American Journal of Food Science and Technology, 2023, Vol. 11, No. 5, 175-182
Available online at http://pubs.sciepub.com/ajfst/11/5/2
Published by Science and Education Publishing
DOI:10.12691/ajfst-11-5-2

Comparative Study of the Physico-Chemical and Biochemical Parameters of the Pulp of Two Varieties of Watermelon (*Citrullus Lanatus*) Grown in Côte D'Ivoire

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Received October 08, 2023; Revised November 10, 2023; Accepted November 17, 2023

Abstract Watermelon (*Citrullus lanatus*) has been described as an important source of nutritional compounds. Investigations carried out in Côte d'Ivoire show that there is very little scientific data on it. The aim of this study was to compare the physico-chemical and biochemical compositions of the pulp of two watermelon cultivars (Kaolack and Sugar Baby) from Jacqueville, Divo and Bassam, by production area and variety. The results showed that the Kaolack variety from Jacqueville was more acidic (0.17±0.00%) and had higher lipid contents (0.1±0.01 mg/g), while that from Divo had a higher dry matter content (5.37±0.06%). And finally, the Kaolack variety from Bassam appeared to be sweeter ESS (7.8±0.10%) and had a higher moisture content (98.47±0.06%) and pH (5.38±0.01). Sugar Baby from Jacqueville had high dry matter (5.73±0.4%) and fiber (0.46±0.01%), Sugar Baby from Divo was more concentrated in acid (0.17±0.00%), protein (0.58±0.02%) and moisture (97.57±0, 06%) and the Sugar Baby variety from Bassam was more concentrated in ESS sugar (7.89±0.06%) with a pH of (5.47±0.01) and high carbohydrate (11.65±0.07 mg/g), total sugar (0.70±0.00 mg/g) and reducing agent (0.52±0.00 mg/g) contents. The study highlighted the physico-chemical and biochemical composition of watermelon varieties grown in Côte d'Ivoire. However, these parameters differed from one production area to another and from one variety to another, which could be due to the impact of the production area and the variety.

Keywords: *watermelon, production areas, variety, Côte d'Ivoire, nutritional compound, comparative study*

Cite This Article: Gbraguhé Désirée Victoire, Adjouman Yao Désiré, Adou Marc, Akely Pierre Martial Thierry, and Tetchi Fabrice Achille, "Comparative Study of the Physico-Chemical and Biochemical Parameters of the Pulp of Two Varieties of Watermelon (Citrullus Lanatus) Grown in Côte D'ivoire." American Journal of Food Science and Technology, vol. 11, no. 5 (2023): 175-182. doi: 10.12691/ajfst-11-5-2.

1. Introduction

Fruits and vegetables are a group of plant foods with excellent gastronomic properties. Fruits and vegetables have very interesting biological properties, which can be applied in various fields of medicine and pharmacology, as well as in the balance of the diet, given their very high nutritional values [1].

Among the fruits is the watermelon (Citrullus lanatus), a member of the Cucurbitaceae family native to tropical Africa [2]. It is one of the five most widely consumed fruits in the world [3]. This is due to the fact that watermelon is now produced in different parts of the world, with global production estimated at over 166 million tonnes in 2018 [4]. Nutritionally speaking, watermelon contains nutrients and phytochemicals known to be beneficial to human health [5]. Epidemiological studies have demonstrated that it possesses antioxidants with anti-inflammatory and antihypertensive properties, as well as a protective effect against carbon tetrachloride-induced toxicity [5]. Watermelon's sweetness is mainly due to a combination of sucrose, glucose and fructose [6]. A plethora of evidence shows that watermelon can be effective for weight loss due to its low sodium, saturated fat and cholesterol content. Several clinical studies have shown a positive correlation between a diet rich in phytochemicals and a reduced risk of cardiovascular disease [7]. As a result, watermelon consumption has been associated with various health benefits, such as a reduced risk of developing heart disease, age-related degenerative pathologies and certain types of cancer, particularly those of the prostate, lung, colon, breast and oral cavity [1].

The aim of this study is to analyze the physico-chemical and biochemical parameters of the pulp of two varieties of watermelon (Citrullus lanatus) grown in three production zones in Côte d'Ivoire, and to determine

whether the production zone or the variety grown has an impact on watermelon parameters. The aim is to compare the parameters of one watermelon variety from the three production zones (Jacqueville, Divo and Bassam) and to compare the parameters of two watermelon varieties from the same production zone.

2. Materials and Methods

2.1. Materials

The plant material consisted of watermelon (Citrullus lanatus) varieties Kaolack and Sugar Baby from the towns of Jacqueville, Divo and Bassam. The ripe watermelons were picked from the watermelon plantations during the harvest period, which differs from one town to another. They were sorted to retain those that were healthy. They were then transported to the laboratory for testing.

