Identification of High-Sugar Dwarf Coconut Varieties for Coconut Water-Based Sugar Production in Côte d'Ivoire"

Abstract

Coconut cultivation is a vital cash crop with significant potential for employment generation, particularly for youth and women. Its diverse applications in the agro-industry include the use of coconut water for consumption (beverage) and the production of sugar suitable for diabetic diets. This study aimed to identify high-sugar-yielding dwarf coconut varieties in Côte d'Ivoire. Ten dwarf cultivars were selected from the international collection, and a total of 150 nuts, 9-month-old nuts were harvested from 50 randomly selected trees (3 nuts per cultivar), were analyzed. Biochemical parameters, including Brix level, dry matter, pH, reducing and total sugars, and macronutrient content, were determined using standard methods. Among the varieties, the Malayan Red Dwarf exhibited the lowest dry matter content (6.22±0.32%), while the Sri Lanka Green Dwarf had the highest (7.46±0.05%). All cultivars exceeded the Codex Alimentarius 2022 standard of 5.0% Brix, with green cultivars such as Tacunan Green Dwarf, Thailand Green Dwarf, Brazil Green Dwarf, Pilipog Green Dwarf, and Sri Lanka Green Dwarf showing total soluble solids values close to or above 7. In conclusion, these high-Brix cultivars are suitable for coconut water sugar production

Keywords : identification, sweetest dwarf, coconut water

Introduction

Coconut cultivation spans approximately 12 million hectares globally, with an annual production of 61.5 million tonnes of copra (**FAO, 2014**). This crop serves as a primary source of income for 10 million families worldwide (**Yao et al., 2011**). In Côte d'Ivoire, coconut plantations cover 50,000 hectares, primarily in the coastal regions, yielding approximately 70,000 tonnes of copra annually (Assa et al., 2012). Coconut cultivation sustains over 20,000 families in these areas, where alternative cash crops are limited (**MINADER, 2014**). Copra, the primary by-product of coconut harvesting, is valuable, but other parts of the coconut plant are also utilized. The husks are employed for making ropes and nets, and the shells are used for fuel and activated charcoal **(CIRAD, 2007**). The kernel and water within the nut are vital components, with coconut water being used in various industries. Coconut palms are categorized into three ecotypes: tall, dwarf, and hybrid (**Prades, 2011**). Tall varieties represent the majority of global plantations, while dwarf palms are generally cultivated for their "mouth nuts" and hybrids and tall palms are more suited for copra production (**UNCTAD, 2016**). The demand for coconut-derived products, including coconut milk, water-based drinks, and coconut water-based soft drinks, has risen sharply in recent years (**Prades *et al.*, 2012**). Coconut water is also used in traditional medicine, microbiology, and can be processed into vinegar and wine (**Sanchez *et al.,* 1985; Augustine, 2007**). Recently, immature coconut water has gained attention as a potential source for table sugar production, deemed a profitable activity (**Akpro, 2019**).

Several studies indicate that the sugar content of immature coconut water correlates with its total soluble solids (**Assa et al., 2007; Akpro, 2019**). Akpro et al. (2018) demonstrated the feasibility of producing various forms of sugar from 8–9-month-old coconut water. Furthermore, dwarf coconut varieties are generally sweeter than tall and hybrid varieties, with their water being more favored for consumption due to its superior taste (**Prades *et al*., 2012**). Previous research has also identified several key nutrients in coconut water, including potassium, and it is recognized as a low-fat, carbohydrate-rich liquid with sugars such as fructose, glucose, and sucrose (**Assa *et al.,* 2006; Naozuka *et al*., 2011**). Given these properties, coconut water has gained recognition as an energy drink for athletes (**Rolle, 2007**).

Côte d'Ivoire hosts an international collection of coconut palms, including 16 varieties of dwarf coconuts. However, no comparative studies have focused on their sugar content. This study aims to identify the sweetest dwarf varieties suitable for water-based sugar production from immature coconuts, based on biochemical analysis.

