


# Physico-Chemical and Nutritional Characteristics of Five Varieties and One Accession of Mango from Burkina Faso

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## Abstract

The mango varieties *Eldon*, *Haden*, *Paheri*, *Tommy Atkins*, *Zill* and the accession *SBMA-1* are among the 45 varieties and 47 accessions of mango identified in Burkina Faso. The aim of this study was to determine the physico-chemical and nutritional parameters of these mango varieties and accessions for better valorization. Physicochemical and nutritional parameters were determined using standard methods. Results showed that the *SBMA-1* accession recorded the highest mass ( $638.10 \pm 106.67$  g), pulp content ( $85.06\% \pm 3.93\%$ ), pulp/core ( $10.54 \pm 1.97$ ) and pulp/peel ( $12.03 \pm 2.15$ ) ratios, pH ( $3.61 \pm 0.61$ ) and titratable acidity content ( $0.99\% \pm 0.04\%$ ). The *Paheri* variety had the lowest mass ( $120.43 \pm 25.97$  g), the lowest water content ( $74.31\% \pm 0.07\%$ ) and the highest pH ( $5.11 \pm 0.03$ ); on the other hand, it recorded the highest ESS content ( $26.47\% \pm 0.06\%$ ) and the highest ESS/AT ratio ( $133.10 \pm 7.25$ ). *Haden* had the highest values for  $L^*$  ( $55.41 \pm 0.06$ );  $a^*$  ( $10.94 \pm 0.35$ ) and  $\Delta E$  ( $69.00 \pm 0.12$ ). The *Eldon* variety recorded the highest levels of total sugars ( $28.08\% \pm 5.8\%$ ), total protein ( $2.69\% \pm 1.14\%$ ) and the highest energy value ( $126.88 \pm 25.55$  kcal/100 g). The highest total fat content ( $0.50\% \pm 0.03\%$ ) was found in the *Tommy Atkins* variety. The *Zill* variety recorded the highest total ash content ( $0.95\% \pm 0.25\%$ ). The results also showed that the peel and pulp of the *Zill* variety had the highest levels of total phenolic compounds, at  $5798.99 \pm 16.95$  mg EAG/100 g and  $30.41 \pm 0.1$  mg EAG/100 g respectively. The present study is a contribution to knowledge of the nutritional characteristics

of mango varieties produced in Burkina Faso. This could help guide the choice of mango varieties for orchard renewal, processing and fresh consumption.

## Keywords

Mango Varieties, Mango Accession, Physicochemical and Nutritional Parameters, Burkina Faso

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## 1. Introduction

The mango tree (*Mangifera indica* L.) is one of the most widespread fruit trees. Its cultivation is adapted to different agroecological zones ranging from sub-humid to semi-arid [1] [2]. In West Africa, mango has been introduced under a wide variety of production systems [3]. These ranged from hut tree production to mechanized plantations rationally designed as part of an intensive system, to more or less homogeneous extensive village system stands [3]. The first mango trees planted in this area were the fibrous, polyembryonnés mangoes introduced in the 19th century. Grafted monoembryonic varieties were planted after 1890. First with the *Amélie* variety and then, to a much lesser extent, with the *Divine* and *Julie* varieties [4]. Burkina Faso is one of the largest mango producers in West Africa. The first grafted mango plantations were established in 1954 in the Hauts-Bassins region (Orodara) [5] [6]. Production is now widespread in 04 of the country's 13 regions [7]. Annual production is estimated at between 160,000 and 300,000 tons, representing between 11% and 18% of West African production [8] [9]. The mango, the fruit of the mango tree, is one of the most popular fruits in the world because of its attractive color, delicious flavor and excellent nutritional properties. Mangoes are rich in carbohydrates, vitamins, minerals and phytochemicals [10], which have a strong antioxidant effect that can reduce the incidence of chronic cardiovascular disease. Mangoes are also one of the most economically and culturally important tropical fruits, providing income, food security and health to smallholder farmers and consumers in general [11]-[13].

In Burkina Faso, mango is consumed as is and sold on national, sub-regional and international markets. 13% of mango production is exported as fresh fruit to international markets [14]. Only 20% of production is processed in small-scale or industrial units into dried mangoes, nectar, puree, jam, etc. [4] [14]. Mangoes exported from Burkina Faso fall into different quality categories: certified organic fresh mangoes, fair trade mangoes and conventional/classic mangoes [9]. Burkina Faso has a large number of mango cultivars/varieties of different origins (West Indies, Burkina Faso, Florida, India and Mali). These cultivars/varieties can be found both in orchards and in urban areas [15]. All of these cultivars/varieties are not well known to growers and are therefore not widely used. The INERA station carried out an inventory in which more than forty cultivars/varieties and 47 mango accessions were identified in areas of high mango production [15]. Twenty of these varieties, including the best-known and most widely used (*Amélie*, *Brooks*,

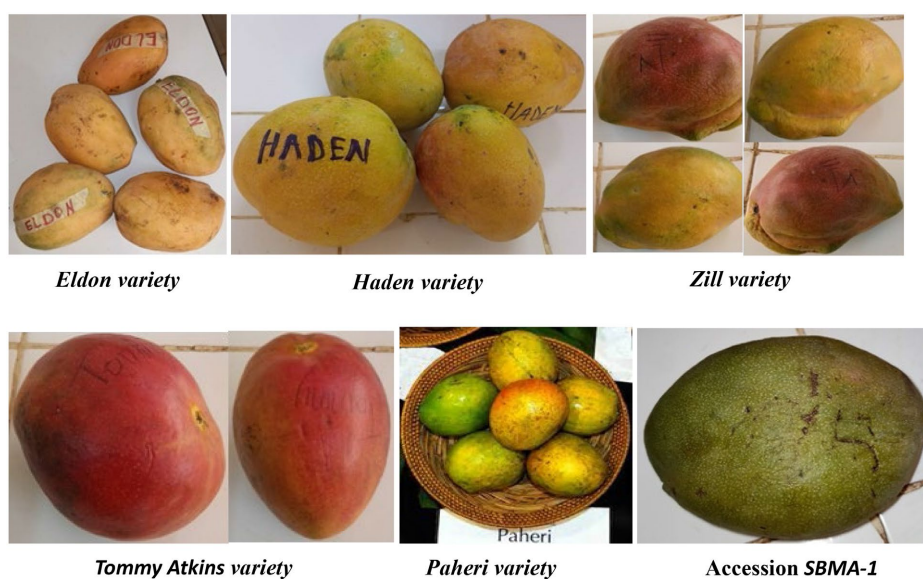
*Kent, Keitt, Lippens* and *Springfield*), were subjected to physico-chemical, nutritional and technological characterization [16]. The *Haden, Eldon, Paheri, Tommy Atkins, Zill* varieties and the *SBMA-1* accession are among the approximately forty mango varieties and 47 mango accessions listed in Burkina Faso. However, these varieties have only recently (2006 - 2010) been introduced into the mango variety collection field at the INERA station in Banfora [15]. They are not yet widely used in orchards. Therefore, the present study aims to determine the physico-chemical and nutritional characteristics of these mango varieties and accessions produced, in order to complete their agronomic characterization and contribute to their dissemination to mango growers in Burkina Faso.

