

Nutrient Parameters of Mangoes Produced in the Departments of Korhogo and Sinématiali, Northern Côte d'Ivoire

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ABSTRACT

In Côte d'Ivoire, commercial mango production is concentrated in the north. Several mango varieties are produced, but little is known about the nutritional characteristics of their pulp, almond and peel. Therefore, the present study was carried out to characterize these organs of seven mango varieties produced in the Korhogo and Sinématiali departments. Nutrient parameters were determined by measuring lipids, proteins, carbohydrates, vitamin C, ash content, fiber content and energy value. Lipid analysis was carried out in accordance with ISO 659. The total protein content of mango organs was determined by the Kjeldahl method. Ash content was in mangoes organ was obtained by muffle furnace method. The crude fiber content of the samples was determined using the method of Weende. The energy value was calculated using the method of Livesey and Brown. Determination of vitamin C in the samples was based on the reduction of 2,6 dichlorophenol-indophenol by the latter. Ash contents ranged from $2.05\% \pm 0.07\%$ to $4.25\% \pm 0.07\%$. The highest values were obtained in the peel of the varieties Kent (Ouollo), Mademoiselle and Amelie (Natio), followed by the peel of the varieties Palmer produced in Natio ($3.85\% \pm 0.08\%$), Kent produced in Torgo ($3.84\% \pm 0.07\%$) and Keitt produced in Natio ($3.75\% \pm 0.08\%$). Vitamin C content ranged from 4.33 ± 0.07 mg/100 g to 18.33 ± 0.03 mg/100 g. The highest levels are found in the pulp of the Kent (Donnonnakaha) variety and in the almond of the Palmer variety. The almond is a significant source of lipids. Mango organs have a very high energy value (304.71 kcal/100 g to 427.81 kcal/100 g). To our knowledge, it is the first time this study has been carried out in Côte d'Ivoire.

Keywords: Côte d'Ivoire, mangoes, nutrient, varieties.

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1. INTRODUCTION

Mango (*Mangifera indica* L.) is a climacteric fruit with high nutritional and economic potential. Its cultivation is adapted to different agro-ecological zones ranging from sub-humid to semi-arid [1]. In West Africa, mango offers numerous nutritional advantages and represents an essential source of income [2]. Mango plays an important role in the economic development of production zones. Côte d'Ivoire is one of the leading mango-producing countries

in West Africa. National production is estimated at 150,000 tonnes (t), concentrated in the north of the country [3], [4]. Côte d'Ivoire exports mainly mangoes of the Kent (80%), Keitt (7%) and Amélie (3%) varieties [5]. The Kent variety is the most popular for export, to the detriment of other varieties which are virtually unknown thanks to its organoleptic and physicochemical qualities, in particular its low water content, which gives it a long commercial life [5].



Apart from these three main export varieties, several others exist in Côte d'Ivoire's production zones [6]. These varieties, which are little known and therefore less valued, represent 10% of orchards in production, and are tending to disappear in favour of the Kent variety [7]. This study covers all the possible varieties present in the orchards whose mango is the subject of our study. Unfortunately, only the Kent variety exists in Sinématiali, as all the other varieties have been grafted onto the Kent. However, in Korhogo, precisely in Natio, apart from Kent, there are still a few plants of six other varieties, notably Cameroun, Zill, Amélie, Keitt, Mademoiselle and Palmer [6]. The cultivation of cotton, once considered the main export crop and the basis of the region's development, has now been abandoned in favor of cashew and mango crops [8]. Mango production and marketing play an important role in the region's economic development. Fruit processing industries produce large quantities of waste, generally consisting of the peel of these fruits, 45% of which comes from mangoes [9]. The need is to recycle this fruit waste from the fruit processing industries [10]. These agro-resources can be incorporated into food products to partially replace flour, fat or sugar [11]. In Côte d'Ivoire, in Korhogo to be precise, dried mango production units generate residues that are most often stored in the open air or abandoned in nature, thus contributing to heavy environmental pollution. These residues, particularly the peel and almond, are rich in nutrients and can be incorporated into the manufacture of compound foods [12]. Nutritionally, mango is an essential source of provitamin A (4800 IU), vitamin C (13 mg/100 g) and minerals [13]. The energy value of its pulp varies from 50 to 60 calories per 100 g of fresh product [13]. Regular consumption of mango could also be an effective means of combating avitaminosis A [14]. Despite the nutritional and economic importance of mango, and the dietary interest that people attach to it, its performance is hampered by major problems. The management of mangoes and their by-products is still marked by significant losses, due to the limited processing of uneaten organs such as the peel and almond, often treated as waste, and the neglect of other varieties. The main objective of this study is to valorize mango organs and neglected varieties in order to boost local economies, while minimizing the environmental impact of mango production in production areas. Specifically, it will assess the nutritional parameters of the peel, pulp and almond of mangoes grown in the Korhogo and Sinématiali departments. This analysis aims to identify opportunities for economic and environmental valorization of by-products, while promoting a sustainable agricultural resource management approach. By highlighting the nutritional differences between these organs, this study will offer avenues for maximizing the economic and ecological benefits of mango production in the Korhogo and Sinématiali departments.