1. Materials and Methods

1.1 Plant material

The plant material consisted of 9-month-old immature coconuts of 10 dwarf coconut varieties from the international collection held by Marc Delorme of the Centre National de Recherche Agronomique (CNRA, Côte d'Ivoire). These are Mandag Brown Dwarf (MBD), Malayan Yellow Dwarf (MYD), Niu Leka Dwarf (NLAD), Malayan Red Dwarf (MRD), Equatorial Guinea Green Dwarf (EGD), Catigan Green Dwarf (CATD), Tacunan Green Dwarf (TACD), Pilipog Green Dwarf (PILD), Sri Lanka Green Dwarf (PGD) and Thaïlande Green Dwarf (THD).

1.2 Methods

1.2.1. Sampling plan

Five trees were randomly selected for each cultivar, giving a total of 50 trees. From each tree, 3 immature nuts, 9 months old, were randomly collected from different positions in order to form a representative sample. A total of 150 nuts were analysed.

1.2.2. Physico-chemical characterisation of coconut water

1.2.2.1. Determination of the volume of coconut water

After harvesting, the nuts were shelled using a stainless steel machete. The nuts were opened and the water collected in a graduated cylinder. The volume of water in each nut was thus quantified.

1.2.2.2. Determining the Brix level (°Bx) of coconut water

Brix is the percentage of sugar in a liquid product. It is determined by the method recommended by the AOAC (1990). Using an electronic refractometer, the sugar concentration was determined by placing a drop of coconut water on the refractometer slide and covering it with the coverslip. The reading was taken through the prism on the graduated ruler at the bottom of the apparatus and illuminated by the electric lamp.

1.2.2.3. Determination of pH of coconut water

pH is a parameter used to assess the acidity, basicity or neutrality of a liquid product. For each sample, the pH was determined using an electronic pH meter.

1.2.2.4. Determination of dry matter

The dry matter content was determined according to the methods recommended by the AOAC (1990). A quantity of 5 g of coconut water was weighed and placed in tared porcelain crucibles of known mass (M0). The crucible and sample (M1) were oven-dried at 105 °C until the mass of the sample remained constant. The crucible containing the dry product was then removed from the oven, cooled in a desiccator and weighed (M2). The dry matter content (DMC) is determined by the following expression.

$$\text{DMC} = \frac{M2-M0}{M1-M0} * 100$$

M0: Mass of empty crucible; **M**1: Mass of empty crucible **+** fresh sample**; M2**: Mass of empty crucible **+** dried sample

1.2.2.5. Determination of ash content of coconut water

The ash content is determined according to the **AOAC (1990**) method. Five (5) grams (Me) of coconut water were placed in a porcelain crucible of known initial mass (M0) and then placed in a muffle furnace heated to 900 °C for 3 hours. After cooling, the empty crucible plus the sample (M1) was weighed on an electronic balance. The ash content is obtained using the following equation:

$$\text{Ash } (\%) = \frac{(M1-M0)}{Me} * 100$$

M0: mass (g) of the empty crucible; **Me**: mass (g) of the sample; **M1**: mass (g) of the whole (crucible + ash) after incineration

1.2.2.6. Determination of reducing sugars in coconut water

The reducing sugar content is determined by the technique described by **Bernfeld (1955)**.

To a test tube containing 1 ml of coconut water, 0,5 ml of distilled water and 0,5 ml of DNS were added. The mixture was homogenised and placed in a boiling water bath (temperature ??) for 5 minutes. Then 2 mL of distilled water was added to the reaction medium while cooling on the bench. The optical density (OD) was read on a spectrophotometer at a wavelength of 540 nm in the presence of a control containing 1 mL of distilled water. The calibration curve was used to calculate the reducing sugar concentrations of the samples according to the following formula:

$$\text{Reducing sugar } (\%) = \text{df } \left\{ \frac{5*(DO_E - DO_B)*10^3}{9.525} \right\}$$

df: dilution factor ; **ODS**: optical density of sample ; **ODB**: optical density of blank

1.2.2.7. Determination of crude fibre in coconut water

The fibre content was determined by the **AOAC (1990**) method. To one (1) gram (g) of coconut water was added 50 mL of sulphuric acid, normality 0,25 N. The mixture was boiled for 30 minutes under reflux cooling. To this new solution, 50 mL of sodium hydroxide, standard 0.31 N, was added and boiled for 30 min. The extract obtained after boiling was filtered through Whatman filter paper and the residue was washed three times with hot distilled water until a clear filtrate was obtained. The residue was oven dried at 105 °C for 8 hours. It was cooled in a desiccator and then weighed (M1). The residue obtained was calcined in an oven at 550 °C for 3 hours, cooled in a desiccator and the ash was weighed (M2). The fibre content is given by the following formula:

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$$\textbf{Fiber content} \quad (\%) = \frac{(M1-M2)}{Me} * 100$$

M1: mass (g) of dried residue; **M2**: mass (g) of ash obtained; **Me**: mass (g) of sample

1.2.2.8. Determination of lipids in coconut water

The SOXHLET method according to **AFNOR (1986)** was used to determine the fat content. Ten (10) grams of dehydrated coconut water were ground, then placed in a Wathman cartridge and capped with cotton to prevent rising during heating. Next, 100 mL of hexane was transferred to the extraction flask. The flask was then connected to the extractor. The coolant valves were opened and the heating caps turned on for 4 hours. The extraction flask was then removed from the SOXHLET unit and the solvent evaporated using a rotary steamer. The flask containing the fat was dried in an oven at 60°C for 20 min, cooled in a desiccator and weighed. The lipid content was calculated using the following formula

$$\textbf{Lipids} \quad (\%) = \frac{(M1-M0)}{Me} x100$$

M1: mass (g) of dried residue; **M0**: mass (g) of ash obtained; **Me**: mass (g) of sample.

1.2.2.9. Determination of protein in coconut water

The protein content was determined by the Kjeldahl method (**AOAC, 1990**).
To a mineralisation tube containing 1 g of sample, a pinch of catalyst (selenium + potassium sulphate (K_2SO_4)) and 20 mL of 95% sulphuric acid were added successively. The mixture was placed in a digester at 400°C for 3 hours. After cooling, the clear solution obtained was transferred to a 100 mL volumetric flask and made up to the mark with distilled water. The mineralisation tube containing 10 mL of the resulting mineralizate and 10 mL of sodium hydroxide (40%) was then placed in a distillation apparatus and the extension tube connected to the apparatus condenser was immersed in an Erlenmeyer flask containing 20 mL of boric acid in the presence of a colour indicator (mixed indicator). After 10 minutes of distillation, the conical flask is removed from the distillation apparatus and the total nitrogen content of the mixture is titrated with a 0.1 N sulphuric acid solution. The nitrogen content is determined according to the following formula :

$$\textbf{Nitrogen content} = \frac{(Va - V0) * MN * Na * 100}{1000 \, Pe}$$

Na : Normality of sulfuric acid (0.1 N), **Va**: Volume of sulfuric acid poured at the bend, **Vo**: Volume of control (0.15 mL), **MN**: Molar mass of nitrogen, **Pe** : Test sample

Protein content is deduced on the basis of nitrogen content, given that 100 g of protein provides around 16 g of amino

Protein content = Nitrogen content x 6.25

1.2.2.10. Determination of the carbohydrate content of coconut water

The carbohydrate content of each variety was determined using the following calculation:

Carbohydrate content = 100 – (% Moisture + % Protein + % Lipids + % Ash + % Fiber)

1.2.2.11. Determination of the energy value (EV) of coconut water

Gross energy is the sum of the energy values provided by the different food components. These energy values are 23.7 kJ/g, 39.5 kJ/g and 17.2 kJ/g for proteins, lipids and carbohydrates respectively (Guillaume et al., 1999). The energy value of coconut water is expressed by the following formula :

EV (kJ/100g) = (23.7 x Protein content) + (39.5 x lipids) + (17.2 Fibre) + (17.2 carbohydrates content)

23.7: amount released by 1g of protein
39.5: amount released per 1g lipid
17.2: amount released per 1g carbohydrate
17.2: amount released per 1g fiber

1.2.2.12. Statistical analysis of data

All measurements were performed in triplicate (3 experiments). Statistical analysis of the data was performed using SPSS software. The significance of differences was calculated using the DUNCAN test at the 5% significance level.

2. The results

2.1. Water content, Brix, pH and fibre content

The nut water volume, Brix level, pH and fibre content of the ten dwarf coconut varieties studied are presented in Table 1.