## 2. Materials and Methods

### 2.1. Material

#### Plant Material

Mangoes of the varieties *Eldon, Haden, Paheri, Tommy Atkins, Zill* and the *SBMA-1* accession (**Figure 1**) formed the plant material for the present study.



Source: KANTE/TRAORE, 2021.

**Figure 1.** Photographs of fruit from the five varieties and one accession of mango.

### 2.2. Methods

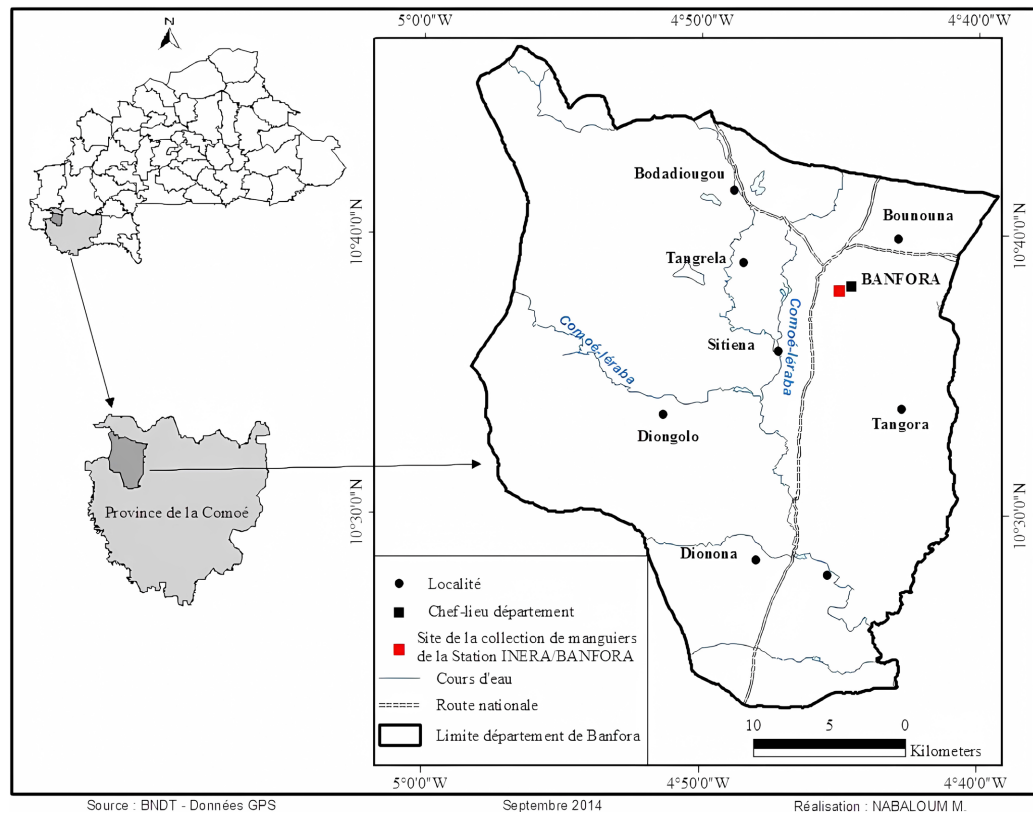
#### 2.2.1. Sampling

Mango varieties and Accessions were collected in the varietal collection field of the Institute de l'Environnement et de Recherches Agricoles (INERA) Banfora station located in western Burkina Faso, in the Cascades region (**Figure 2**). Two waves of sampling were carried out.

- ✓The first wave of sampling took place in March 2021;
- ✓The second wave of sampling took place in June 2021.

For each sampling, 10 physiologically ripe mangoes were taken from a single

plant of each mango variety, coded and placed in cartons at the Département Technologie Alimentaire (DTA), where they were subjected to ripening at room temperature in a laboratory room until taste ripeness.



Source: GUIRA, 2014.

**Figure 2.** Geographical location of INERA Banfora's variety collection field.

### 2.2.2. Sample Preparation

Once the mangoes had reached taste maturity, they were sorted, washed, peeled and pitted. The pulp was recovered, crushed, packaged in 450 g plastic bottles and placed in a freezer to await analysis.

### 2.2.3. Determination of Material Balance

After peeling and pitting, the various parts of the mango were collected separately and weighed. The material balance was determined by dividing the mass of each part of the fruit by the total mass of the fruit.

$$\%(\text{Core, skin or pulp}) = \frac{Px}{Pt} \times 100$$

where: Px = weight of each part of the mango (core, skin or pulp); Pt = total weight of mango

### 2.2.4. Determination of Moisture Content

Water/moisture content was determined by drying 5 g of mango puree in an oven at 105°C, in accordance with AFNOR standard [17]. Water content was calculated

using the following equation:

$$\%(\text{water}) = \frac{(M0 - M)}{M0} \times 100$$

$M0$  = initial sample weight;

$M$  = final sample weight.

