivory Coast.

Sampling

Six coconut palms were haphazardly chosen per cultivar, giving 24 palms samples. Among these, six bunches at six different stages of maturity (ranks) were simultaneously harvested. Maturation ranks were as follows: 17, 19, 21, 23, 25 and 26, corresponding respectively to fruits of 5, 7, 9, 11, 13 and 14 months old after conception. Five fruits from each bunch of a coconut palm were sampled. Their waters were homogenized to form a representative sample for analysis. This study was repeated over three successive harvest campaigns. Harvested fruits were sheltered to prevent the effects of sun and rain. Then, coconut water samples were analyzed less than 24 h after the harvest. Experiments were conducted using the same palms over two successive years; in 2007 and 2008 from February to April.

Sensory analyses

Sensory methods included descriptive tests, relating to the realization of sensory profiles of coconut water tastes. It was besides; on hedonic tests intended to assess the preferred level of the coconut water samples. Contrary to hedonic analyses, the descriptive tests required skilled tasters. So, a jury of 13 tasters was formed on the Marc Delorme station after the selection tests. These were consisted on the determination of gustatory acuteness according to the norms NF V09-002 of AFNOR (1984). They included identification tests of basic tastes (sour, bitter, salty and sweet) and determination of their perceptibility thresholds from substances witnessed. A room was adjusted for the tests according to norms NF V09-105 (AFNOR, 1984).

Descriptive tests

Panelists performed descriptive tests of the coconut water on a scale of notation in 5 points according to norm NF V09-16 (AFNOR, 1984). Tested parameters were sweet, salty and sour tastes. Concentrations of the tasting witnesses were prepared by addition of the witness substance in the mineral water (Table 1). Their maximum values were determined according to bibliographic data (Campos et al., 1996). For each tested taste, every subject savored successively the sample and the tasting witnesses. The intensity of the taste was immediately noted on the form. Gathered numerical informations were converted into corresponding concentrations of the substances witnesses. Indeed, for a given taste, 5 points on the scale represented respectively 5 successive concentrations of the tasting witness. These data allowed the sensory profiles establishment of the coconut water according to cultivars and maturity stages.

Hedonic tests

These tests were performed to assess the degree of samples gustatory evaluation. They required 35 not trained tasters, on a 5 points notation scale. Each taster registered on a form, a numerical value characteristic of the savored sample, according to his own

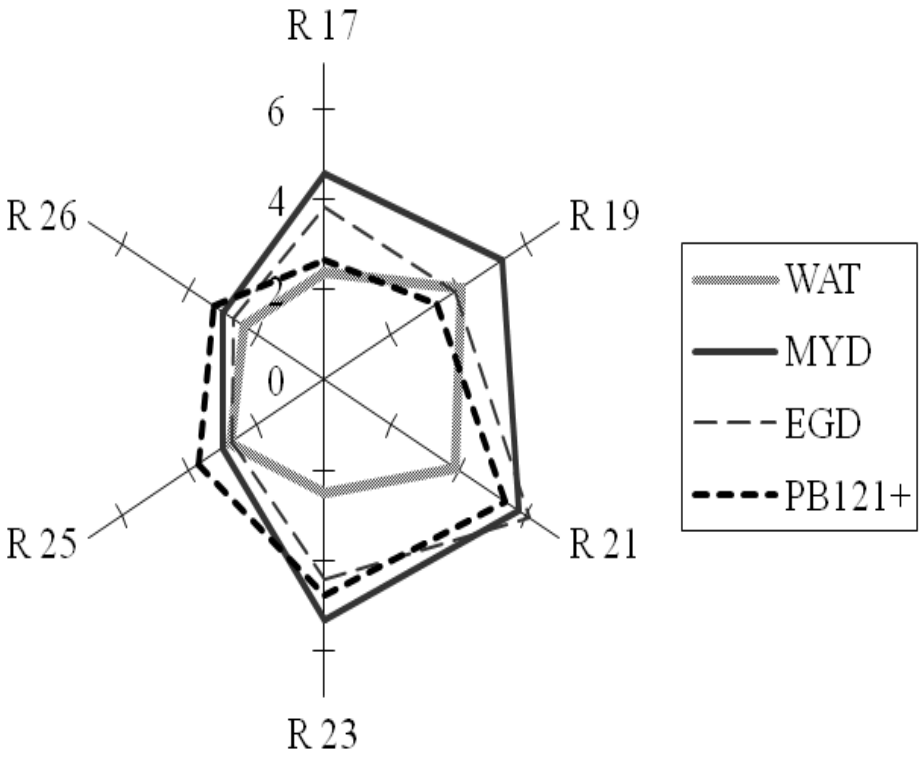

Figure 1. Sweet sensory profile of the coconut water according to cultivars and nuts maturity stages (LDS: 0.74).

evaluation. So, value 1 meaned no preference, 2 points indicated a weak preference, 3 translated a medium preference, 4 meaned a strong preference and 5 a very strong preference.