Among the varieties studied, the lowest volume was observed in Sri Lanka Green Dwarf (116.66±1.52 mL), which was significantly different from the other varieties. Thailand Green Dwarf, Malayan Red Dwarf, Tacunan Green Dwarf and Malayan Yellow Dwarf have statistically identical water volumes at the 5% threshold of 276.66±4.50 mL, 308.33±2.46 mL, 332.33±3.00 mL and 333±4.27 mL respectively. New Guinea Brown Dwarf has the highest water volume (370.66±46.7) and is statistically different from the other cultivars.

The highest pH values are observed in Niu Leka Dwarf (5.69±0.06), Catigan Green Dwarf (5.68±0.01), Malayan Yellow Dwarf (5.63±0.2) and Equatorial Guinea Green Dwarf (5.56±0.24) with statistically identical values ($p < 0.5$). The lowest pH value was observed in the Malayan Red Dwarf (5.13±0.02).

The Brix (soluble solids) of the water of the varieties studied ranged from 7.46±0.05% (Sri Lanka Green Dwarf) to 6.22±0.32% (Malayan Red Dwarf), with significant differences. Using statistical tests, the varieties can be divided into two groups according to their soluble solids content. The first group can be formed by Sri Lanka Green Dwarf (7.46±0.05), Pilipog Green Dwarf (7.26±0.30), Brazil Green Dwarf (7.10±0.36), Thailand Green Dwarf (7.00±0.17) and Tacunan Green Dwarf (6.93±0.51%). The second group, with values statistically inferior to the first, includes Malayan Red Dwarf, Madang Brown Dwarf, Catigan Green Dwarf, Niu Leka Dwarf and Malayan Yellow Dwarf, with contents of 6.22±0.32 ; 6.33±0.41% ; 6.40±0.43% ; 6.5±0.51% and 6.74±0.12%, respectively.

Fibre content varied between cultivars, with significantly lower values ranging from 0.08±0.01% (BGD) to 0.31±0.02% (NLAD).

Table 1: Amount of water, Brix level, pH and fibre content of ten dwarf coconut varieties

Variétés	Water volume (mL)	Brix degree (%)	pH	Fiber content (%)
MBD	370.66 ± 46.7^{c}	6.33 ±0.41^{ab}	5.39 ± 0.16^{bcd}	0.25±0.0^{d}
MYD	333.00±42.7^{bc}	6.74±0.12^{abcd}	5.63±0.2^{ef}	0.17±0.03^{bc}
NLAD	341.66±18.9^{c}	6.5±0.51^{abc}	5.69±0.06^{f}	0.31±0.02^{e}
MRD	308.33±24.6^{bc}	6.22±0.32^{a}	5.13±0.02^{a}	0.12±0.02^{ab}
BGD	340.00±13.2^{bc}	7.10±0.36^{cde}	5.56±0.24^{ef}	0.08±0.01^{a}
CATD	339.33±18.1^{c}	6.40±0.43^{ab}	5.68±0.01^{f}	0.13±0.00^{ab}
TACD	332.33±30.0^{k}	6.93±0.51^{bcde}	5.48±0.18^{cde}	0.18±0.02^{c}
PILD	362.00±45.1^{c}	7.26±0.30^{de}	5.51±0.06^{de}	0.10±0.03^{a}
PGD	116.66±15.2^{a}	7.46±0.05^{e}	5.34±0.00^{bc}	0.30±0.03^{de}
THD	276.66±45.0^{b}	7.00±0.17^{bcde}	5.31±0.09^{b}	0.28±0.03^{de}

Values are means ± standard deviations of three measurements (n=3). The same superscript letter in the same column indicates that there is no significant difference at the 5% level between samples for the parameter concerned

2.2. Biochemical composition of nut water from 10 dwarf coconut varieties

2.2.1. Dry matter, ash, protein and fat contents

The dry matter, ash, protein and fat contents are summarised in Table 2. The results show that TACD variety has the lowest dry matter content (5.42±0.22%) while Thailand Green Dwarf variety has the highest dry matter content (7.02±0.42%). Other recorded values are 5.46±0.30% for Sri Lanka Green Dwarf, 5.79±0.28% for Malayan Red Dwarf, 5.88±0.26% for Malayan Yellow Dwarf, 5.99±0. 30% for P5 green dwarf, 6.06±0.48% for green dwarf P2, 6.13±0.13% for New Guinea Brown Dwarf, 6.52±0.45% for Thailand Green Dwarf and 6.60±0.14% for Niu Leka Dwarf.