### 2.2.5. Determination of Color

The color of the samples was analyzed using a colorimeter (Model NO PCE-CSM 1) based on the CIE-Lab color system, where the  $L^*$  (luminosity) value ranges from black (0) to white (100), the  $a^*$  value ranges from green (-60) to red (+60) and the  $b^*$  value ranges from blue (-60) to yellow (+60).

### 2.2.6. Determination of Soluble Solids Content

Soluble solids content (SS) was determined using a digital refractometer (Bellingham + Stanley). A drop of mango pulp was placed in the refractometer's orbit, and the Brix value was read directly from the display.

### 2.2.7. Determination of pH and Titratable Acidity (TA)

Titrateable acidity was determined in accordance with French standards [18]. To do this, 5 g of mango pulp was weighed into a Falcon tube, and then suspended in 30 ml of distilled water. After 1 hour of magnetic stirring, the pH was measured directly using a pH meter (Neo-Tech.SA, SI Analytics) previously calibrated with buffer solutions pH = 4, pH = 7 and pH = 9.18. 20 ml of this solution was taken and titrated with 0.1 N NaOH in the presence of a few drops of phenolphthalein. The titrateable acidity was obtained according to the equation:

$$\%AT = \frac{N \times VT \times V(\text{NaOH})}{PE \times VP} \times 0.070 \times 100$$

$N$  = soda normality;

$PE$  = test sample;

$VP$  = volume of sample solution taken for titration;

$VT$  = total volume of sample solution;

$V$  = volume of NaOH solution required for titration;

0.070 = conversion factor to citric acid equivalent.

### 2.2.8. Determination of the Soluble Solids/Titratable Acidity Ratio

The carbohydrate/acid balance is a very important quality factor in fruit. It expresses the ratio between the rate of soluble solids (SS) and the rate of titrateable acidity (AT) and can be used to determine the stage of fruit maturity or to determine the aptitude of the pulp for a given transformation. It is calculated according to the following formula:

$$\text{Ratio (R)} = \frac{SS}{AT} \times 100$$

where: SS = soluble solids, AT = Titratable acidity.

### 2.2.9. Determination of Total Ash Content

Total ash was determined by incineration in a muffle furnace at 550 °C in accordance with ISO 2171 [19]. For the analyses, a 5 g test sample of crushed pulp from each mango variety was weighed into a previously washed and weighed porcelain crucible. The crucible containing the pulp was then placed in a muffle furnace at 550 °C overnight, cooled in a desiccator for 1 hour and weighed again. The ash content was calculated according to the following formula:

$$\%C = \frac{PF - PV}{PE} \times 100$$

*% C* = percentage of total ash;

*PE* = test sample;

*PF* = final weight;

*PV* = weight of empty crucible.

### 2.2.10. Determination of Fat Content

The fat content (FC) of the pulp of each mango variety was determined using the Soxhlet extraction method in accordance with ISO 659 [20]. This method involves weighing the sample into a cellulose cartridge and extracting the fat continuously with a lipophilic organic solvent. After extraction, the fats are separated from the extraction solvent by distillation using a rotary evaporator. A 5 g sample of mango pulp from each variety was placed in a Soxhlet extraction cartridge. The cartridge containing the test sample was plugged with absorbent cotton and placed in the Soxhlet extraction device. The device was then placed on a 500 ml flask containing approximately 250 ml of hexane and topped with a refrigeration system connected to a cryostat to condense the solvent vapors. After 5 h of extraction, the MG was separated from the solvent by rotavapor distillation. The flask containing the fat was then placed for 30 min in an oven at 105 °C, cooled for 30 min in a desiccator and weighed. The fat content was calculated according to the equation below:

$$\%MG = \frac{PF - PV}{PE} \times 100$$

*FP*: final weight (flask + fat);

*PV*: empty weight of flask;

*PE*: test sample.

### 2.2.11. Determination of Protein Content

The protein content of mango cultivars and accessions was determined by the Kjeldahl method according to ISO 1871 [21]. This method is based on the determination of total nitrogen.

One gram (1 g) of crushed mango pulp was introduced into a Kjeldahl matrass, and a Djelbabs catalyst pellet and 20 ml of concentrated sulfuric acid were added. Mineralization was carried out at a progressive temperature of 100 to 550 °C for about four hours. The resulting mineralizate was cooled and made up to 50 ml with distilled water, then neutralized with a 10 N NaOH solution. The neutralized solution was distilled and the distillate was collected in an Erlenmeyer flask

containing 20 ml of boric acid and a few drops of helianthine and bromocresol green. Distillation was stopped when the volume of the distillate reached 150 ml. The distillate was then titrated with 0.1 N sulfuric acid until the solution changed from green to pink. A blank was also titrated under the same conditions as the samples.

$$\%P = \frac{14 \times 0.1 \times (VE - VB) \times 10^{-3}}{PE} \times 6.25 \times 100$$

$VE$  = Burette drop (sample);

$VB$  = Burette drop (blank);

$PE$  = test sample;

0.1 = sulfuric acid titer;

14 = molecular weight of nitrogen;

6.25 = nitrogen to protein conversion factor;

$\% P$  = Protein content.

### 2.2.12. Determination of Total Sugar Content

Total sugars were determined by the orcinol method described by Montreuil and Spik [22]. Twenty (20) mg of pulp were taken into a beaker and 10 ml of distilled water was added. The mixture was stirred magnetically for 10 min, then transferred to a 50 ml volumetric flask, topped up with distilled water and homogenized. In test tubes, 0.5 ml homogenate was taken, 1 ml orcinol reagent and 3.5 ml  $H_2SO_4$  (60%) were added respectively. The test tubes were homogenized and then placed in a boiling water bath for 20 min. They were then placed in the dark for 45 min and then at room temperature for 10 min. After homogenization, absorbance was measured at 510 nm using a spectrophotometer. Total sugar content was determined from a calibration curve using D-glucose as the reference sugar.

