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Evaluation of Physicochemical, Nutrient Parameters and Antioxidant Compound in Pulp of Kent and Brooks Mango Sorting Waste During Fermentation

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Abstract This study aims to evaluate physicochemical, nutritional parameters and antioxidant compound of pulps from Kent and Brooks mango sorting waste during fermentation. These mangoes collected from two, export and processing, units in Korhogo, northern Côte d'Ivoire were ripen at 25°C during 8 (Kent) and 5 (Brooks) days. After riping, pulp of each mango variety was subjected to natural fermentation during 9 days. Physicochemical and nutritional parameters with antioxidant compound of pulps were determined every 3 days during 9 days. Physicochemical analysis showed increased acidity of Kent pulp (17.33 to 31.33 meq/100g) and Brooks (19.33 to 29.33 meq/100g). However, pH decreased for Kent (4.10±0.00 to 2.97±0.00) and Brooks (3.59±0.03 to 3.36±0.01). Moisture incresead with Kent (78.66±0.05% to 85.60±0.80%) and Brooks (84.66±1.15% to 89.3±0.57%). Soluble dry extract decresead for Kent (18.33±1.2 to 14.16±0.05°Brix) and Brooks (13.33±0.57 to 11.10±0.10°Brix). Alcohol level was dropped with Kent (10.33 to 7.66%) and Brooks (8.33 to 6.56%). For nutritional parameters, fat incresead for Kent pulp (0.39±0.00 to 2.11±0.01%) and Brooks (0.07±0.01 to 1.89±0.14%). Total sugar decresead for Kent (8.57±0.50% to 3.63±0.42%) and increased with Brooks (1.34±0.00% to 3.33±0.00%). Reducing sugars decresead with Kent (2.60±0.4 to 1.89±0.14%) and incresead for Brooks (0.15±0.01 to 0.17±0.02%). Protein incresead for Kent (4.45±0.59 to 6.25±0.41g/100g) and decreased with Brooks (4.99±1.15 to 3.49±0.28g/100g). Antioxidant compound analysis in pulp showed a decrease of carotenoids for Kent (16.60±0.41 to 43.31±4.28µg/100g) and incresead for Brooks (19.14 to 11.50µg/100g). Vitamin C decreased for Kent (16.22 to 4.70mg/100g) and Brooks (17.05 to 12.11mg/100g). Vitamin A, also decreased with Kent (1.37±0.04 to 3.60±0.36µg/100g) and Brooks (1.59 to 0.95±0.00µg/100g). Polyphenols decreased with Kent (187.56 to 129.29mg/100g) and Brooks (144.13 to 130.36mg/100g). Caracteristics of phytochemical, nutritional and antioxidant compound found with fermented pulps from Kent and Brooks mango sorting waste can be used in agri-food and nutraceutical sectors.

Keywords: *Mango, Kent, Brooks, fermentation, physicochemical, nutrient, antioxidant*

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1. Introduction

Mango has significant nutritional role by providing essential micronutrients required for optimal physiological function and by exerting protective from chronic diseases, including cardiovascular, neurodegenerative, metabolic disorders, and cancer [1]. It is also highly appreciated for its sweet flavor and its richness in vitamins (vitamins A and C) and minerals [2]. Mango production has been steadily increasing, reaching an estimated 51 million tons in 2022 around the world [3]. It is second most produced tropical fruit worldwide after banana [4]. In Côte d'Ivoire, mango production is estimated at 180,000 tons annually and generated approximately 40 to 50 billion CFA francs in revenue [5,6]. For this performance, Côte d'Ivoire is lead of African exporter and third-largest global supplier of fresh mangoes [7]. Despite its nutritional and economic importance and its popularity among consumers, mango exploitation is hindered by substantial post-harvest losses. Each year, 30 to 40% of mangoes rot in orchards due to limited consumption, inadequate preservation, and insufficient export capacity [8]. These losses result in

significant financial setbacks for producers, estimated at over 3.3 billion CFA francs annually [9]. Post-harvest deterioration is primarily attributed to pathological degradation, high respiration rates, transpiration, mechanical injuries, and ethylene production [10]. Processing mangoes into derivative products has been proposed as a strategy to mitigate these losses. However, the transformation rate in Côte d'Ivoire remains low less than 10% despite recent efforts by stakeholders and public authorities [11]. High quantities of Kent and Brooks mangoes varieties are produced in northern Côte d'Ivoire. Unfortenatly, the post-harvest loss rates of these mangoes are around 40% [8]. The aims of this study is to evaluate physicochemical, nutritional parameters and antioxidant compound in pulps of Kent and Brooks mango sorting waste during fermentation.