2.2. Methods

2.2.1. Sampling and Extraction of Watermelon Juice

A sample of 10 ripe fruits per watermelon variety (Kaolack and Sugar Baby) was collected from growers in the three production zones (Jacqueville, Divo and Bassam) of this study. Each sample was then sent directly to the laboratory. In view of their perishable nature, the watermelons were taken care of on arrival at the laboratory for the various extractions and tests. Watermelon juice preparation was carried out in several stages using the method described by Combo et al [8] with a few modifications. Ripe watermelon fruit were washed with water to remove heavy dirt, then washed again in 1:10 diluted bleach for 20 minutes, then rinsed with water. The fruit was then peeled. This stage involved removing the skin covering the fruit with a kitchen knife (stainless steel) and all the white outer flesh covering the red (edible) flesh. The fruit was then cut into strips and the seeds removed. The watermelon strips were placed in a Mixer (Blender LB20E, Torrington, USA, 2002) and ground. The crushed material was filtered through a 0.5 mm mesh sieve to obtain the watermelon juice from each sample. The juices obtained were filled into PET plastic bottles prior to testing.

2.2.2. Determination of Water Content

Water content was determined according to AOAC method no. 925.09 [9]. Test samples of 5 mL watermelon juice in crucibles were placed in an oven (MEMERT, Schwa Bach West Germany) at 105°C for 24 hours. On removal from the oven, the crucibles containing the dried samples were placed in a desiccator for around 45 min. The dry mass plus crucibles were weighed using a precision balance (Sertorius BP 110 S, Germany). The tests were repeated three (3) times for each sample.

$$\textbf{Water content}(\%) = \frac{(\mathbf{m_1} - \mathbf{m_2})}{(\mathbf{m_1} - \mathbf{m_0})} \times 100$$

m_0 : Weighed sample weight
m_1 : Crucible weight after drying
m_2 : Weight of empty crucible

2.2.3. Determining pH

The pH was measured using a pH meter, by inserting the probe into the sample and reading the result directly on the meter's display. The sample was brought to a temperature of around 20°C [10]. The tests were repeated three (3) times for each sample.

2.2.4. Refractometric Dry Extract

Soluble dry extract (SDE) was measured (in °Brix) using a hand-held digital refractometer (ATAGO Pocket PAL-a, Japan) in accordance with AOAC method no. 925.09 [9]. A few drops of the watermelon juice obtained were placed on the lens, followed by a Brix reading after five (5) seconds. The tests were repeated three (3) times for each sample.

2.2.5. Determination of Titratable Acidity

The titratable acidity of the juices, expressed as citric acid per unit volume, was determined using the method described by Kimaryo et al [11]. 5 mL juice diluted in 50 mL distilled water from each sample was assayed with a 0.1 N sodium hydroxide solution. The results obtained were the average of three trials.

$$\textbf{Titratable acidity}(\%) = \frac{(\textbf{NaOH x VNaOH x}0,09)}{(\textbf{Vsample})} \times 100$$

V_{sample}: sample volume
$N._{NaOH}$: normality of soda added (meq-g/L)
$V._{NaOH}$: volume of soda added (mL)
0.09: milliequivalent gram of lactic acid

2.2.6. Determination of Dry Matter

Dry matter content was determined using the AOAC No. 985.26 drying method [12]. Test portions of 10 mL of watermelon juice were placed in an oven set at 105 ± 2°C for 24 hours to constant weight. Crucibles (sample + capsule) removed from the oven were weighed after cooling in a desiccator. The tests were repeated three (3) times for each sample.

$$\textbf{Dry matter content}(\%) = \frac{(p)}{(Pe)} \times 100$$

Pe: Initial sample weight
P= P2-P1; P2: weight of crucible after drying; P1: weight of weighed empty crucible

2.2.7. Determination of Ash Content

The ash content of watermelon juice samples was determined using the AOAC method [9]. 5 ml of sample was weighed and oven-dried, then ground in an incinerator capsule. The sample capsules were placed in a muffle furnace and incinerated at 550 ± 15°C for 24 hours. On leaving the furnace, the capsules were cooled in a desiccator before being weighed. The percentage of ash was calculated from the mass of the residue after incineration. The tests were repeated three (3) times for each sample.

$$\textbf{Ash}(\%) = \frac{(\mathbf{m_1} - \mathbf{m_0})}{\mathbf{m_e}} \times 100$$

m_0: mass (g) of empty crucible.
m_e: mass (g) of sample.
m_1: mass (g) of the whole (capsule + ash) after incineration.