### 2.2.13. Determination of Phenolic Compounds

Phenolic compounds of mango cultivars and accessions were determined in extracts of pulp and powder of freeze-dried mango peel by spectrophotometry using the Folin-Ciocalteu reagent with modifications [23]. Methanol-HCl (1%) was used for extraction. A test sample of 2.5 g of mango pulp and 0.01 g of freeze-dried peel powder was placed in a 50 ml flask to which the extraction solvent was added. The flask was protected from light with aluminum foil. The mixture was placed under magnetic stirring for 10 min and then refrigerated. After 24 h maceration, the mixture was filtered through 0.45  $\mu m$  Wattman filter paper.

An aliquot of 0.250 ml of the extract was taken and 1.25 ml of Folin-Ciocalteu reagent (0.2 N) was added. After incubation for 5 minutes, 1 ml of sodium carbonate solution (7.5 g/L) was added. The mixture was then placed in a water bath at 65°C for 20 min, after which the absorbance at 760 nm was read against a blank. Measurements were performed in triplicate. The total polyphenol content was determined from a calibration curve plotted at different concentrations of gallic acid standard. Results were expressed as mg gallic acid equivalent (GAE) per 100 g of material.

### 3. Statistical Analysis

For the statistical analysis, MS Excel was used to create the graphs. XLSTAT 2016.02.27444 was used to analyze the statistical data. Data variation and validity of the results were confirmed by one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison method at 5% threshold.

## 4. Results and Discussion

### 4.1. Mass and Material Balance for the Five Cultivars and the Mango Accession

The material balance for the five varieties and the mango accession (**Table 1**), shows that the mass varied from 120.43 g to 638.10 g. The *SBMA-1* accession recorded the highest value ( $638.10 \pm 106.67$ ) and the *Paheri* variety recorded the lowest value ( $120.43 \pm 25.97$ ). The mass of the *Paheri* variety is significantly different from the masses of the other varieties. According to the Codex standard [24] on mango sizing, the *Zill* mango variety can be classified as size A (200 - 350 g), the *Haden* and *Tommy Atkins* varieties as size B (351 - 550 g) and the *Eldon* mango variety and *SBMA-1* accession as size C (551 - 800 g). The size of the *Paheri* variety is smaller than the Codex standard size A [24]. This means that this variety cannot be exported. The weights of the *Eldon*, *Haden*, *Tommy Atkins* and *SBMA-1* accession mango varieties are close to those of the 20 Burkina Faso mango varieties studied by Kanté-Traoré, [16], which ranged from  $204 \pm 11.91$  to  $843.43 \pm 35.93$  g. They are also close to those found by De Laroussilhe [25]. And Bafodé [26] and to those of mango varieties found in the European market [27].

The proportion of the kernel of the different varieties and mango accession varied from 8.25% to 19.42%. The highest proportion was observed with the *Paheri* variety and the lowest value with the *SBMA-1* accession. Only the kernel proportion of the *Paheri* variety was significantly different from those of the other varieties. The kernel proportions of the mango varieties in the present study are close to those found by Kanté-Traoré, [16] in the 20 Burkina mango varieties ( $5.19 \pm 0.63$  to  $16.93 \pm 1.50$ ), except that of the *Paheri* variety, which is higher. They are also similar to those found in Cameroon mangoes, which ranged from 12% to 17% [28].

The percentage of peel of different mango varieties and one accession ranged from 7.22% to 18.88%. *Paheri* variety had the highest value and *SBMA-1* accession had the lowest value. The peel percentage of *Paheri* variety and *SBMA-1* accession is significantly different from the skin percentage of other varieties. The peel proportion of *Eldon*, *Haden*, *Tommy Atkins*, *Zill* and the *SBMA-1* accession are similar to those of the six best known and most used mango varieties in Burkina ( $10.50\%$  to  $13.93\%$ ) [16]. On the other hand, the skin content of the *Paheri* variety is close to that of the *Julie* ( $18.43 \pm 2.64$ ) and *Francis* ( $20.56 \pm 0.15$ ) varieties [16] and also to that of the Cameroonian mango varieties (17% and 19 %) reported by Kansci *et al.* [28].

The pulp content of the five mango varieties and accessions studied ranged

from 51.18% to 85.06%. The highest pulp value was recorded for the *SBMA-1* accession, while the *Paheri* variety had the lowest pulp value. The pulp content of *Paheri* variety is significantly different from that of other mango varieties. These results are similar to those found in Burkina mangoes, which ranged from 64.55% to 80.32% [16]. The flesh content of the *Zill* variety is close to that of the *Keitt* variety from Cameroon (72%) [28]. On the other hand, the pulp content of the *Eldon* variety is higher than that found by Kansci *et al.*, [28] in the *Keitt* variety from Cameroon, but close to that found by Passannet *et al.*, [29] in the *Cœur de bœuf* variety (78.68%) from Tchad.

The pulp/Kernel ratio of mango varieties and accessions ranged from 2.69 to 10.54. The highest value was recorded for the *SBMA-1* accession and the lowest for the *Paheri* variety. These results are similar to those found in Burkina mangoes, which ranged from 3.81 to 11.67; [16]. The pulp/peel ratio ranged from 2.78 to 12.03. The *SBMA-1* accession recorded the highest value and the *Paheri* variety the lowest. These values are similar to those found with the 14 Burkina mango varieties, which ranged from 3.16 to 9.03 [7].

Pulp/peel ratios are a good indicator of the suitability of mango varieties for industrial processing [7] [30].