Sugars determination

The coconut water sugars were determined with spectrophotometer (Spectronic Genesis 5) according to Dubois et al. (1965) methods. It was about the determination of total soluble sugars with the sulfuric-phenol method and reducer sugars with 2-hydroxy-3, 5-dinitrobenzoic acid (DNS).

Statistical analyses

Data were treated with statistical software GenStat (GenStat Discovery, Edition 2). So, an analysis of variances (ANOVA) with two classification criteria was performed at 1 and 5% significant level for treatments of the coconut water sensory profiles and sugar contents. Criteria of classification were cultivars and maturity stages, Campaigns constituted blocks. Averages values were compared by the least significant difference (LSD). Results of hedonic tests were compared by Duncan test.

RESULTS

Statistical analysis showed significant variations during nuts ripening with a highly significant interaction ($p < 0.01$) between cultivars and ranks for each tested parameters.

Sensory profiles

Sweet taste predominated in the water of especially immature nuts whoever were the studied cultivars. It was maximal for dwarf cultivars MYD and EGD at rank 21 and equivalent to respective contents of 5.80 and 6.10% (Figure 1). The sweet taste of the coconut water lowered, whoever was the cultivar, beyond the rank 21 up to nuts full maturity. So, it was minimal at WAT rank 26 with a perception equivalent to 2.39%. But, at full maturity, PB121+ nuts water had the strongest sweet taste. The coconut water had lesser salty and sour (acid) tastes in comparison with its sweet taste. So, the salty taste, expressed in percentage of sodium chloride (NaCl), decreased from rank 17 ($11.90.10^{-2}$%) to 26 ($8.90.10^{-2}$%) for WAT. On the contrary, salty tastes of MYD, EGD and PB121+ nuts water, went down at the rank 21. They increased later up to the rank 26 with a maximum value equivalent to $12.6.10^{-2}$% content for EGD (Figure 2). The sour taste of the coconut water, expressed in percentage of citric acid, evolved during the ripening of nuts. So, for WAT cultivar, it augmented from the rank 21 ($1.9.10^{-2}$%) to 26 ($1.2.10^{-2}$%). The sour tastes went down up to 21 where they represented a minimal content of $1.1.10^{-2}$% for EGD and PB121+. Values increased then until $1.8.10^{-2}$ at 26 for MYD (Figure 3).