After furnace mineralisation, the mineral content ranged from 0.17±0.01% (Niu Leka Dwarf) to 0.29±0.01% (Tacuna Green Dwarf). The ash content of Niu Leka Dwarf was significantly identical to that of Malayan Red Dwarf (0.18±0.01%), but statistically different from that of the other cultivars studied. The latter have identical ash contents. Pilipog Green Dwarf (0.22±0.04%), Catigan Green Dwarf (0.24±0.01%), Thailand Green Dwarf (0.24±0.05%), Nain Vert Sri Lanka (0.24±0.01%), Malayan Yellow Dwarf (0.26±0.02%) and Guinea Green Dwarf (0.27±0.00%) have almost the same mineral content ($p<0.5$).

The lipid contents of the coconut varieties ranged from 1.48±0.03% (Madang Brown Dwarf) to 2.63±0.21% (Catigan Green Dwarf), with statistical differences and similarities among the varieties.

Protein levels in water from dwarf varieties in this study were low, ranging from 0.18±0.01% to 0.34±0.05%. With the exception of Catigan Green Dwarf (0.18±0.01%), Tacunan Green Dwarf (0.22±0.03%) and Malayan Red Dwarf (0.25±0.09%), the water from all other varieties has statistically identical protein levels. The values are as follows: 0.27±0.02% for PILD, 0.30±0.03% for THD, 0.30±0.06% for BGD, 0.30±0.07% for MYD, 0.31±0.06% for PGD, 0.32±0.05% for MBD and 0.34±0.05% for NLAD.

Table 2: Dry matter, ash, lipid and water protein contents of the dwarfs studied

Varieties	DM (%)	Ash (%)	Lipids (%)	Proteins (%)
MBD	6.13±0.13^{cd}	0.27±0.03^{de}	1,48±0,03^{a}	0,32±0,05^{a}
MYD	5.88±0.26^{bc}	0.26±0.02^{cde}	2.36±0.22^{bcd}	0.30±0.07^{a}
NLAD	6.60±0.14^{d}	0.17±0.01^{a}	2.56±0.45^{cd}	0.34±0.05^{a}
MRD	5.79±0.28^{b}	0.18±0.01^{ab}	2.53±0.48^{cd}	0.25±0.09^{a}
BGD	7.02±0.42^{e}	0.27±0 ^{de}	1.99±0,05^{ab}	0.30±0.06^{a}
CATD	6.06±0.48^{cd}	0.24±0,01^{cd}	2,63±0,21^{d}	0,18±0.01^{a}
TACD	5.42±0.22^{a}	0.29±0.01^{e}	2.61±0.20^{d}	0.22±0.03^{a}
PILD	5.99±0.30^{bcd}	0.22±0.04^{bc}	2.06±0.03^{bc}	0.27±0.02^{a}
PGD	5.46±0.30^{a}	0.24±0.01^{cd}	1.89±0.02^{ab}	0.31±0.06^{a}
THD	6.52±0.45^{de}	0.24±0.05^{cd}	1.93±0.50^{ab}	0.300±0.03^{a}

Values are means ± standard deviations of three measurements (n=3). The same superscript letter in the same column indicates that there is no significant difference at the 5% threshold between samples for the parameter concerned

2.2.2. Carbohydrates and energy values

The carbohydrate content of coconut water varies from one variety to another. The minimum and maximum values are 2.68±0.58% (MRD) and 4.35±0.51% (BGD), respectively. For the other varieties, the carbohydrate content was 2.69±0.37% for Nain Vert P3, 2.70±0.06% for Nain Vert Sri Lanka, 2.78±0.42% for Malayan Yellow Dwarf, 2.87±0. 33% for Green Dwarf P2, 3.21±0.31% for Niu Leka Dwarf, 3.32±0.31% for Pilipog Green Dwarf, 3.58±0.84% for Thailand Green Dwarf and 3.80±0.14% for New Guinea Brown Dwarf.