**Table 1.** Mass and material balance of the five cultivars and the mango accession.

Varieties	Mass (g)	Kernel (%)	Peel (%)	Pulp (%)	Pulp/Kernel	Pulp/Peel
<i>Eldon</i>	604.88 ± 66.49 <sup>d</sup>	10.01 ± 1.94 <sup>abc</sup>	10.26 ± 1.78 <sup>ab</sup>	78.98 ± 6.22 <sup>bc</sup>	8.15 ± 1.75 <sup>bc</sup>	7.94 ± 1.72 <sup>bcd</sup>
<i>Haden</i>	465.05 ± 103.73 <sup>bcd</sup>	9.58 ± 1.15 <sup>abc</sup>	11.03 ± 1.95 <sup>ab</sup>	76.82 ± 0.87 <sup>bc</sup>	8.07 ± 1.33 <sup>bc</sup>	7.08 ± 0.88 <sup>abc</sup>
<i>Paheri</i>	120.43 ± 25.97 <sup>a</sup>	19.42 ± 4.52 <sup>d</sup>	18.88 ± 2.44 <sup>d</sup>	51.18 ± 12.99 <sup>a</sup>	2.69 ± 0.92 <sup>a</sup>	2.78 ± 0.78 <sup>a</sup>
<i>Tommy Atkins</i>	523.72 ± 59.99 <sup>cd</sup>	12.51 ± 1.59 <sup>bc</sup>	9.01 ± 2.37 <sup>ab</sup>	76.54 ± 4.41 <sup>bc</sup>	6.22 ± 2.31 <sup>b</sup>	8.93 ± 0.98 <sup>cd</sup>
<i>Zill</i>	336.97 ± 31.50 <sup>b</sup>	12.34 ± 0.33 <sup>abc</sup>	12.99 ± 2.17 <sup>bc</sup>	71.32 ± 3.02 <sup>bc</sup>	5.78 ± 1.29 <sup>ab</sup>	5.64 ± 0.15 <sup>abc</sup>
<i>SBMA-1</i>	638.10 ± 106.67 <sup>d</sup>	8.25 ± 1.12 <sup>a</sup>	7.22 ± 1.16 <sup>a</sup>	85.06 ± 3.93 <sup>c</sup>	10.54 ± 1.97 <sup>c</sup>	12.03 ± 2.15 <sup>d</sup>

NB: Values bearing the same letters are not significantly different ( $p < 0.05$ ).

## 4.2. Pulp Color of the 5 Mango Varieties and Accessions

The pulp color variables of the investigated varieties and accession are presented in **Table 2** below. The  $L^*$  values of the five varieties and the mango accession ranged from 41.85 to 55.41. Statistical analysis showed no difference between cultivars and accessions. *Haden* and *Tommy Atkins* recorded the highest values of  $55.41 \pm 0.06$  and  $51.56 \pm 0.32$ , respectively. *Zill* had the lowest value. The  $L^*$  values found in this study are in the same order of magnitude as those found in Burkina mangoes (37.97 to 53.15) [7] [31]. On the other hand, they are lower than those found by Morales *et al.*, [32] in Colombian-Caribbean mangoes (66 to 76). This difference could well be explained by the ecological difference between the two regions. The flesh of the *Haden*, *Tommy Atkins* and *Eldon* varieties is susceptible to browning, given the high  $L^*$  value. In fact, Robles-Sanchez *et al.* [33] and Elsheshetawy *et al.*, [30] reported that pulp  $L^*$  values are indicators of browning during

fruit processing due to contact between oxygen and polyphenol oxidases (PPO) in mango pulp. For pulp preservation,

The  $a^*$  values for the five varieties and the accession ranged from 0.74 to 10.94. *Haden* and *Paheri* were significantly different from the other varieties. *Haden* had the highest value and *Zill* the lowest. The  $a^*$  values found are lower than those found in Colombian-Caribbean mangoes, which ranged from 7 to 26 [32], and in Burkina mangoes, which ranged from 4.25 to 17.75 [7]. The positive  $a^*$  values obtained show that all the varieties and accessions studied have a yellow-orange color [7].

The  $b^*$  values ranged from 29.75 to 41.38. Statistical analysis showed no difference between varieties and accessions. *Tommy Atkins* had the highest value and *Eldon* the lowest. The  $b^*$  values found are lower than those found in Colombian-Caribbean mangoes, which ranged from 43 to 50 [32], but similar to those found in Burkina mangoes, which ranged from 22.94 to 56.07 [7]. Based on the  $a^*$  and  $b^*$  values, the pulp of the 05 cultivars and the accessions in this study were yellow-orange in color, with the *Haden* variety having a brighter color.

The  $c^*$  values ranged from 30.10 to 41.48. Statistical analysis showed no difference between cultivars and accessions. *Tommy Atkins* had the highest value and *Eldon* the lowest. Observations show that  $b^*$  and  $c^*$  values are about the same. The  $c^*$  values found are close to those found in Burkina mangoes, which ranged from 23.41 to 58.82 [16].

The  $\Delta E$  values ranged from 53.12 to 69.00. Statistical analysis showed no significant differences between cultivars and accessions. However, the *Haden* and *Tommy Atkins* cultivars had the highest values, while the *Zill* cultivar had the lowest. These values are similar to those found in Burkina mangoes, which ranged from 44.61 to 79.27 [7].

The positive values of  $L^*$ ,  $a^*$ ,  $b^*$ ,  $c^*$ ,  $\Delta E$  in the present study provide information about the yellow-orange flesh color of the varieties. This color is the majority color of most mango varieties and is appreciated by consumers. Lauricella *et al.* [34] reported that the mesocarp color index is considered a good quality and consumer perception parameter.

**Table 2.** Color variables of the five mango varieties and accession studied.

Varieties	$L^*$	$a^*$	$b^*$	$c^*$	$h^\circ$	$\Delta E$
<i>Eldon</i>	48.32 ± 0.23 <sup>a</sup>	4.61 ± 0.24 <sup>a</sup>	29.75 ± 0.8 <sup>a</sup>	30.10 ± 0.8 <sup>a</sup>	0.008 <sup>a</sup>	56.83 ± 0.23 <sup>a</sup>
<i>Haden</i>	55.41 ± 0.06 <sup>a</sup>	10.94 ± 0.35 <sup>b</sup>	39.64 ± 0.39 <sup>a</sup>	41.12 ± 0.29 <sup>a</sup>	0.008 <sup>a</sup>	69.00 ± 0.12 <sup>a</sup>
<i>Paheri</i>	46.94 ± 0.64 <sup>a</sup>	5.87 ± 0.59 <sup>ab</sup>	31.48 ± 1.62 <sup>a</sup>	32.03 ± 1.50 <sup>a</sup>	0.009 <sup>a</sup>	56.83 ± 1.36 <sup>a</sup>
<i>Tommy Atkins</i>	51.56 ± 0.32 <sup>a</sup>	2.86 ± 0.20 <sup>a</sup>	41.38 ± 0.26 <sup>a</sup>	41.48 ± 0.27 <sup>a</sup>	0.011 <sup>a</sup>	66.18 ± 0.42 <sup>a</sup>
<i>Zill</i>	41.85 ± 12.92 <sup>a</sup>	0.74 ± 5.32 <sup>a</sup>	32.17 ± 7.92 <sup>a</sup>	32.47 ± 7.93 <sup>a</sup>	0.009 <sup>a</sup>	53.12 ± 14.35 <sup>a</sup>
<i>SBMA-1</i>	42.30 ± 14.86 <sup>a</sup>	2.89 ± 0.69 <sup>a</sup>	32.98 ± 9.12 <sup>a</sup>	33.11 ± 9.13 <sup>a</sup>	0.007 <sup>a</sup>	53.75 ± 17.27 <sup>a</sup>