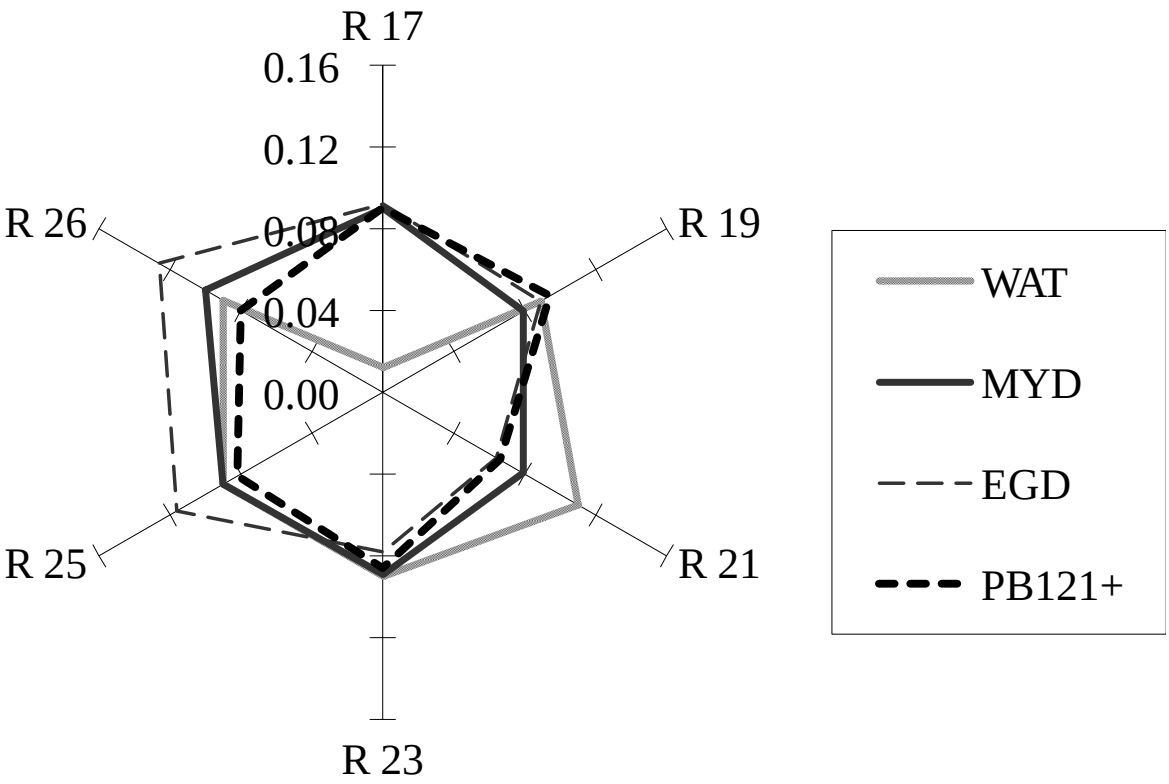

Figure 2. Salty sensory profile of the coconut water according to cultivars and nuts maturity stages. LDS: 0.02.

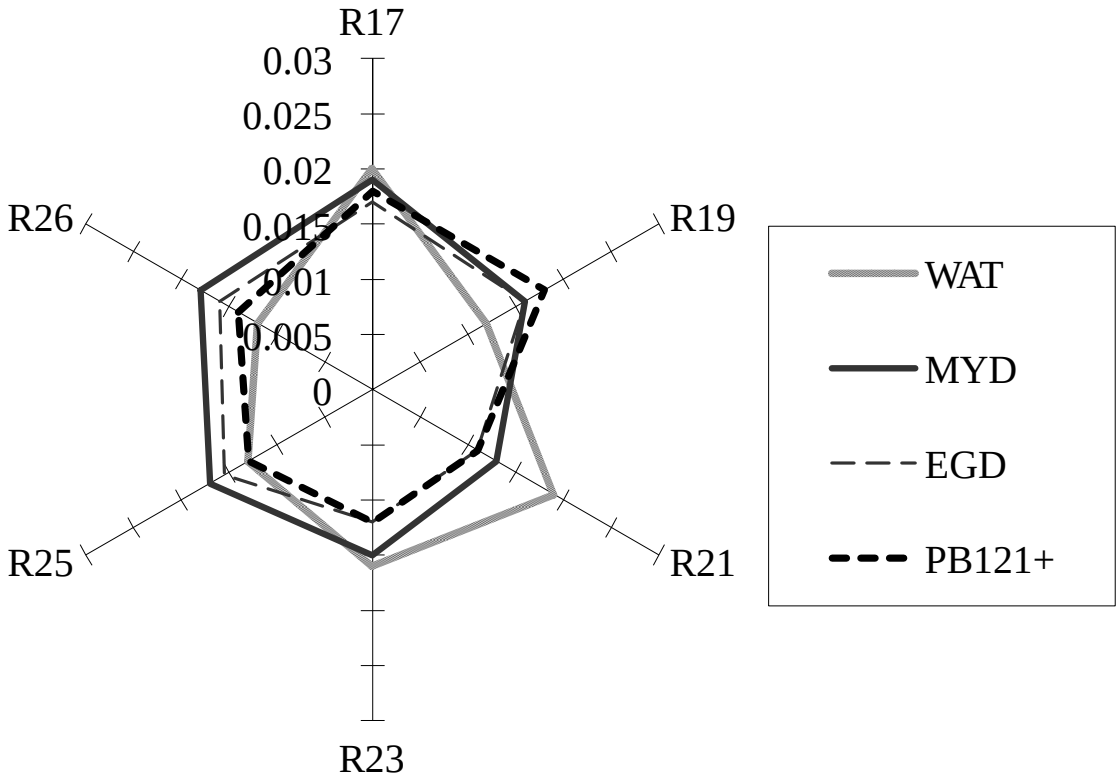

Figure 3. Sour sensory profile of coconut water according to cultivars and nuts maturity stages. LDS: 0.005.