2. MATERIALS AND METHODS

2.1. Biological Materials

The biological material used consists of the various organs (peel, pulp and almond) of mature and green

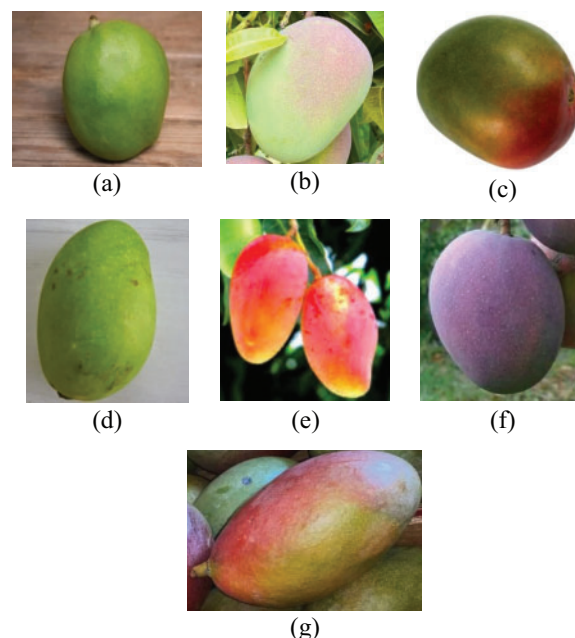


Fig. 1. Different mangoes harvested in the Korhogo and Sinématiali departments: (a) Amélie, (b) Kéitt, (c) Kent, (d) Cameroun, (e) Mademoiselle, (f) Zill, and (g) Palmer.

(unripe) mangoes (Fig. 1) harvested in the Korhogo and Sinématiali departments during March 2023.

2.2. Technical Equipment and Apparatus

The equipment used in the laboratory analyses consisted of Soxhlet extractor, precision balance (Ohaus), drying oven (Mettler), furnace (Nabertherm), desiccator (Duran), centrifuge (Simplex), rotary evaporator (Buchi) and laboratory glassware

2.3. Chemicals

Solvents used are hexane and distilled water. Reagents used are sodium hydroxide (0.1 N; 40%), sulfuric acid, sodium sulfate, boric acid, methyl red, bromocresol green, 2,6-dichlorophenolindophenol, metaphosphoric acid and acetic acid.

2.4. Sampling

Sampling was carried out in the Korhogo and Sinématiali departments during the 2023 mango season in Côte d'Ivoire. Sampling was carried out in three different orchards for each department using the simple random sampling method. Mangoes were harvested at the mature green stage. They were washed, wiped and peeled. The various parts of the mango, notably the peel, pulp and almond, were then sun-dried for a week on boards placed on a support about a metre high, and ground to powder separately. Analyses were carried out on the powder from the various organs. In all, we have 36 samples.