Values bearing the same letters are not significantly different ( $p < 0.05$ ).

### 4.3. Chemical Characteristics of the 5 Varieties and the Mango Accession

The chemical parameters of the varieties studied are presented in **Table 3** below.

The pH of the 5 varieties and the mango accession ranged from 3.61 to 5.11. *Paheri* variety had the highest pH and *SBMA-1* accession had the lowest pH. There was a significant difference among varieties and accessions. The pH of the *Haden* variety is similar to that of the *Julie* variety from Burkina [7] and that of the *Mangotine* variety from Tchad, which was 4.70 [28]. The pH of the *Paheri* variety is similar to that of postharvest ripened Indian mangoes (5.25) [35] and to that of the *Alphonso* variety (5.1) [36]. The *Tommy Atkins* and *Zill* varieties have pH values close to that of the *Ataulfo* variety (4.1) [37].

The titratable acidity (TA) of mango ranged from 0.20% to 0.99%. The accession *SBMA-1* and the varieties *Eldon* and *Zill* recorded the highest values. The TA values of *SBMA-1*, *Eldon* and *Zill* were significantly different. *Paheri*, *Tommy Atkins* and *Haden* had the lowest values. The titratable acidity of the *SBMA-1* accession (0.99%) is close to that of the *Dixon* variety from Burkina (1.01%) [7]. The acidity of the *Paheri* variety is close to the average found in postharvest ripened Indian mangoes (0.19%) [35]. In terms of pH and titratable acidity, *Paheri* is the least acidic variety, while *Eldon* and *SBMA-1* are the most acidic.

The soluble solids (SS) content of the 5 varieties and the mango accession ranged from 19.37% (*Tommy Atkins* variety) to 26.47% (*Paheri* variety). The SS contents of the 5 varieties and the mango accessions are in the same order of magnitude as those reported by Kanté-Traoré, [16] in the 20 varieties (11.00 to 23.10%) of Burkina mango, except that of the *Paheri* variety, which has a higher SS content. The SS content of the *Tommy Atkins* variety is close to that of the Bangui variety from Tchad [29]. While that of the *Haden* variety is similar to that of the *Ataulfo* variety (21.6%) [37] and to that of Indian mangoes, whose average was 21.35% [35] [38]. On the other hand, it is higher than that of *Alphonso* variety (20%) [36]. The SS content gives an indication of the sweetness of the fruit [35]. It is also an important parameter for processing. High SS levels indicate that the mango varieties and accessions studied have a very sweet taste. *Paheri* is the sweetest variety.

**Table 3.** Chemical characteristics of mango varieties and the accession.

Varieties	Moisture (%)	pH	TA (%)	SS (%)	SS/TA
<i>Eldon</i>	80.28 ± 0.09 <sup>d</sup>	3.83 ± 0.00 <sup>b</sup>	0.61 ± 0.04 <sup>c</sup>	20.33 ± 0.06 <sup>b</sup>	33.33 ± 2.10 <sup>b</sup>
<i>Haden</i>	78.68 ± 0.09 <sup>b</sup>	4.76 ± 0.02 <sup>e</sup>	0.25 ± 0.01 <sup>a</sup>	21.27 ± 0.12 <sup>c</sup>	87.06 ± 4.91 <sup>d</sup>
<i>Paheri</i>	74.31 ± 0.07 <sup>a</sup>	5.11 ± 0.03 <sup>f</sup>	0.20 ± 0.01 <sup>a</sup>	26.47 ± 0.06 <sup>e</sup>	133.10 ± 7.25 <sup>e</sup>
<i>Tommy Atkins</i>	80.76 ± 0.07 <sup>c</sup>	4.41 ± 0.00 <sup>d</sup>	0.23 ± 0.01 <sup>a</sup>	19.37 ± 0.06 <sup>a</sup>	84.03 ± 3.58 <sup>d</sup>
<i>Zill</i>	79.43 ± 0.06 <sup>c</sup>	4.24 ± 0.03 <sup>c</sup>	0.45 ± 0.01 <sup>b</sup>	20.17 ± 0.06 <sup>b</sup>	44.40 ± 1.24 <sup>c</sup>
<i>SBMA-1</i>	78.55 ± 0.08 <sup>b</sup>	3.61 ± 0.01 <sup>a</sup>	0.99 ± 0.04 <sup>d</sup>	22.57 ± 0.06 <sup>d</sup>	22.76 ± 1.05 <sup>a</sup>

Values bearing the same letters are not significantly different ( $p < 0.05$ ).

The SS/TA ratio ranged from 22.76 to 133.10. *Pahe*ri variety had the highest ratio and *SBMA-1* accession had the lowest value. These results are higher than those found in the 20 Burkina Faso mango varieties, which ranged from 9.79 to 62.59 [16]. The very high SS/TA ratio of *Pahe*ri confirms its very sweet character compared to other varieties.

#### 4.4. Mineral Element Contents of the 5 Mango Varieties and the Accession

The Fe, K, Mg, Na and Zn contents of the five mango varieties and accession are summarized in **Table 4** below.