2.2.8. Determination of Fiber Content

Total fiber content was determined using the AOAC method [12]. A 2 mL sample was weighed, dried and ground in a flask. The weighed mass was homogenized in 50 mL 0.25 N sulfuric acid and boiled for 30 min under reflux refrigeration. 50 mL of 0.31 N sodium hydroxide was added to the contents and boiled for 30 min under refluxing condenser. The extract obtained was filtered through Whatman filter paper and the residue was washed several times with hot water until the alkalis were completely removed. The residue was oven-dried at 105°C for 8 h, cooled in a desiccator and weighed. The residue obtained was incinerated in an oven at 550°C for 3 h, cooled in a desiccator and the ashes weighed. The tests were repeated three (3) times for each sample.

$$\textbf{Fiber content}(\%) = \frac{(\mathbf{m_1} - \mathbf{m_2}) \times 100}{\mathbf{m_e}}$$

m_1: mass (g) of dried residue
m_2: mass (g) of ash obtained
m_e: mass (g) of sample

2.2.9. Determination of Total And Reducing Sugar Content

2.2.9.1. Determination of Ethanosoluble Sugars

Ethanosoluble sugars were extracted from samples using the technique described by Martinez-Herrara et al [13]. A quantity of l g of sample was placed in a centrifuge tube. Ten (10) mL of ethanol (80%, v/v) was added and the mixture homogenized, then centrifuged at 4200 rpm for 10 min in a centrifuge (SIGMA 3-16 P, Germany). The supernatant was collected and stored in a 50 mL Erlenmeyer flask. The pellet was taken up in 10 mL ethanol (80%, v/v) and treated under the same conditions as before. The new supernatant was added to the first supernatant in the 50 mL Erlenmeyer flask. The ethanol in this mixture was evaporated in a water bath to one-third the volume of the extract. The concentrated extract was adjusted to 10 mL and used for the determination of ethanosoluble sugars.

2.2.9.2. Determination of Total Sugar Content

Total sugars were determined according to the technique of Dubois et al [14] using phenol and concentrated sulfuric acid. 150 µL of ethanosoluble extract was taken in a test tube. To this volume was added 1 mL phenol (5%, w/v) and 1 mL concentrated sulfuric acid (97%) respectively. The reaction medium was homogenized and allowed to cool for 5 min. Optical density was read at 490 nm using a spectrophotometer (Model MS-V 5100, Spain) against a control containing 150 µL of distilled water in place of the ethanosoluble extract. Optical density was converted to total sugars using a calibration line obtained from a glucose solution (2 mg/mL).

2.2.9.3. Determination of Reducing Sugar Content

Reducing sugars were determined using the Bernfeld technique [15], using 3,5 dinitrosalycilic acid (DNS). The ethanosoluble extract (150 µL) was collected in a test tube. To this volume, 300 µL of DNS solution was added. The mixture was heated in a boiling water bath for 5 min. After cooling for 5 min on the bench, 2 mL distilled water was added to the reaction medium. Optical density was read at 540 nm on a spectrophotometer (Model MS-V5100, Spain) against a control containing 150 µL of distilled water and 300 µL of DNS. Optical density was converted to reducing sugars using a calibration line obtained from a glucose solution (2 mg/mL).

2.2.10. Protein Determination

Protein content was determined according to method [12]. Total nitrogen was determined by the Kjeldahl method after sulfuric mineralization in the presence of selenium catalyst. 1 mL of watermelon juice in the presence of 20 mL of concentrated sulfuric acid at 400°C and 0.5 g of mineralization catalyst were introduced and mineralized under heat for 24h. After mineralization and cooling of the samples, the sample was transferred to a 100 mL flask and topped up with 50 mL distilled water. 10 mL of the mixture was withdrawn and 10 mL of 40% NaOH solution was added to the withdrawn mixture. The whole mixture was then distilled for 10 min, taking care to trap the distillate in a flask containing 20 mL boric acid (2%) with added mixed indicator (methyl red + bromocresol green). The distillate obtained was titrated with a 0.01 N sulfuric acid solution until it turned orange. Analyses were performed in triplicate.

$$\textit{Total protein}(\%) = \frac{(\mathbf{V_1} - \mathbf{V_0}) \times 14 \times 6,25 \times \mathbf{N}}{\mathbf{m_e}}$$

V_0: volume (mL) of sulfuric acid solution poured for blank test.
V_1: volume (mL) of sulfuric acid solution poured for the test (sample).
N: normality of sulfuric acid solution: 0.01.
m_e: sample mass (g).