2.5. Evaluation of Nutrient Parameters of Mango Organ

2.5.1. Lipid Determination

Lipid content was carried out in accordance with ISO 659 [15]. 10 g of sample were weighed and introduced into a cellulose extraction cartridge which had been tared beforehand. The cartridge containing the sample was plugged with cotton and placed in the Soxhlet extractor. Total lipids

were extracted with 300 mL of hexane for seven hours at boiling point, after which the hexane was evaporated using a rotary evaporator. The flask containing the fat and traces of solvent was then placed in an oven for one hour at 103°C, then cooled in a desiccator for 30 min. The whole batch (flask + lipids) was weighed at the end of the operation:

$$\text{Lipid (\%)} = \frac{(m_1 - m_0) \times 100}{m_e}$$

where

m_0 – mass (g) of empty balloon

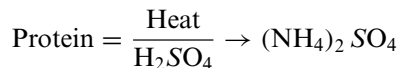
m_e – sample mass (g)

m_1 – mass (g) of total (flask + lipids) after incineration

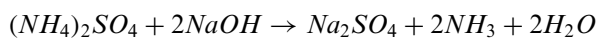
2.5.2. Protein Determination

Total protein content of mango organ powder was determined by the Kjeldahl method [16]. This method is based on the transformation of organic nitrogen into mineral nitrogen in ammoniacal form $(\text{NH}_4)_2\text{SO}_4$ by the oxidative action of boiling sulfuric acid on organic matter in the presence of a catalyst:

Mineralization: 1 g of powder (m_e) was mineralized in a Kjeldahl matron at 400°C for two hours with 20 mL of concentrated sulfuric acid in the presence of a pinch of mineralization catalyst (sodium sulfate). The mineralizate was cooled completely, transferred to a 100 mL flask and made up to volume with distilled water:



Distillation: 10 mm of the diluted mineralizate were withdrawn and added to 10 mL of 40% NaOH. The whole was distilled for 10 min, trapping the distillate in a flask containing 20 mL boric acid with added mixed indicator (methyl red + bromocresol green):



Titration: The resulting distillate was titrated with a 0.01 N sulfuric acid solution until it turned from green to pink (V1). A blank test (V0) was carried out. Calculation of total protein as a percentage of dry sample mass (dry matter):

$$\text{Total protein (\%)} = \frac{(V_1 - V_0) \times 14 \times 6.25 \times N}{m_e}$$

where

6.25 – nitrogen-to-protein conversion factor

14 – molar mass of nitrogen

V_0 – volume (mL) of sulfuric acid solution poured for blank test

V_1 – volume (mL) of sulfuric acid solution poured for test (sample)

N – normality of sulfuric acid solution (0.01)

m_e – sample mass (g).

2.5.3. Raw Fiber Determination

Crude or insoluble fibers include cellulose, some hemicelluloses and lignin. The crude fiber content of the

samples was determined using the Weende method [17]. In this method, the sample is boiled with sulfuric acid and then treated with sodium hydroxide. The residue obtained is dried, then calcined and weighed. The procedure involves introducing 2 g of sample into a beaker containing 50 mL of 0.25 N sulfuric acid. The mixture was then boiled for 30 min. After this, 50 mL of 0.31 N sodium hydroxide was added to the boiling mixture for 30 min. After filtration, the residue was washed several times with hot distilled water until the alkalis were completely removed. The resulting insolubles were dried at 105°C for 8 h and weighed (m_1). This dry residue was incinerated at 550°C in a muffle furnace previously heated to 550°C for 3 h, and the ash was weighed (m_2). The crude fiber content was given by the following relationship:

$$\text{Raw fiber (\%)} = \frac{(m_1 - m_2) \times 100}{m_e}$$

where

m_1 – mass (g) of dried residue

m_2 – mass (g) of ash obtained

m_e – sample mass (g)

2.5.4. Ash Content

The ash content of mango organs was determined by the Elie method [16]. 5 g of sample were weighed into pre-heated porcelain crucibles. The crucibles were then placed in a muffle furnace at 550°C for 5 hours. On leaving the furnace, the crucibles were cooled in a desiccator, before being weighed and the percentage ash was determined according to the following equation:

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

where

m_0 – mass (g) of empty crucible

m_1 – mass (g) of the whole (crucible + ash) after incineration

m_e – flour mass (g).