The Fe content ranged from 7.84 to 23.23 mg. *Eldon* variety had the highest Fe content and *Pahe*ri variety had the lowest. These values are much higher than those found in mangoes in general, which average 0.16 mg [39]. This could be explained by the pedoclimatic conditions.

The K content ranged from 63.41 to 161.65 mg. The *Zill* cultivar had the highest K content and the *Tommy Atkins* cultivar had the lowest. The K value found in the *Zill* variety is close to that found in mangoes in general, which is 168 mg [39].

Mg content ranged from 12.60 to 23.78 mg. The *Zill* variety had the highest value and the *Eldon* variety had the lowest value. The Mg content of the *Eldon* variety is slightly higher than that found in mangoes in general, which is 10 mg [39].

The Na content ranged from 1.23 to 4.23 mg. These values are higher than those found in mango in general, which is 1 mg [39]. The *Tommy Atkins* cultivar and the *SBMA-1* accession did not show any trace of sodium.

The Zn content ranged from 0.37 to 2.64 mg. The highest value was recorded in the *Haden* variety and the lowest in the *Zill* cultivar. The values found are higher than those found in mango in general, which is 0.09 mg [39].

**Table 4.** Mineral content of the five mango varieties and the accession (mg/100 g DM).

Varieties	Fe	K	Mg	Na	Zn
<i>Eldon</i>	23.23	99.99	12.60	1.41	0.82
<i>Haden</i>	10.28	139.99	15.98	4.23	2.64
<i>Pahe</i> ri	7.84	102.21	24.64	1.24	1.10
<i>Tommy Atkins</i>	14.00	63.41	19.63	nd	1.90
<i>Zill</i>	10.23	161.65	23.78	1.23	0.37
<i>SBMA-1</i>	10.03	101.18	17.71	nd	0.63

#### 4.5. Nutritional Characteristics of the Five Mango Varieties and the Accession

**Table 5** shows the nutritional content of the 05 varieties and accession.

Fat content (FC) of mango varieties and accessions ranged from 0.18% (*Zill* variety) to 0.50% (*Tommy Atkins* variety). The fat content of *Zill* was significantly

different from that of *Eldon* and *Tommy Atkins*. The fat contents obtained in the present study are higher than those found in mangoes from Cameroon, whose fat contents ranged from 0.17% to 0.33% [28].

Total ash content ranged from 0.22% to 0.95%. The *Zill* variety had the highest ash, while the *Tommy Atkins* variety had the lowest ash content. The ash contents of *Eldon*, *Paheri* and *Tommy Atkins* were significantly different from those of *Haden* and *Zill*. The ash contents obtained are close to those reported by Kanté-Traoré, [16] for the 20 Burkina mango varieties (0.48% to 1.41%). However, the ash content of the *Zill* variety is higher than those found in mangoes from Cameroon, which ranged from 0.32 to 0.49% [28]. The ash content of the mangoes studied is lower than that found in mangoes from Congo ( $2.63\% \pm 0.14\%$ ) [40].

Protein (P) content ranged from 0.42% (*Tommy Atkins*) to 2.69% (*Eldon*). The protein content of *Paheri*, *Tommy Atkins* and the *SBMA-1* accession was significantly different from that of *Eldon* and *Zill*. The values obtained are higher than those found in mangoes from Cameroon, which ranged from 0.16% to 0.24% [28]. Also, the protein content of *Eldon*, *Haden* and *Paheri* varieties is higher than those found by Kanté-Traoré, [16] in the 20 mango varieties (0.21% to 0.77%).

The total sugar content of the five varieties and an accession ranged from 14.50% to 28.08%. The total sugar contents of the five varieties and the mango accession were not significantly different. These sugar contents are higher than those obtained in mangoes from Cameroon (9.43% to 15.16%) [28] and those found in mangoes in general, which were 13.66% [39]. However, they are lower than those found in 14 mango varieties from Burkina, which ranged from 68.47% to 76.79% [7].

The energy value (EV) of the five mango varieties and accessions ranged from 66.63 Kcal/100 g to 126.88 Kcal/100 g (fresh weight). The highest value was recorded for variety *Eldon* and the lowest for accession *SBMA-1*. The energy values of the five mango varieties and accession were not significantly different. These results are higher than those found in mango in general, which is 60 Kcal/100 g [39].

**Table 5.** Nutritional characteristics of the five mango varieties and accessions.

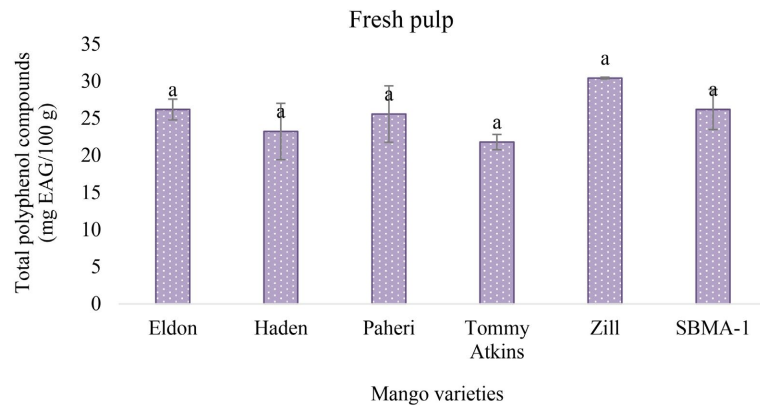
Varieties	Fat (%)	Ash (%)	P (%)	TS (%)	EV (Kcal/100g Mf)
<i>Eldon</i>	0.43 ± 0.05 <sup>b</sup>	0.42 ± 0.07 <sup>a</sup>	2.69 ± 1.14 <sup>c</sup>	28.08 ± 5.80 <sup>d</sup>	126.88 ± 25.55 <sup>c</sup>
<i>Haden</i>	0.38 ± 0.02 <sup>ab</sup>	0.91 ± 0.21 <sup>b</sup>	1.62 ± 0.03 <sup>abc</sup>	25.85 ± 0.87 <sup>cd</sup>	113.25 ± 3.47 <sup>bc</sup>
<i>Paheri</i>	0.39 ± 0.00 <sup>ab</sup>	0.46 ± 0.04 <sup>a</sup>	0.90 ± 0.33 <sup>a</sup>	16.97 ± 1.08 <sup>abc</sup>	74.99 ± 5.60 <sup>ab</sup>
<i>Tommy Atkins</i>	0.50 ± 0.03 <sup>b</sup>	0.22 ± 0.12 <sup>a</sup>	0.42 ± 0.09 <sup>a</sup>	23.38 ± 3.72 <sup>bcd</sup>	99.71 ± 14.36 <sup>abc</sup>
<i>Zill</i>	0.18 ± 0.05 <sup>a</sup>	0.95 ± 0.25 <sup>b</sup>	2.45 ± 0.24 <sup>bc</sup>	14.50 ± 5.08 <sup>ab</sup>	69.41 ± 20.03 <sup>a</sup>
<i>SBMA-1</i>	0.27 ± 0.17 <sup>ab</sup>	0.58 ± 0.03 <sup>ab</sup>	0.80 ± 0.13 <sup>a</sup>	15.24 ± 0.73 <sup>ab</sup>	66.63 ± 5.01 <sup>a</sup>