2.2.11. Lipid Determination

Lipids were determined using the AFNOR method **[16].** A quantity of 10 mL of sample was introduced into a cellulose extraction cartridge which had been tared beforehand. The cartridge containing the sample was plugged with cotton and placed in a Soxhlet extractor. Total lipid extraction was performed using 300 mL of refluxing hexane for 7 hours at boiling point. The hexane was evaporated using a rotary evaporator. The extraction flask was incubated at 100°C for 20 min, then dried. The whole set (flask + lipids) was weighed. Analyses were performed in triplicate.

$$\textbf{Lipides}(\%) = \frac{(\mathbf{m_1} - \mathbf{m_0}) \times 100}{\mathbf{m_e}}$$

m_0: mass (g) of empty flask
m_e: mass (g) of sample
m_1: mass (g) of the whole (flask + lipids) after incineration

2.3. Statistical Processing of Data

Data from physicochemical and biochemical analysis for the comparative study of parameters of one watermelon variety (Kaolack or Sugar Baby) from the three production zones were statistically processed using SPSS 20.0 statistical software. The 1-factor ANOVA test was used to verify the homogeneity of variance at the 5% threshold. Duncan's test at the 5% threshold was used to check the significance of parameters with a homogeneous distribution.

Data from physicochemical and biochemical analysis for the comparative study of parameters of two watermelon varieties (Kaolack and Sugar Baby) from the same production area were statistically processed using SPSS 20.0 statistical software. Equality of variance was verified by Levene's test at the 5% threshold. The Student's T-test was used to verify the equality of the means of the different parameters.

3.Results and Discussion

3.1. Results

3.1.1. Physico-Chemical and Biochemical Characteristics of Watermelon Varieties (Kaolack and Sugar Baby) from Jacqueville, Divo and Bassam

Average values for pH, moisture content, titratable acidity, SSE, dry matter, ash content and fiber content of Kaolack and Sugar Baby watermelon samples from different zones are shown in Table 1, respectively. Significant differences ($p<0.05$) were recorded in the physico-chemical parameters of each sample, except for ash content, where no significant difference ($P>0.05$) was observed between samples of the Kaolack and Sugar Baby varieties from Jacqueville and Bassam.

- pH and titratable acidity values

The pH of the Kaolack variety samples collected in the different study areas ranged from 5.18 to 5.38, and titratable acidity from 0.15 to 0.17%. In contrast to the Divo and Bassam samples, the Jacqueville sample had the highest pH value (5.38) and the lowest titratable acidity (0.15) (Table 1). The results (Table 1) also show that the Sugar Baby watermelon variety from the three study areas had a pH value ranging from 5.02 to 5.47 and a titratable acidity content of between 0.15 and 0.17%. The Sugar Baby watermelon variety from Bassam had a higher pH (5.47) and lower titratable acidity (0.15) than samples from Jacqueville and Divo.

- Moisture and dry matter content

Average moisture and dry matter content values for the Kaolack watermelon variety from the study areas are shown in Table 1. They ranged from 94.63 to 98.47% for moisture and from 1.53 to 5.37% for dry matter. Unlike the samples from Jacqueville and Divo, those from Bassam had a higher moisture content (98.47%). Samples from Divo had the highest dry matter content (5.37%) compared to samples from Jacqueville and Bassam. For the Sugar Baby variety recovered, moisture and dry matter contents ranged from 94.23-97.57% and 2.47-5.73% respectively for the three study areas (Table 1). The watermelon sample from Jacqueville was richer in dry matter (5.73%), while that from Divo had a high moisture content (97.57%).

- Soluble solids content (ºBrix)

The Kaolack watermelon variety from the study sites had a SSE content ranging from 7.06 to 7.8 ºBrix. In contrast, the ESS content of the Sugar Baby variety ranged from 7.22 to 7.89 ºBrix (Table 1). The Kaolack and Sugar Baby watermelon varieties from Bassam had higher ESS contents (7.80 ºBrix Kaolack variety and 7.89 ºBrix Sugar Baby variety). As a result, they appear to be sweeter than those from Jacqueville and Divo.

- Ash and fiber content

Ash and fiber content of the Kaolack watermelon variety from Jacqueville, Divo and Bassam ranged from 0.19 to 0.24% and 0.22 to 0.40% respectively. And those of the Sugar Baby variety varied from 0.23 to 0.34% and 0.19 to 0.46% respectively (Table 1). However, the results showed that the Kaolack and Sugar Baby varieties from Jacqueville had higher fiber concentrations (0.40%) and (0.46%) respectively. And Kaolack and Sugar Baby samples from Divo had higher ash contents (0.24%) and (0.34%).