2.5.5. Carbohydrate Determination

Total carbohydrate content was determined by dividing the total matter by the other biochemical compounds using following formula:

$$G (\text{g}/100 \text{ g de MS}) = 100 - (H + C + P + \text{MG})$$

where

G – total carbohydrate content (%)

H – moisture content (%)

P – crude protein content (%)

MG – fat content (%)

C – ash content (%)

2.5.6. Energy Value

The energy value was calculated with 4 kcal/g for carbohydrates, 4 kcal/g for protein and 9 kcal/g for fat according to the Livesey and Brown method [18]:

$$\text{VE} = 4G + 4P + 9\text{MG}$$

where

VE – energy value in kcal/100 g dry matter

G – total carbohydrate content

P – crude protein content

MG – fat content

2.5.7. Vitamin C Content

The method used for the determination of vitamin C in samples was that described by Pongracz *et al.* [19], whose principle is based on the reduction of 2,6 DCPIP (2,6 dichlorophenol-indophenol) by the latter.

10 g of ground sample was solubilized in 40 mL of metaphosphoric acid-acetic acid (2%; w/v). The resulting mixture was centrifuged at 3000 rpm for 20 min. The supernatant was transferred to a 50 mL volumetric flask and made up to volume with boiled distilled water, cooled in the absence of air. A 10 mL test portion was introduced into an Erlenmeyer flask and titrated with 2.6 DCPIP at 0.5 g/l until a persistent pink colour was obtained. The vitamin C content of the sample was determined by the following expression:

$$\text{VitaminC (mg/100g)} = \frac{C_{2,6\text{DCPIP}} \times V_e \times 5}{P_e} \times 100$$

where

V_e – volume of 2,6- dichlorophenol indophenol obtained by filtrate titration,

$C_{2,6\text{DCPIP}}$ – dichlorophenol indophenol concentration (0.5 g/l)

P_e – test drive

2.5.8. Statistical Analysis

Statistically significant differences were highlighted by the Student-Newman-Keuls test at 0.05 risk using SPSS version 20.0 software. Graphs were produced using Excel 2016.

3. RESULTS

3.1. Crude Fiber Content

Table I shows that crude fiber contents ranged from $1.05\% \pm 0.06\%$ to $3.09\% \pm 0.06\%$. The highest percentage was obtained in peel of Cameroun variety, followed by almond of Kent $2.93\% \pm 0.6\%$ and Zill $2.91\% \pm 0.6\%$ varieties produced at Natio. The lowest percentages were obtained in peel and pulp of Amelie variety. In general, mango almond contains more crude fiber than pulp and peel respectively, with respective averages of $2.11\% \pm 0.64\%$, $1.97\% \pm 0.46\%$ and $1.87\% \pm 0.74\%$. There is a significant difference between different values.

3.2. Ash Content

Ash contents ranged from $2.05\% \pm 0.07\%$ to $4.25\% \pm 0.07\%$. The highest values were obtained in peel of varieties Kent (Ouollo), Mademoiselle and Amelie (Natio), followed by peel of varieties Palmer produced at Natio ($3.85\% \pm 0.08\%$), Kent produced at Torgo ($3.84\% \pm 0.07\%$) and Keitt produced at Natio ($3.75\% \pm 0.08\%$). The lowest ash sample was obtained in pulp of Kent variety grown at Klokakaha (Table I). Average ash levels in peel, almond and pulp were $3.56\% \pm 0.53\%$, $2.93\% \pm 0.43\%$ and 2.62%