Values bearing the same letters are not significantly different ( $p < 0.05$ ).

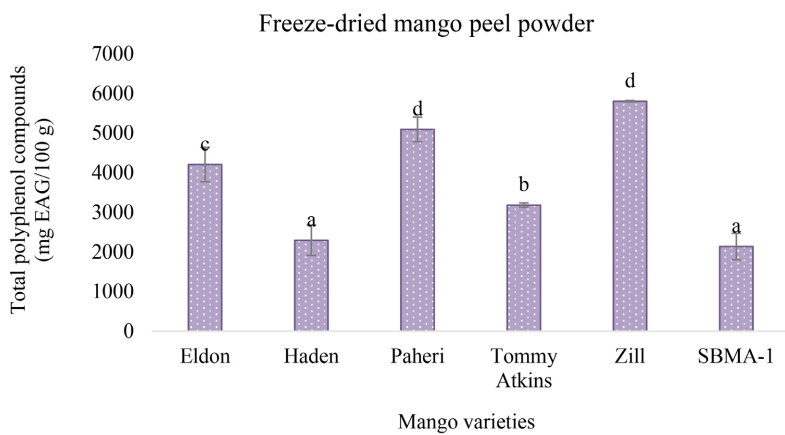
#### 4.6. Total Phenolic Compounds

**Figures 3-4** below show the total phenolic compound contents in the pulp and

freeze-dried peel powder of the 05 mango cultivars and accession analyzed.



**Figure 3.** Total phenolic compound content in fresh pulp of 05 varieties and mango accession.



Values bearing the same letters are not significantly different ( $p < 0.05$ ).

**Figure 4.** Total phenolic compound content in freeze-dried peel powder of 05 varieties and mango accession.

The results show that the total phenolic compound content of the fresh pulp of the five mango varieties and accession ranged from 21.79 to 30.41 mg EAG/100 g (**Figure 3**). While the values obtained in freeze-dried peel powder ranged from 2293.02 to 5798.99 mg EAG/100 g (**Figure 4**). The observations made show that there is no significant difference between the phenolic compound contents of the fresh flesh of the 05 mango varieties and accession. On the other hand, the phenolic compound contents of the peel powder of *Haden* variety and SBMA-1 accession are significantly different from those of *Eldon*, *Paheri*, *Tommy Atkins* and *Zill* varieties for  $P \leq 5\%$ . The highest levels of fresh pulp ( $30.41 \pm 0.12$  mg EAG/100 g) and freeze-dried peel powder ( $5798.66 \pm 16.95$  mg EAG/100 g) are found in the *Zill* variety. Regarding the content of phenolic compounds, polyphenols are more abundant in the peel than in the fresh pulp. This could be explained by the ripening process, which leads to a reduction of phenolic compounds and acids. The levels found in the fresh pulp of the 05 mango varieties and accessions in the

present study are lower than those of the *Ataulfo* variety, which was 120 mg EAG/100 g [37]. They are also lower than those of the 20 Burkina mango varieties (48.15 and 110.41 mg EAG/100 g fresh pulp) [16]. The phenolic compound content of the *Zill* variety pulp is close to that of Indian mangoes, which was  $32.81 \pm 5.64$  mg GAE/100 g [35]. Sogi *et al.*, [41] reported phenolic compound contents ranging from 962.2 mg/100 g in vacuum-dried pulp of *Tommy Atkins* variety to 1725.2 mg/100 g in freeze-dried pulp of the same variety. Phenolic compounds are a group of secondary metabolites that are considered natural antioxidants with multiple biological benefits for human health [32]. Mango peel is very rich in gallic acid and could be used in the treatment of diabetes [42]. Since mango skin is also an edible part of the fruit, it should be consumed at the same time as the flesh. It could be used as a nutraceutical [42].

## 5. Conclusion

This study determined the physico-chemical and nutritional characteristics of 05 varieties and one accession of mango produced in Burkina Faso. The results obtained from the material balance show that these varieties are very fleshy, with the exception of the Paheri variety. These varieties are also very sweet, with a soluble extract  $\geq 20$  Brix. Only accession SBMA-1 could be considered acidic in terms of its TA. These varieties can be used for industrial production of puree, nectar, jam, chutney, preserves, etc. The Paheri variety could be used for the production of mango butter considering the size of its kernel. The mango varieties studied also have good nutritional potential. Consumption of mangoes from these five varieties and their accession could have a beneficial effect on human health due to their high content of phenolic compounds. The mango varieties Eldon, Haden, Paheri, Tommy Atkins, Zill and the SBMA-1 accession could contribute to a better valorization of the mango sector in Burkina Faso.

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## Author Contributions

All authors contributed to the study's conception and design. KANTE/TRAORE Hyacinthe is the initiator of the research and co-director of the master's program, while Aïcha ILBoudo is the student who determined the physico-chemical and nutritional parameters in the laboratory. She wrote the first draft of the manuscript, and all authors reviewed and edited it. All authors read and approved the final version of the manuscript.

## Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

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