2. Material and Methods

2.1. Material

2.1.1. Biological Material

The biological material consisted of pulp from Kent and Brooks mango varieties (Figure 1). These mangoes samples were collected from two, export and processing, units (Ivoire Organics and COOP-CA) in Korhogo, northern Côte d'Ivoire, between May and July 2022.

Figure 1. Kent (A) and Brooks (B) Mango Varieties

2.1.2. Technical Materials

The materials used were Kjeldhall apparatus (Gerhardt, France), pH meter (Hanna instrument, Belgium), refractometer (ATC, China), blender (Binatone BLG-402-350W, China) and spectrophotometer (PG Instruments, England).

2.1.3. Reagents Chemicals

Solvents were n-hexane, petroleum ether, ethanol, methanol and acetone. All solvents were purchased from Merck.The reagents (metaphosphoric acid and vanillin) were purchased from Sigma-Aldrich, as were the following: metaphosphoric acid, NaOH (0.1N), Folin-Ciocalteu reagent, dichlorophenol-indophenol (DCPIP) reagent and 3.5-dinitrosalicylic acid (DNS). All chemicals and reagents involved in this study were of analytical grade.

2.2. Methods

2.2.1. Treatment of Kent and Brooks Mango Samples

The samples of mangoes were ripen at 25°C during 8 (Kent) and 5 (Brooks) days. After riping (day 0), pulp of each mango variety was subjected to natural fermentation during 9 days [12,13]. Physicochemical and nutritional parameters with antioxidant compound of fermented pulps from Kent and Brooks mango varieties were determined every 3 days during 9 days after crushing with blender (Binatone BLG-402-350W).

2.2.2. Physicochemical Analysis of Pulps from Kent and Brooks

For physicochemical parametrers, soluble dry extracts, alcohol, moisture pH and acidity of Kent and Brooks pulp were determined during fermentation each 3 days until 9 days. Soluble dry extracts and alcohol of pulp from Kent and Brooks mangoes were measured using a refractometer (ATC). A drop of crushed pulp was placed on screen of a refractometer and value of soluble dry extracts and alcohol was read directly in its eyepiece. Moisture was determined using [14] official methods. Moisture was determined by difference of weight before and after drying 10 g of pulps from Kent and Brooks mangoes in an oven (Memmert, Belgium) at 105°C until constant weight. For pH analysis of pulps from Kent and Brooks, AFNOR standard (1986) method was used, which consisted of using of 5 g of crushed homogenized with 25 mL of distilled water. Then filtered through filter paper and pH was measured by immersing the electrode of a pH meter (Hanna instrument, Belgium) into the filtrate. Acidity analysis of pulps from Kent and Brooks were carried out with 10 mL of filtrate which titrated with NaOH (0.1 N).

2.2.3. Nutritional Analysis of Pulps from Kent and Brooks

For nutritional parametrers of pulps from Kent and Brooks mangoes during fermentation, fat, protein, total sugars, reducing sugars were determined. Fat of crushed pulps were analyzed with Soxhlet extraction method (ISO 734-1, 2000). Crushed pulps were placed in an extraction cartridge and sealed. Then was placed in Soxhlet extractor and fat extracted using 200 mL of hexane solvent ebb and flow. After 7 hours, solvent was recovered using a rotary evaporator. Fat (FF) contents of pulps were calculated using following equation:

$$FF(\%) = \left(FW - WO\right) / SX100 \quad (1)$$

FW: Weight of flask (g) + fat content of pulp (g); *WO*: Weight of empty flask (g); S: sample (g).

The total sugars content of pulps were determined using a calibration curve of glucose (10 mg/100 mL) as standard. Reducing sugars content of pulps were determined according to [15]. One (1) g of crushed pulp is dissolved in 50 mL of warm distilled water. After filtration, the volume is completed at 100 mL. To 1 mL of solution were added successively 0.5 mL of distilled water and 0.5 mL

of 3.5-dinitrosalicylic acid (DNS). After 5 minutes at ambient temperature, the absorbance was read with a spectrophotometer at 580 nm. Reducing sugars content of pulps of Kent and Brooks were determined using [16] method as follow: 5 g of crushed pulp were homogenised in 20 mL of boiling distilled water. The mixture was filtered and volume adjusted to 50 mL. Then 0.5 mL of distilled water and 0.5 mL of DNS solution were successively added to 1 mL of the filtrate. Mixture was heated in a boiling water bath for 5 min. After cooling, 2 mL of distilled water was added and the absorbance was read at 490 nm against a blank. Proteins of pulps from Kent and Brooks were determined through Kjeldhal method (NF V 03-050, 1970).