TABLE I: NUTRITIONAL VALUE OF THE ALMOND, PEEL AND PULP OF DIFFERENT MANGO VARIETIES

Samples	Mango organs	Ash (%)	Fibers (%)
Kent Klokakaha (Korhogo)	Almond	2.85 ± 0.07^b	1.89 ± 0.06^c
	Peel	3.54 ± 0.07^a	1.29 ± 0.06^c
	Pulp	2.05 ± 0.07^c	2.24 ± 0.06^b
Kent Torgo (Korhogo)	Almond	3.59 ± 0.14^a	1.44 ± 0.06^d
	Peel	3.84 ± 0.07^a	1.29 ± 0.06^c
	Pulp	2.45 ± 0.07^c	1.45 ± 0.06^d
Kent Natio (Korhogo)	Almond	2.60 ± 0.00^b	2.93 ± 0.06^a
	Peel	3.25 ± 0.07^a	1.26 ± 0.06^c
	Pulp	2.40 ± 0.14^c	1.68 ± 0.06^d
Palmer Natio (Korhogo)	Almond	3.65 ± 0.07^a	1.18 ± 0.06^c
	Peel	3.85 ± 0.08^a	2.83 ± 0.06^a
	Pulp	2.50 ± 0.14^c	1.78 ± 0.06^d
Keitt Natio (Korhogo)	Almond	2.35 ± 0.07^c	2.64 ± 0.06^a
	Peel	3.75 ± 0.08^a	2.30 ± 0.06^b
	Pulp	2.20 ± 0.00^c	2.34 ± 0.06^b
Zill Natio (Korhogo)	Almond	2.60 ± 0.14^b	2.91 ± 0.06^a
	Peel	3.39 ± 0.00^a	2.74 ± 0.06^a
	Pulp	2.65 ± 0.07^b	2.24 ± 0.06^b
Mademoiselle Natio (Korhogo)	Almond	2.74 ± 0.08^b	2.12 ± 0.06^c
	Peel	4.25 ± 0.07^a	1.26 ± 0.06^c
	Pulp	2.89 ± 0.14^b	2.36 ± 0.06^b
Amélie Natio (Korhogo)	Almond	3.30 ± 0.07^a	2.64 ± 0.06^a
	Peel	4.04 ± 0.14^a	1.05 ± 0.06^c
	Pulp	2.80 ± 0.14^b	1.09 ± 0.06^c
Cameroun Natio (Korhogo)	Almond	2.80 ± 0.14^b	2.59 ± 0.06^b
	Peel	2.64 ± 0.07^b	3.09 ± 0.06^a
	Pulp	2.25 ± 0.07^c	2.49 ± 0.06^b