- Carbohydrate content, total sugars, reducing sugars

Analysis of the biochemical parameters of Kaolack and Sugar Baby watermelon variety samples from the three study sites shows a significant difference ($p < 0.05$) in the distribution of carbohydrates, total sugars and reducing sugars (Table 2). Total sugars obtained from samples of the Kaolack variety ranged from 0.39 to 0.63 g/100 g, reducing sugars from 0.22 to 0.48 g/100 g, while carbohydrates varied from 7.63 to 10.67 g/100 g. As for the Sugar Baby variety, total sugars, reducing sugars and carbohydrate contents ranged respectively from 0.36 to 0.70 g/100g; 0.24 to 0.52 g/100g; 7.14 to 11.65 g/100g. In contrast to the Jacqueville and Divo samples, the Bassam samples showed the highest concentrations of total sugars (0.63 g/100g), reducing sugars (0.48 g/100g) and carbohydrates (10.67 g/100g) for the Kaolack variety, and also for the Sugar Baby variety (total sugars (0.70 g/100g), reducing sugars (0.52 g/100g) and carbohydrates (11.65 g/100g).

- Lipid and protein content

The Kaolack and Sugar Baby watermelon samples from the study sites show a significant difference ($p<0.05$) in lipid repair. However, no significant difference ($P>0.05$) was observed in the protein distribution of Kaolack samples from Divo and Bassam. The lipid and protein content of samples of the Kaolack variety ranged from 0.03 to 0.1 mg/100g and 0.44 to 0.52 mg/100g respectively. Sugar Baby samples ranged from 0.01 to 0.11 mg/100g and 0.43 to 0.54 mg/100g respectively (Table 2). Samples of the Kaolack variety from Jacqueville were more concentrated in lipids. Protein content according to the Ducan test was similar in the Divo and Bassam samples, and more abundant than in the Jacqueville sample. Samples of the Sugar Baby variety from Jacqueville were richer in lipids, while those from Divo were richer in protein.

Table 1. Physico-chemical parameters for 100 g of watermelon pulp of the Kaolack and Sugar Baby varieties

	pH	T. Humidity (%)	Titratable acidity (%)	ESS (ºBrix)	Dry matter (%)	Ash (%)	Fiber (%)
V.K.$_{JAC}$	5,18±0,01^{a}	95,27±0,15^{b}	0,17±0,00^{c}	7,06±0,06^{a}	4,77±0,11^{b}	0,2±0,01^{a}	0,4±0,01^{c}
V.K.$_{DIV}$	5,22±0,01^{b}	94,63±0,06^{a}	0,15±0,00^{a}	7,41±0,15^{b}	5,37±0,06^{c}	0,24±0,01^{b}	0,3±0,02^{b}
V.K.$_{BASS}$	5,38±0,01^{c}	98,47±0,06^{c}	0,16±0,00^{b}	7,8±0,10^{c}	1,53±0,06^{a}	0,19±0,01^{a}	0,22±0,01^{a}
V.SB.$_{JJAC}$	5,28±0,01^{b}	94,23±0,42^{a}	0,16±0,00^{b}	7,35±0,06^{ab}	5,73±0,4^{c}	0,23±0,01^{a}	0,46±0,01^{c}
V.SB.$_{DIV}$	5,02±0,01^{a}	97,57±0,06^{c}	0,17±0,00^{c}	7,22±0,1^{a}	2,47±0,11^{a}	0,32±0,02^{b}	0,34±0,03^{b}
V.SB.$_{BASS}$	5,47±0,01^{c}	96,83±0,12^{b}	0,15±0,00^{a}	7,89±0,06^{b}	3,18±0,12^{b}	0,24±0,01^{a}	0,19±0,01^{a}

Values in the same column that do not have the same letter are significantly different (p<0.05). Values are expressed as Mean ± Standard deviation (n=3). V.K.$_{JAC:}$ Variété Kaolack Jacqueville, V.K.$_{DIV:}$ Variété Kaolack Divo, V.K.$_{BAS:}$ Variété Kaolack Bassam, V.SB$_{JAC:}$ Variété Sugar Baby Jacqueville, V.SB.$_{DIV:}$ Variété Sugar Baby Divo, V.SB$_{BAS:}$ Variété Sugar Baby Bassam, ESS: soluble dry extract.