Table 2. Gustatory preferences for the coconut water on 5 points scale according to cultivars and maturity stages.

Cultivars	Maturity stages						Score / cultivar
	R17	R19	R21	R23	R25	R26	
WAT	2.91^{d}	4.2^{b}	3.12^{d}	2.73^{d}	3.03^{d}	1.76^{e}	2.96^{d}
MYD	2.78^{d}	4.08^{b}	4.61^{a}	3.50^{bc}	2.42^{e}	2.22^{e}	3.27^{c}
EDG	2.00^{e}	4.81^{a}	3.50^{bc}	3.38^{c}	3.03^{d}	2.69^{d}	3.23^{c}
PB121+	1.77^{e}	3.17^{d}	4.37^{b}	3.57^{c}	3.14^{d}	3.11^{d}	3.19^{d}
Score / rank	2.36^{e}	4.08^{a}	3.90^{b}	3.29^{c}	2.91^{d}	2.45^{d}	3.16^{d}

Scores followed by the same letter (from a to e) are not significantly different.

Gustatory preference

The preference of coconut water augmented until the rank 19 or 21 for all tested cultivars with maximal scores for EGD (4.81) and MYD (4.61). Beyond the rank 21, preferences decreased until the rank 26 where they were 2.22 for MYD and minimal (1.76) for WAT. Coconut water of EGD, MYD and PB121+ at ranks 21 and 23 were moderately preferred with notes wobbling between 3.38 and 3.50 (Table 2). However, coconut water of ranks 25 and 26 was not generally appreciated whoever was the cultivar. These samples had average notes of 3 at rank 25 and 2 at rank 26.

Sugars contents

The evolution of total sugars (TS) and reducer sugars (RS) contents during nuts ripening included an increasing stage followed by a decreasing phase (Table 3). So, for WAT, total sugars (3.98 g.100 ml^{-1}) and reducer sugars (3.88 g.100 ml^{-1}) contents were maximal at the rank 19. For MYD, the maximum contents of total sugars (5.13 g.100 ml^{-1}) were obtained at the rank 19. However, they were 4.82 and 3.83 g.100 ml^{-1} in the rank 21 respectively for EGD and PB121 +. Not reducers sugars (NRS) contents had an evolution opposite to those of reducer and total sugars. Indeed, for WAT, MYD and EGD cultivars, respective maximum values of 1.74, 1.88 and 1.53 g.100 ml^{-1} were obtained at the rank 26. As for the PB121 +, its maximum content (1.31 g.100 ml^{-1}) was obtained at the rank 25.

DISCUSSION

The results of our study showed gustatory characteristics differences of coconut water according to varieties and maturiy stages. The EGD coconut water of rank 26 had the most salty taste and that of WAT rank 21, the most sour. Sweet, salty and sour tastes of the studied coconuts water corresponded to those of Campos et al. (1996) on the immature nuts. So, sweet taste predominated in coconut water whatever were cultivars and the maturity stages. This justified its evaluation according to this sensory criterion into the investigated populations, according to Assa et al. (2006). Specifically, the coconut water from MYD and EGD cultivars fruits of ranks 19 (7 months) and 21 (9 months) had the most sweet taste. These samples were more appreciated by most of testers. They are moreover, most appreciating by the consumers. Indeed, the water of immature coconuts is more used thanks to these virtues and especially its sweet taste (Nadanasabapathy and Kumar, 1999). This justifies its uses in the manufacture of energetic and refreshing drinks (Jackson et al., 2004). The immature coconut water from WAT and PB121^{+} was not appreciated by the consumers because it is not much sweetened. So, nuts water of these cultivars could be promoted in drinks only after addition of sweetening compounds. Moreover, previous results (Assa et al., 2007) revealed sugars chromatographic profiles of WAT, MYD, EGD and PB121+ coconut water. The results showed qualitatively, identical sugars, for these cultivars. Indeed, fructose, sucrose, glucose and sorbitol are majority sugars with different concentrations according to varieties. These results showed that coconut water from MYD had total sugars content statistically identical to that of EGD at the rank 21. It confirms the sensory profiles obtained in our study. So, the coconut water sweet tastes perception has the same evolutions as those of their total sugars contents. The consumer could therefore act efficiently as mean of the coconut water sugars contents valuation. However, at the rank 19, water of EGD nuts with little sweetness than that of MYD, is the most appreciated by the tasters. It means that, except the total sugars contents of the coconut water, other factors would intervene for its preference.