TABLE I: CONTINUED

Samples	Mango organs	Ash (%)	Fibers (%)
Kent Donnonnakaha (Sinématiali)	Almond	2.78 ± 0.12 ^b	1.18 ± 0.06 ^e
	Peel	3.05 ± 0.07 ^a	1.21 ± 0.06 ^e
	Pulp	2.89 ± 0.01 ^b	1.43 ± 0.06 ^d
Kent Camonnon (Sinématiali)	Almond	3.35 ± 0.07 ^a	2.03 ± 0.06 ^c
	Peel	2.84 ± 0.07 ^b	2.06 ± 0.06 ^c
	Pulp	3.35 ± 0.07 ^a	2.38 ± 0.06 ^b
Kent Ouollo (Sinématiali)	Almond	2.55 ± 0.07 ^c	1.77 ± 0.06 ^d
	Peel	4.25 ± 0.07 ^a	2.05 ± 0.06 ^a
	Pulp	3.05 ± 0.07 ^a	2.18 ± 0.06 ^b
Average	Almond	2.93 ± 0.43 ^a	2.11 ± 0.64 ^c
	Peel	3.56 ± 0.53 ^a	1.87 ± 0.74 ^c
	Pulp	2.62 ± 0.38 ^b	1.97 ± 0.46 ^c
Samples	Mango organs	Vitamin C(mg/100 g)	Lipids (%)
Kent Klokakaha (Korhogo)	Almond	10.00 ± 0.00 ^c	10.05 ± 0.89 ^a
	Peel	8.33 ± 0.03 ^d	0.31 ± 0.00 ^b
	Pulp	5.00 ± 0.00 ^e	0.23 ± 0.01 ^b
Kent Torgo (Korhogo)	Almond	5.00 ± 0.00 ^e	10.10 ± 0.89 ^a
	Peel	7.50 ± 0.05 ^c	0.20 ± 0.01 ^b
	Pulp	8.33 ± 0.06 ^d	0.35 ± 0.01 ^b
Kent Natio (Korhogo)	Almond	4.33 ± 0.07 ^c	13.01 ± 0.89 ^a
	Peel	5.00 ± 0.00 ^e	0.13 ± 0.01 ^b
	Pulp	10.00 ± 0.09 ^c	0.20 ± 0.00 ^b
Palmer Natio (Korhogo)	Almond	18.33 ± 0.06 ^a	12.21 ± 0.89 ^a
	Peel	10.00 ± 0.00 ^c	0.24 ± 0.01 ^b
	Pulp	11.67 ± 0.06 ^c	0.24 ± 0.00 ^b
Keitt Natio (Korhogo)	Almond	5.83 ± 1.06 ^e	14.29 ± 0.89 ^a
	Peel	10.00 ± 0.00 ^c	0.13 ± 0.01 ^b
	Pulp	12.50 ± 0.00 ^b	0.36 ± 0.00 ^b
Zill Natio (Korhogo)	Almond	10.00 ± 0.00 ^c	15.15 ± 0.89 ^a
	Peel	12.50 ± 0.00 ^b	0.25 ± 0.06 ^b
	Pulp	5.33 ± 0.03 ^e	0.26 ± 0.05 ^b
Mademoiselle Natio (Korhogo)	Almond	10.00 ± 0.09 ^c	15.82 ± 0.89 ^a
	Peel	10.00 ± 0.00 ^c	0.35 ± 0.04 ^b
	Pulp	10.83 ± 0.03 ^c	0.29 ± 0.03 ^b
Amélie Natio (Korhogo)	Almond	11.67 ± 0.06 ^c	12.06 ± 0.89 ^a
	Peel	11.67 ± 0.06 ^c	0.32 ± 0.02 ^b
	Pulp	10.00 ± 0.00 ^c	0.27 ± 0.01 ^b
Cameroun Natio (Korhogo)	Almond	15.00 ± 0.00 ^a	8.76 ± 0.89 ^a
	Peel	11.67 ± 0.03 ^c	0.32 ± 0.01 ^b
	Pulp	10.83 ± 0.03 ^c	0.18 ± 0.01 ^b
Kent Donnonnakaha (Sinématiali)	Almond	11.67 ± 0.06 ^c	11.87 ± 0.89 ^a
	Peel	15.00 ± 0.00 ^a	0.44 ± 0.04 ^b
	Pulp	18.33 ± 0.03 ^a	0.16 ± 0.03 ^b
Kent Camonnon (Sinématiali)	Almond	13.33 ± 0.03 ^b	10.44 ± 0.89 ^a
	Peel	8.33 ± 0.03 ^d	0.25 ± 0.01 ^b
	Pulp	12.50 ± 0.05 ^b	0.17 ± 0.01 ^b
Kent Ouollo (Sinématiali)	Almond	9.17 ± 0.03 ^d	13.66 ± 0.76 ^a
	Peel	11.67 ± 0.06 ^c	0.31 ± 0.01 ^b
	Pulp	10.00 ± 0.00 ^c	0.19 ± 0.01 ^b
Average	Almond	10.36 ± 4.10 ^c	12.29 ± 2.19 ^a
	Peel	10.14 ± 2.63 ^c	0.27 ± 0.09 ^b
	Pulp	10.49 ± 3.42 ^c	0.24 ± 0.07 ^b

Note: Values in the same column with the same letter show no significant difference at risk $p < 0.05$.

± 0.38%, respectively. There is a significant difference between the values.

3.3. Vitamin C Content

Vitamin C contents ranged from 4.33 ± 0.07 to 18.33 ± 0.03 mg/100 g (Table I). The highest levels were found in

pulp of Kent (Donnonnakaha) variety and in almond of palmer variety. The lowest content was found in almond of Kent variety produced at Natio (Korhogo). At pulp level, Kent from Donnonnakaha contains the most vitamin C, followed by Keitt from Natio and Kent from Camonnon (12.5 ± 0.05 mg/100 g). Zill pulp (5.83 ± 0.03 mg/100 g) is

the least rich in vitamin C. On average, pulp contains 10.49 ± 3.42 mg/100 g, almond 10.36 ± 4.10 mg/100 g and peel 10.14 ± 2.63 mg/100 g. There is no significant difference between the average for almond, peel and mango pulp at risk $p < 0.05$. Vitamin C averages in samples from Sinématiali department ranged from 11.39 ± 2.10 to 13.61 ± 4.28 , compared with 6.44 ± 3.10 mg/100 g and 7.78 ± 2.55 mg/100 g for those from Korhogo department.