Table 2. Biochemical parameters for 100 g of watermelon pulp of the Kaolack and Sugar Baby varieties

	Total sugars (g/g)	Reducing sugars (g/g)	Carbohydrates (g/g)	Lipids (mg/g)	Protein (mg/g)
V.K.$_{JAC}$	0,57±0,00^{b}	0,43±0,00^{b}	10,18±0,00^{b}	0,1±0,01^{c}	0,44±0,02^{a}
V.K.$_{DIV}$	0,39±0,00^{a}	0,22±0,00^{a}	7,63±0,00^{a}	0,07±0,01^{b}	0,52±0,01^{b}
V.K.$_{BASS}$	0,63±0,00^{c}	0,48±0,00^{c}	10,67±0,00^{c}	0,03±0,01^{a}	0,50±0,01^{b}
V.SB.$_{JJAC}$	0,36±0,00^{a}	0,24±0,00^{a}	7,14±0,03^{a}	0,11±0,01^{c}	0,54±0,01^{b}
V.SB.$_{DIV}$	0,40±0,00^{b}	0,27±0,00^{b}	9,14±0,03^{b}	0,07±0,01^{b}	0,58±0,02^{c}
V.SB.$_{BASS}$	0,70±0,00^{c}	0,52±0,00^{c}	11,65±0,07^{c}	0,01±0,01^{a}	0,43±0,02^{a}

Values in the same column that do not have the same letter are significantly different (p<0.05). Values are expressed as Mean ± Standard deviation (n=3). V.K.$_{JAC:}$ Variété Kaolack Jacqueville, V.K.$_{DIV:}$ Variété Kaolack Divo, V.K.$_{BAS:}$ Variété Kaolack Bassam, V.SB$_{JAC:}$ Variété Sugar Baby Jacqueville, V.SB.$_{DIV:}$ Variété Sugar Baby Divo, V.SB$_{BAS:}$ Variété Sugar Baby Bassam

Table 3. Physico-chemical and biochemical parameters for 100 ml of Kaolack and Sugar Baby watermelon juice for each study site

	JACQUEVILLE		DIVO		BASSAM	
	kAOLACK	SUGAR BABY	kAOLACK	SUGAR BABY	kAOLACK	SUGAR BABY
pH	5,18±0,01^{a}	5,28±0,01^{b}	5,22±0,01^{b}	5,02±0,01^{a}	5,38±0,01^{a}	5,47±0,01^{b}
Humidity (%)	95,27±0,15^{b}	94,23±0,42^{a}	94,63±0,06^{a}	97,57±0,06^{b}	98,47±0,06^{b}	96,83±0,12^{a}
Titratable acidity (%)	0,17±0,00^{b}	0,16±0,00^{a}	0,15±0,00^{a}	0,17±0,00^{b}	0,16±0,00^{b}	0,15±0,00^{a}
ESS (ºBrix)	7,06±0,06^{a}	7,35±0,06^{b}	7,41±0,15^{a}	7,22±0,1^{b}	7,8±0,10^{a}	7,89±0,06^{b}
Dry matter (%)	4,77±0,11^{a}	5,73±0,4^{b}	5,37±0,06^{b}	2,47±0,11^{a}	1,53±0,06^{a}	3,18±0,12^{b}
Ash (%)	0,2±0,01^{a}	0,23±0,01^{b}	0,24±0,01^{a}	0,32±0,02^{b}	0,19±0,01^{a}	0,24±0,01^{b}
Fiber	0,4±0,01^{a}	0,46±0,01^{b}	0,3±0,02^{a}	0,34±0,03^{a}	0,22±0,01^{b}	0,19±0,01^{a}
Total sugars (g/g)	0,57±0,00^{b}	0,36±0,00^{a}	0,39±0,00^{a}	0,40±0,00^{b}	0,63±0,00^{a}	0,70±0,00^{b}
Reducing sugars (g/g)	0,43±0,00^{b}	0,24±0,00^{a}	0,22±0,00^{a}	0,27±0,00^{b}	0,48±0,00^{a}	0,52±0,00^{b}
Carbohydrates (g/g)	10,18±0,00^{b}	7,14±0,03^{a}	7,63±0,00^{a}	9,14±0,03^{b}	10,67±0,00^{a}	11,65±0,07^{b}
Lipids (mg/g)	0,1±0,01^{a}	0,11±0,01^{a}	0,07±0,01^{a}	0,07±0,01^{a}	0,03±0,01^{b}	0,01±0,01^{a}
Protein (mg/g)	0,44±0,02^{a}	0,54±0,01^{b}	0,52±0,01^{a}	0,58±0,02^{b}	0,50±0,01^{b}	0,43±0,02^{a}

Values in the same column that do not have the same letter are significantly different (p<0.05). Values are expressed as Mean ± Standard deviation (n=3). V.K.$_{JAC:}$ Variété Kaolack Jacqueville, V.K.$_{DIV:}$ Variété Kaolack Divo, V.K.$_{BAS:}$ Variété Kaolack Bassam, V.SB$_{JAC:}$ Variété Sugar Baby Jacqueville, V.SB.$_{DIV:}$ Variété Sugar Baby Divo, V.SB$_{BAS:}$ Variété Sugar Baby Bassam, ESS: soluble dry extract.