Indeed, according to Lemordant (1988), the main sweet constituents have different sweetening powers. So, sucrose is used as reference with a sweetening power of 1. Fructose and sorbitol have respective sweetening powers of 1.7 and 0.7; while those of glucose, glycerol and galactose are 0.5. This difference of sweetening powers suggests distances between coconut sugars contents and their gustatory preferences. So, the maximum proportions in sucrose and fructose of the coconut water from EGD at ranks 19 and 21 would justify

Table 3. Sugars contents (g.100 g^{-1}) of coconut water of different cultivars at different maturity stages.

Cultivars	Ranks (R)	TS	RS	NRS	P intra cultivar
WAT	R17	3.53	3.5	0.03	P<0.01
	R19	3.98[b]	3.88	0.11	
	R21	3.66	2.94	0.74	
	R23	2.22	1.08	1.14	
	R25	1.87	0.45	1.42	
	R26	2.01	0.25	1.74	
MYD	R17	4.33[b]	4.15	0.18	P<0.01
	R19	5.03[a]	4.42	0.39	
	R21	5.13[a]	3.76	1.37	
	R23	3.52	1.82	1.71	
	R25	2.51	0.70	1.82	
	R26	2.19	0.29	1.88	
EGD	R17	3.80	3.42	0.38	P<0.01
	R19	4.75[a]	4.41	0.08	
	R21	4.82[a]	4.38	0.46	
	R23	3.05	1.71	1.34	
	R25	2.22	0.89	1.33	
	R26	2.26	0.71	1.53	
PB121 +	R17	2.50	2.38	0.12	P<0.01
	R19	3.41	3.22	0.18	
	R21	3.83	3.59	0.24	
	R23	3.62	2.85	0.76	
	R25	2.76	1.45	1.31	
	R26	2.51	1.57	0.92	
P inter cultivar		P<0.01	P<0.01	P = 0.05	
LSD		0.44	0.52	0.26	

TS: Total sugars. RS: reducer sugars. NRS: not reducer sugars; p: significant level. LSD: little significant difference.

their preference in comparison with that of MYD (Assa et al., 2007). Besides, according to some oral information, at rank 19; the coconut aroma of EGD would be more pleasant, preferable to that of MYD. Moreover, there is a biochemical explanation of the gustatory characteristics evolution of coconut water during the ripening of nuts. Indeed, at the early immature stages; immediately after fecundation, inflorescence sap sugars enter the fruit across the peduncle. They lead to a complete conversion of sucrose in glucose and especially in fructose, which has high sweetening power. It is effective under the effect of an enzyme (the invertase) exiting in the peduncle (Delrot, 2000). However, from the rank 19 or 21, the glucose of coconut water is progressively redeployed into kernel's sucrose and polysaccharides. This is due to hydrolysis reactions implicating alcohols functions (Omotosho and Odeyemi, 2012). At genetic level, the coconut water gustatory characteristics do not seem to be heritable parameters. Indeed, the coconut water sensory profiles from hybrid $PB121^{+}$, MYD and WAT (Bourdeix et al., 1992) shows a sweet taste very close to that of the male parent GOA, between ranks 17 and 19. On the contrary, it gets closer to the female parent; MYD between ranks 21 and 23. It is beyond the two parent's values between ranks 25 and 26.

The salty and sour tastes perception of hybrid PB121+ nuts water is close to those of the male parent especially from the rank 23. So, inventory and study on genes responsible of coconut water taste would allow to more understanding their expression and their regulation following Delseny et al. (2002) previous studies on *Arabidopsis thaliana.*

Conclusion

The coconut water sensory characterization during nuts ripening was performed to give indicators for an efficient

technological promotion. This study underlines compliance between the sweet sensory profiles of coconut water and its sugars contents obtained by physic-chemical tests. Our results show that the immature coconut water from Dwarf cultivars (MYD and EGD) at ranks 19 and 21 are more appreciated. Indeed, their sensory characteristics, with sweetness predominance, better meet needs of consumers. Specifically, these dwarf cultivars could be recommended to the peasants and other coconut actors of coastal regions where there is a big consumption of immature nuts water. Moreover, the coconut water of MYD and EDG cultivars can be specifically promoted as sweet and nutritious drinks in order to augment the profitability of the coconut tree.

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