2.2.4. Antioxidant Compound Analysis of Pulps from Kent and Brooks

Antioxidant compound contents determined during fermentation of pulps from Kent and Brooks mangoes were vitamin C, vitamin A, polyphenols and carotenoids. Vitamin C of pulps were determined by titration using [17] method. Ten (10) g of crushed pulps from Kent and Brooks were soaked for 10 min in 40 mL of solution of metaphosphoric acid-acetic acid (2%, w/v). The mixture was then centrifuged at 3000 rpm for 20 min and supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. 10 mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L. For polyphenols content of Kent and Brooks pulps analysis, method of [18] was used. One (1) g of pulp was soaked in 10 mL of methanol 70 % (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin-Ciocalteu's reagent and neutralized by 1 mL of 20 % (w/v) sodium carbonate. Reaction mixture was incubated for 30 min at ambient temperature. Absorbance was measured at 725 nm by using a spectrophotometer (PG Instruments, England). Carotenoids content of Kent and Brooks mangoes pulps were carried out according to [19]. Carotenoids contents were estimated using a calibration curve of beta-carotene (1 mg/mL) as standard. Two (2) g of Kent an Brooks crushed pulps were mixed three (3) times with 50 mL of acetone until loss of pigmentation. The mixture obtained was filtered and carotenoids contents were extracted with 100 mL of petroleum ether. Then absorbance of extracted fraction was read at 450 nm by using a spectrophotometer. Vitamin A contents of pulps were determined with dividing the β-carotene content by [12] and described by [20].

2.2.5. Statistical Analysis

Results were analysis using Microsoft Excel 2016 and statistical analysis were performed with SPSS software (version 11). The experiments are carried out with 3 repetitions. Variance analysis (ANOVA) was performed to determine differences between the averages were assessed with Turkey multiple comparison tests. Differences were considered significant at $p<0.05$. Results were expressed with standard error on mean (mean ± SEM).

3. Results and Discussion

Table 1 presents values of physicochemical parameters (soluble dry extract, pH, acidity, moistures and alcohol) of pulps from Kent and Brooks mangoes varieties analyzed during natural fermentation every 3 days for 9 days. Results are significantly different ($p<0.05$). pH of pulp decreased from 4.10±0.00 to 2.97±0.00 for Kent and 3.59±0.03 to 3.36±0.01 with Brooks. However, acidity of Kent pulp was increased from 17.33 to 31.33 meq/100g and from 19.33 to 29.33 meq/100g for Brooks. This acidity decrease could be due to conversion of sugars into organic acids by microorganisms during fermentation [22]. Acidity contributes to hygienic quality of food by limiting growth of some pathogenic germs [23]. Moisture of Kent pulp was increased from 78.66±0.05 % to 85.60±0.80 % and from 84.66±1.15 % to 89.3±0.57 % for Brooks's pulp. This decrease of moisture was also observed by [21] on apple variety fermentation in Morocco. However, soluble dry extract and alcohol contents of fermented pulps of the two mangoes varieties were decreased. Soluble dry extract content of Kent pulp was decreased from 18.33±1.2 to 14.16±0.05°Brix and those of Brooks's pulp from 13.33±0.57 to 11.10±0.10°Brix. It is correlated with acidity [24]. Soluble dry extract during fermentation can be attributed to high microbial load, leading to biodegradation and reduced stability [25]. Concerning alcohol content of Kent and Brooks varieties, it decreased from day 0 to day 3 and it remained then stable until day 9 during fermentation. Alcohol content of Kent decreased from 10.33 ± 1.52% to 7.66 ± 0.57% and from 8.33 ± 0.57% to 6.56 ± 0.20% for Brooks. This decreased could be due to conversion of alcohols into organic acids during fermentation [26].

Table 1. Physicochemical Parameters of Kent and Brooks Ripe Mango During Fermentation (Days)