Energy values ranged from 133.98±0.76 kJ (Sri Lanka Green Dwarf) to 169.18±12.66 kJ (Niu Leka Dwarf). The other varieties recorded values of 169.18±12.66 kJ for New Guinea Brown Dwarf, 146.88±5.5 kJ for Pilipog Green Dwarf, 151.35±3.52 kJ for Malayan Yelow Dwarf, 154. 40±11.71 kJ for Malayan Red Dwarf, 154.27±11.69 kJ for Thai Green Dwarf, 158.26±4.04 kJ for Tacunan Green Dwarf, 160.01±12.48 kJ for Catigan Green Dwarf and 162.50±6.14 kJ for Equatorial Guinea Green Dwarf. All analysed data are presented in **Table 3**

Table 3. Carbohydrate content and Energy values of water from the dwarfs studied

Variétés	Carbohydrates content (%)	Energy values (kJ/100g)
MBD	$3.80{\pm}0.14^{ef}$	$135.82{\pm}1.60^{b}$
MYD	$2.78{\pm}0.42^{bcd}$	$151.35{\pm}3.52^{c}$
NLAD	$3.21{\pm}0.31^{b}$	$169.18{\pm}12.66^{c}$
MRD	$2.68{\pm}0.58^{a}$	$154.40{\pm}11.71^{a}$
BGD	$4.35{\pm}0.51^{f}$	$162.50{\pm}6.14^{c}$
CATD	$2.87{\pm}0.33^{bcd}$	$160.01{\pm}12.48^{c}$
TACD	$2.69{\pm}0.37^{b}$	$158.26{\pm}4.04^{bc}$
PILD	$3.32{\pm}0.31^{cde}$	$146.88{\pm}5.53^{bc}$
PGD	$2.70{\pm}0.06^{bc}$	$133.98{\pm}0.76^{ab}$
THD	$3.58{\pm}0.84^{de}$	$154.27{\pm}11.69^{c}$

Values are means ± standard deviations of three measurements (n=3). The same superscript letter in the same column indicates that there is no significant difference at the 5% threshold between samples for the parameter concerned

2. DISCUSSION

Overall, the nuts of the coconut varieties studied produced low amounts of water. Among these ten varieties, the maximum amount of water is given by the Brown Dwarf New Guinea against the Green Dwarf Sri Lanka, which contains less water in its cavity. The type of ecotype can determine the amount of water in the nut cavity. Dwarfs are the ecotypes with the least water compared to large and hybrids **(Assa *et al.*, 2007 ; Prades, 2011 ; Akpro, 2019**).

The soluble dry matter content ranges from 6.22±0.32% for Malayan Red Dwarf to 7.46±0.05 for Sri Lanka Green Dwarf. These results are justified by the fact that coconut water is an unconcentrated liquid with Brix values ranging from 0 to 20°Bx. However, these results are statistically different and depend on the variety. For coconut water, the Brix values found in this study are optimal and higher than those for large and hybrid varieties. These results confirm those of **Assa *et al.,* (2007**) who showed that dwarfs are sweeter than large and hybrids. These Brix values correspond to the potential sugars present in coconut water. In fact, sugars in a liquid are the only substances with optical activity, i.e. the ability to deflect light when tested by the refractometer. The Brix values of these 10 dwarf accessions exceed the standard of 5.0% (**Codex Alimentarius, 2005-2022).** In fact, the soluble dry extract contents of Malaysian Yellow Dwarf, Equatorial Guinea Green Dwarf and Thai Green Dwarf are close to those observed in the work of **Prades (2011).**

All the varieties studied have an acidic pH ranging from 5.13±0.02 for Nain Rouge Malais to 5.69±0.06 for Nain Niu Leka, which seems to be due to the fact that coconut water contains more acidic than basic elements. These results confirm those of **Assa et al. (2007**) for Nain Vert Guinée-Equatoriale and Nain Jaune Malais and those of Prades (2011) for Nain Vert de Thaïlande (5.31±0.09). These low acidic pH values could be attributed to an increase in certain factors, including the age of the nut and the plant, as well as the components of the coconut water. The water of the varieties studied contains residues of strong and weak acids, in this case amino acids, fatty acids, vitamin C and carbon dioxide dissolved during the ripening of the nut (**Jayalekshmy *et al*., 1988, Assa *et al*., 2007, Kodjo *et al*., 2015**).