3.1.2. Physico-Chemical and Biochemical Characteristics of Two Watermelon Varieties (Kaolack and Sugar Baby) Produced in Côte d'Ivoire

The physico-chemical and biochemical parameters of watermelon varieties (Kaolack and Sugar Baby) from Jacqueville, Divo and Bassam are given in Table 3.

- Watermelon from Jacqueville

The two varieties show significant differences (P<0.05) in pH, moisture content, ESS content, dry matter, ash, fiber, total sugars, reducing sugars, carbohydrates and protein. However, lipid levels in samples of both varieties show no significant difference. This result shows that lipids are evenly distributed in both varieties. Moisture content (95.27%), acids (0.17%), total sugars (0.57 g/100g), reducing sugars (0.43 g/100g) and carbohydrates (10.12 g/100g) were higher in samples of the Kaolack variety. The Sugar Baby variety had a higher pH (5.28) than the Kaolack variety. At ESS level, contents were 7.06% for the Kaolack variety and 7.35% for the Sugar Baby variety. This result shows that the Sugar Baby variety seems to be sweeter than the Kaolack variety, since it has a higher ESS value. Sugar Baby was richer in dry matter, ash, fiber and protein, with values of 5.73%, 0.23%, 0.46% and 0.54 mg/100g respectively.

- Watermelon from Divo

Analysis of the results showed that a significant difference

at the 5% level (P≤0.05) was observed in the averages for pH, moisture content, titratable acidity, ESS, dry matter, centers, total sugars, reducing sugars, carbohydrates and proteins. On the other hand, no significant differences at the 5% level (P≥0.05) were observed for fiber and lipids. The pH, dry matter and SSE values of the samples studied were 5.22; 5.37% and 7.41% respectively for the Kaolack variety, and 5.02; 2.47% and 7.22% for the Sugar Baby variety. Higher pH, dry matter and SSE contents were observed in the Kaolack variety, which appears to be sweeter. On the other hand, Sugar Baby had higher moisture (97.57%), acid (0.17%), ash (0.32%), total sugars (0.40 g/100g), reducing sugars (0.27 g/100g), carbohydrates (9.14 g/100g) and protein (0.58 mg/100g) contents.

- Watermelon from Bassam

A significant difference at the 5% level (P≤0.05) was observed for all the parameters analyzed, except for fiber content, where no significant difference at the 5% level (P≥0.05) was observed. The results showed that the Kaolack variety was wetter (98.74%), more acidic (0.16%), rich in fiber (0.22%), lipids (0.03%) and protein (0.50%). The Sugar Baby variety, on the other hand, had a higher pH (5.47), ESS (7.89%), dry matter (3.18%) and ash (0.24%) content, and was richer in total sugars (0.70 m/100g), reducing sugars (0.52 g/100g) and carbohydrates (11.65 g/100g).

4. Discussion

4.1. Physico-Chemical and Biochemical Characteristics of Watermelon Varieties (Kaolack and Sugar Baby) from Jacqueville, Divo and Bassam

The pH and titratable acidity contents of the watermelon varieties (Kaolack and Sugar Baby) obtained in this study all varied according to production zone. In this study, the pH values were higher than those of the Kaolack (5.01) and Sugar Baby (5.13) varieties recorded by David et al [17] in a previous study carried out in Burkina Faso. Titratable acidity levels were well below those of the Kaolack (5.58%) and Sugar Baby (4.98%) varieties obtained by David et al. [17]. The difference in pH and titratable acidity observed for each variety in the three production zones in this study could be explained by the climatic and soil conditions in which the watermelons were grown. Indeed, Ouattara et al [18] have indicated that the physico-chemical parameters of the fruit are influenced by the production zone. Furthermore, Adou et al [19], in their investigation of cashew apples in Côte d'Ivoire, showed that cashew apples from three different production areas had different pH and titratable acidity contents.

Variations were also observed in the moisture and dry matter content of watermelon varieties from Jacqueville, Divo and Bassam. These variations could be due to climatic conditions. According to Micek et al [20], the moisture content of watermelon can be affected by the amount of rainfall, irrigation practices and soil type in the production area. Dry matter, obtained after evaporation of the water from the fruit pulp, represents the part containing organic and mineral substances [19]. It was therefore influenced by the moisture content of the fruit collected at each site. The moisture values obtained in this study were well above the pulp moisture of ripe watermelon fruit (91%) obtained by Said [21] during his research work in Nigeria. However, the author obtained higher dry matter values (8.9%). According to Hêdiblè et al [22], the differences observed between countries are due to differences in climates and soil types specific to each country.