Mango Variety	Duration	pH	Acidity (meq/100g)	Soluble dry extract (°Brix)
Kent	Day 0	4.10±0.00^{a}	17.33±1.15^{d}	18.33±1.20^{a}
	Day 3	3.67±0.02^{b}	18.00±2.00^{d}	16.16±0.15^{b}
	Day 6	3.31±0.01^{d}	27.00±2.00^{b}	14.93±0.11^{bc}
	Day 9	2.97±0.00^{e}	31.33±1.15^{a}	14.16±0.05^{cd}
Brooks	Day 0	3.59±0.03^{b}	19.33±1.15^{d}	13.33 ± 0.57^{cd}
	Day 3	3.50±0.10^{c}	22.67±2.30^{c}	13.50 ± 0.50^{cd}
	Day 6	3.45±0.01^{c}	25.33±1.15^{c}	12.50 ± 0.43^{de}
	Day 9	3.36±0.01^{d}	29.33±4.16^{ab}	11.10 ± 0.10^{e}
Mango Variety	Duration	Alcoohl (%)	Moisture (%)	
Kent	Day 0	10.33±1.52^{a}	78.66±0.05^{e}	
	Day 3	9.13±0.15^{ab}	81.80±0.87^{d}	
	Day 6	7.66±0.57^{cd}	84.66±0.41^{bc}	
	Day 9	7.66±0.57^{cd}	85.60±0.80^{bc}	
Brooks	Day 0	8.33±0.57^{bc}	84.66±1.15^{bc}	
	Day 3	7.06±0.11^{de}	85.33±1.15^{bc}	
	Day 6	6.56±0.20^{e}	86.33±0.57^{b}	
	Day 9	6.56±0.20^{e}	89.3±0.57^{a}	

Results for analysis of nutritional parametrers (fat, total sugar, reducing sugar and protein) of mangoes pulps during fermentation every 3 days for 9 days are presented in Figure 2 and Figure 3 respectively for Kent and Brooks varieties.

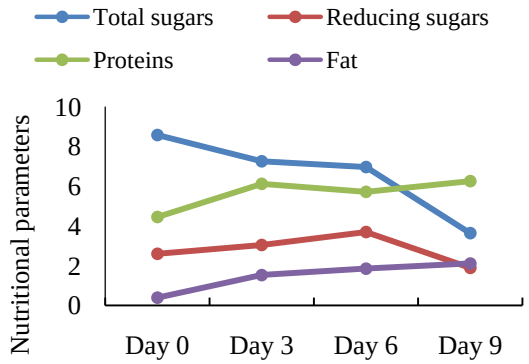

Figure 2. Nutritional parameters of Kent mango during fermentation (days)

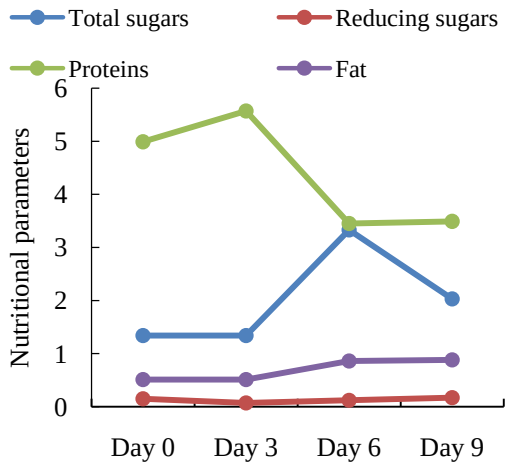

Figure 3. Nutritional parameters of Brooks mango during fermentation (days)

These results were statistically different (P<0.05). Fat content of Kent pulp was increased from 0.39±0.00 to 2.11±0.01% and from 0.07±0.01 to 1.89±0.14% for pulp of Brooks. This increase was reported by [30] on arbutus fruits in Kenya (1.37±0.40 to 2.10±0.10 %) and by [32] on mango varieties in Sri Lanka (0.41±0.02 to 0.86±0.02%). According to [33], this could be explained by increased lipase activity, which promotes release of fatty acids from phospholipids. For total sugar, Kent pulp decreased from 8.57±0.50% to 3.63±0.42%. Total sugar contents of Brooks mango remained stable until day 0 to day 3 (1.34±0.00% to 3.33±0.00%), then indecreased at day 6 (3.33±0.00%) and decreased until day 9 (2.03±0.00%). This decrease could be due to enzymatic activity during fermentation, then reserve polysaccharides are transformed into reducing sugars [27]. Reducing sugars of Kent pulp was increased from 2.60±0.4 to 3.69±0.25% during 6 days before decreased to 1.89±0.14% on the 9th day. For pulp of Brooks mango, reducing sugar was decreased from 0.15±0.01 to 0.12±0.00% during 6 days before increased to 0.17±0.02% on the 9th day. Difference in reducing sugar content of Kent and Brooks varieties would be due to varietal type [28,29]. This increase of sugar levels would be due to hydrolysis of starch to simple sugars under action of amylases [30, 31]. Protein of Kent pulp was increased from 4.45±0.59 to 6.25±0.41 g/100 g and decreased from 4.99±1.15 to 3.49±0.28 g/100 g for pulp of Brooks. This slight increase could be explained by enzymes production by germs such as yeasts and acetic acid bacteria [34].