The fibre content is low for all the varieties studied, with values ranging from 0.18±0.01% to 0.31±0.02%. These contents are lower than those of orange juice and other fruits, which are around 0.8 g/100 g, and can be explained by the fact that coconut water, unlike fruit and vegetables, is naturally low in fibre. Coconut water from these sources is therefore not rich in fibre, but can be considered a source of fibre. This is soluble fibre, which dissolves easily in water and is easily digested by the body.

Brix is also a measure of soluble dry matter, so values should be close to those of the dry matter content of coconut water. Thus, the dry matter contents range from 5.42±0.22% to 7.02±0.42%, while the Brix degrees vary from 6.22±0.32% to 7.46±0.05. Relative to the dry matter, these values are low and could be explained by the liquid nature of our working material (coconut water). Green Dwarf from Equatorial Guinea has a dry matter content of 7.02%, which confirms that of **Assa *et al.,*. (2007**). The dry matter content of water from Malayan Yellow Dwarf (5.88±0.26%) is slightly lower than that of **Akpro (2019**).

The varieties studied all have low ash contents, ranging from 0.17±0.01% for Nain Niu Leka to 0.29±0.01% for Nain Vert P3. These low levels could be explained by the fact that coconut water is low in minerals, which are more commonly found in fruit and vegetables. These ash levels are lower than those determined in nut water from PB121 ordinary hybrids and PB121 vitro plants (**Brou *et al*., 2016**). The low lipid content found would be due to the immature nature of the nuts. At this stage of maturity, all nut components have low lipid contents. The same applies to the protein levels, which are low but identical to the protein levels of the normal PB121 and PB121 vitroplant hybrids studied by **Brou et al. (2016**). These low levels can be explained by the increase in sugar content in coconut water, which is inversely correlated with the increase in fat and protein content (**Assa *et al.,* 2007 ; Brou *et al*., 2016).**

Total sugars, reducing sugars and fibre make up the total carbohydrates. The different dwarf accessions are well supplied with carbohydrates, with significant differences between them. The high carbohydrate content can be explained by the high total soluble solids content, which is reflected in the sweet taste of the nuts. The Guinea Green Dwarf from Equatorial Guinea has the highest carbohydrate content. This high carbohydrate content may be due to the fact that most fruits are rich in carbohydrates. Coconut water is also used to reduce sugar in other fruit juices, and is of interest to industrialists. Fresh coconut water is ideally consumed as a refreshing soft drink. It is also processed without loss of quality attributes, packaged and stored appropriately (**Rethinam and Krishnakumar. 2022**). Unlike sap, which in its original form contains 14-16% sucrose, coconut water contains 6-7% (**Hebbar *et al*., 2022**). The contents of this study confirm those of the **USDA (2010**), which show that coconut water contains up to 5 % carbohydrates.

Coconut water of the varieties studied has high energy values due to the presence of significant amounts of proteins, lipids, carbohydrates and fibres, which are energy sources. However, these values are higher than those reported by the USDA (2010), which found values below 100 kJ. As the Brix value correlates with the sugar content of coconut water, the varieties with potential for producing sugar from coconut water are Malayan Yellow Dwarf, Equatorial Guinea Green Dwarf, Tacunan Green Dwarf, Pilipog Green Dwarf, Sri Lanka Green Dwarf and Tahiland Green Dwarf.

Conclusion

The main objective of this work was to identify dwarf coconut varieties grown in Côte d'Ivoire with a sweeter liquid albumen and a higher Brix degree. This characteristic corresponds to the potential for producing sugar from coconut water. The study involved 10 dwarf coconut varieties. At the end of the study, there were significant differences between the levels of the biochemical parameters assessed.

Firstly, the green dwarf coconut varieties had high values of total soluble solids close to or above 7 for Tacunan Green Dwarf, Thailand Green Dwarf, Brazil Green Dwarf, Pilipog Green Dwarf and Sri Lanka Green Dwarf, while the other varieties had values below 7. For sugar production, green dwarf coconut varieties are most likely to give the best yields. Coconut water has also emerged as the fastest growing market for coconut products. The production of coconut water cans and coconut water sugar capsules for diabetics would also be an innovation to be exploited.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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