There was a variation in the ESS content of each variety from the study sites. This difference could be linked to the influence of the ecological zone. Adou et al [19] drew similar conclusions in their research on cashew apples from Côte d'Ivoire, where they obtained variation in the ESS content of cashew apples from Yamoussokro, Korhogo and Bondoukou. Earlier studies by Sabeetha et al [23] on the pulp of red-fleshed watermelon with seed in Malaysia reported higher ESS values, i.e. 10.46 ºBrix, which are much higher than those obtained in this study.

This study also showed that there were differences in the ash and fiber content of each watermelon variety from the study sites. These differences would be due to the production zone. Indeed, according to Hêdiblè et al [22], the physico-chemical composition of watermelon varieties was influenced by growing region, maturity, climate and cultivation practices. The ash and fiber contents of the watermelon samples reported in this study were lower than those obtained by Obinna-Echem and Koanyie [24] in their study of watermelon pulp in the state of Nigeria.

The two watermelon varieties from Jacqueville, Divo and Bassam also showed variations in the distribution of total, reducing and carbohydrate sugars. This could be explained by the fact that different soil types have different nutrient compositions that can affect watermelon sugar contents [25]. In general, the total and reducing sugar contents of the present study are lower than those obtained by some authors in their respective regions. For example, Chahal and Saini [26] reported 7.76 g/100 g total sugars and 5.52 g/100 g reducing sugars for Indo-American hybrid watermelon. As for carbohydrate content, earlier studies in Nigeria reported lower values (7.50%) than those in the study [27].

The protein and lipid contents of each watermelon variety studied varied from one production area to another, and were lower than those found by Sabeetha et al [23] in their work on watermelon pulp from Malaysia. These low levels can be explained by the fact that protein and lipid levels are linked to polyphenol biosynthesis [28]. In any case, the results of the present study show that watermelon pulp is not a source of protein or lipids. It cannot therefore be a reference food in terms of nutritional protein and lipid intake.

4.2. Physico-Chemical and Biochemical Characteristics of Two Watermelon Varieties (Kaolack and Sugar Baby) Produced in Côte d'Ivoire

This comparative study between Kaolack and Sugar Baby watermelon varieties showed that the cultivars examined at all sites showed significant variability (P<0.05) in pH, moisture, titratable acidity, ESS, dry

matter, ash, total sugars, reducing sugars, carbohydrates and proteins. No significant difference (P>0.05) was observed in lipid content between the two varieties from Jacqueville and Divo, although those from Bassam showed significant variability (P<0.05). There was no difference in fiber content between the two varieties from Divo (P>0.05), but those from Jacqueville and Bassam were significantly different. The differences observed between watermelon varieties could be explained by genomic differences and specific botanical characteristics such as degree of ripeness, harvesting period and type of growing soil [29]. Similar results to this study were found by Sadji et al . [30] who also worked on Kaolack and Sugar Baby watermelon varieties. These authors linked the difference between these varieties to fruit composition, which was influenced by various parameters including degree of ripeness. Our results also concur with those of Ali Mahamat et al [31], who reported a significant difference in pH and SSE between Sugar Baby, Crimson Sweet and Charleston Grey watermelon cultivars. Authors Niane et al [32] also reported a significant difference in titratable acidity, total sugars, reducing sugars and carbohydrates in their study of Crimson Sweet and Charleston Grey watermelon varieties. The authors Eziaghighala et al [33] also observed differences in the moisture, dry matter, ash and protein contents of three watermelon varieties: Dansuke, Orangeglo and Saskatchewan Cream. In addition, authors Yimer and Tehulie. [34] found a difference in the distribution of lipid and fiber content among the watermelon varieties studied.

5. Conclusion

Physico-chemical analysis of watermelon variety samples from the 3 zones of Jacqueville, Divo and Bassam revealed the fruit's richness in biochemical compounds. Among the 3 zones, the Kaolack and Sugar Baby samples from Bassam yielded the highest levels of pH, moisture, ESS, total sugars, reducing sugars and carbohydrates, while the Sugar Baby samples contained the highest varietal levels. Overall, the watermelon samples in this study were characterized by their low protein and lipid content. In this study, the phenolic and antioxidant compounds of the watermelon varieties were not taken into account, so it would be interesting in the future to carry out this study to better valorize them. It would also be interesting to study the impact of the production area on the physicochemical and biochemical parameters of watermelons.

Declaration of Competing Interests

The authors declare that they have no competing interests.

List of abbreviations

V.K.$_{JAC:}$ Kaolack Jacqueville variety
V.K.$_{DIV:}$ Kaolack Divo variety
V.K.$_{BAS:}$ Kaolack Bassam variety
V.SB.$_{JAC:}$ Variety Sugar Baby Jacqueville
V.SB.$_{DIV}$: Variety Sugar Baby Divo
V.SB.$_{BAS:}$ Variety Sugar Baby Bassam

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