Figure 4 and Figure 5 show respectively the results for analysis of antioxidant compound (carotenoid, vitmin C, vitamin A and polyphenols) contents of pulps from Kent and Brooks mangoes during fermentation every 3 days for 9 days. These results were statistically different (P<0.05). Carotenoids decreased from 16.60±0.41 to 43.31±4.28µg/100 g for Kent and increased for Brooks form 19.14 to 11.50 µg/100g. For vitamin A, contents of pulps were also decreased from 1.37±0.04 to 3.60±0.36 µg/100 g and 1.59 to 0.95±0.00 µg/100 g respectively for Kent and Brooks. This difference of values could be related variety type [35]. This decrease can be attributed to browning of mangoes during fermentation thus carotenoid dioxygenases become active. These enzymes catalyse beta-carotene (provitamin A) degradation into volatile or non-volatile compounds, leading to gradual loss of vitamin A [36,37]. Polyphenols content of Kent pulp decreased from 187.56 to 129.29 mg/100g.

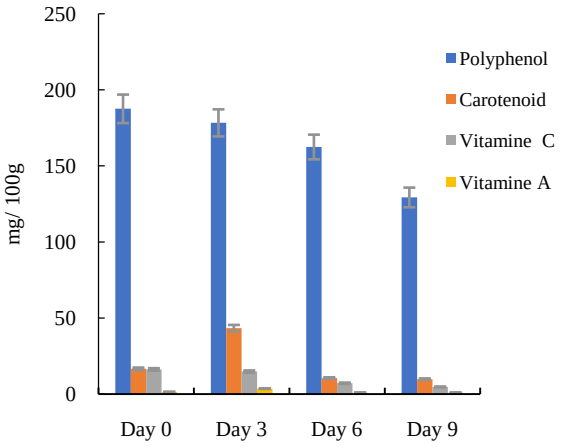

Figure 4. Content of antioxydant compound of pulp from Kent mango during fermentation

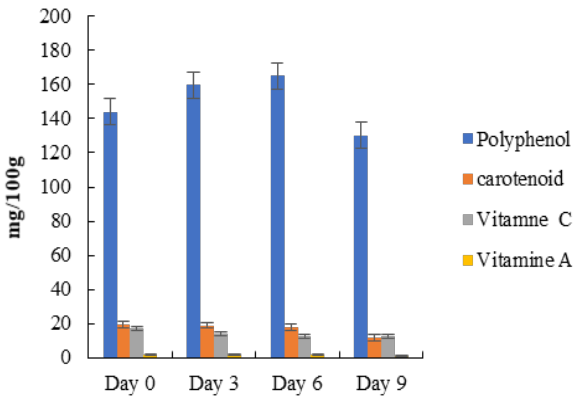

Figure 5. Content of antioxydant compound of pulp from Brooks mango during fermentation

However, polyphenols in Brooks pulp increased from 144.13 to 165.01 mg/100g during 6 days before decreased to 130.36 mg/100g on the 9th day. This trend could be explained by mangoes being exposed to enzymatic oxidation due to polyphenoloxidase (PPO) and peroxidase (POD) activity during fermentation [38]. This oxidation causes browning and change mango pulp colour. Concerning vitamin C, the levels in pulps decreased from 16.22 to 4.70 mg/100g and 17.05 to 12.11 mg/100g respectively for Kent and Brooks. These results were in agreement with those of [39] who observed a decrease of vitamin C during ripening and post-harvest processing of horticultural crops. Variation on vitamin C content observed in this study could be due to the highly unstable nature of this compound, which is degraded by oxidases [40].

4. Conclusion

This study involved evaluating physicochemical, nutrient parameters and antioxidant compound contents of pulps from Kent and Brooks mangoes varieties during fermentation. Fermented pulps of the 2 mangoes varieties revealed a high decrease of soluble dry extract, alcohol and pH. However, an increase in moisture content and acidity were observed. Pulp from Kent exhibited peak total sugar and polyphenol content on first day after ripening (day 0). Pulp also exhibited highest vitamin C content on same day. Then, on day 3, Kent variety showed high carotenoids and vitamin A content while Brooks variety showed high protein and total sugar contents. On day 6, reducing sugar and polyphenol levels peaked in Kent and Brooks varieties. Brooks mango also showed high vitamin A and carotenoids from day 0 to day 6. On day 9 after ripening, protein increased in Kent mango and reducing sugars increased in Brooks mango. While fat content peaked in both varieties. Despite significant drops on some sampling days, nutrient and antioxidant content of Kent and Brooks samples remained high during fermentation. Caracteristics of phytochemical, nutritional and antioxidant compound found with fermented pulps from Kent and Brooks mangoes sorting waste can be used in agri-food and nutraceutical sectors..

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