3.4. Lipid Content

Peels and almond of samples analyzed had lipid contents ranging from $0.13\% \pm 0.01\%$ to $0.44\% \pm 0.04\%$, with the lowest values obtained in peels of Kent and Keitt varieties produced at Natio, and the highest in peel of Kent variety produced at Donnonnakaha, followed by pulp of Keitt variety ($0.36\% \pm 0.00\%$) produced at Natio. Except to almonds, which show high values of $8.76\% \pm 0.89\%$ for Cameroun and $15.82\% \pm 0.89\%$ for Mademoiselle (Table I), mango almonds from Sinématiali department contain more lipids, with an average of $12\% \pm 1.60\%$, compared with those from Korhogo department, with an average of $11.05\% \pm 1.63\%$. On average, of mango organs, almond ($12.29\% \pm 2.19\%$) contains more lipids than peel with $0.27\% \pm 0.09\%$ and pulp with $0.24\% \pm 0.07\%$.

3.5. Protein Content

Protein levels in samples analyzed ranged from $2.32\% \pm 0.05\%$ to $5.56\% \pm 0.05\%$. The lowest values were obtained in peel of Kent and pulps of Keitt and Amelie produced at Natio. The highest values were obtained in almond of Palmer variety at Natio and peel of Zill variety at Natio (Table II). The proportion of protein in almond, peel and pulp was $4.43\% \pm 0.94\%$, $4.24\% \pm 0.93\%$ and $3.86\% \pm 0.82\%$, respectively. There is a significant difference in the protein content of the different mango organs.

3.6. Carbohydrates Content and Energy Values

Carbohydrate values ranged from 64.98% to 83.87%. The lowest value was obtained in almond of Kent variety (Torgo). The highest value was obtained in peel of Kent variety at Natio (Table II). The peel contains more carbohydrates (77.08%) than pulp (74.35%) and almond (68.33%). Samples from Sinématiali department contained more carbohydrates, with averages ranging from 69.03% to 77.04%, compared with 68.78% to 75.02% for Korhogo department. There is a significant difference between the values.

Energy values ranged from 304.71 kcal/100 g to 427.81 kcal/100 g, with the highest value recorded for the Mademoiselle variety, followed by the Zill variety (424.95 kcal/100 g). On the other hand, the lowest value was obtained by the pulp of the Kent variety produced at Torgo, followed by the pulp of Keitt (307.25 kcal/100 g). On average, almonds have a higher energy value than peel and pulp, with respective averages of 403.60 kcal/100 g, 331.22 kcal/100 g, and 318.27 kcal/100 g.

4. DISCUSSION

Crude fiber contents ranged from $1.05\% \pm 0.06\%$ to $3.09\% \pm 0.06\%$. The highest percentage was obtained in

peel of Cameroun variety, followed by almonds of Kent and Zill varieties. The lowest percentages were obtained in peel and pulp of Amelie variety. In general, mango almonds contain more crude fibre than pulp and peel respectively. These values are lower than those found by Bamba *et al.* [20]. These authors found values between $4.95\% \pm 0.02\%$ and $5.32\% \pm 0.01\%$ with $5.22\% \pm 0.13\%$, $4.95\% \pm 0.02\%$ and $5.29\% \pm 0.01\%$ for mango almond and peel and cashew apple respectively. Kanté-Traoré [21] obtained values ranging from 1.87% (Amelie) to 2.77% (Kent) of fresh pulp. Kameni *et al.* [22] obtained 0.7% in pulp of Amélie variety from Cameroon. Dietary fiber is the residue of non-digestible carbohydrates [23]. There are insoluble and soluble fibers with specific physicochemical properties. The viscosity of soluble fibers modulates the sensation of satiety by limiting absorption of certain metabolites, and helps lower serum cholesterol and blood glucose levels [24]. The hydrating properties of insoluble fibers help accelerate intestinal transit and prevent constipation [25]. Dietary fiber may help prevent and control diabetes and lower blood cholesterol levels, which is important for preventing heart disease [24]. Thus, the low crude fiber content of the samples studied could be beneficial for broilers because broilers need a moderate amount of fiber (3% to 5%) for better nutrient absorption [20].

Ash contents ranged from $2.05\% \pm 0.07\%$ to $4.25\% \pm 0.07\%$. The highest values were obtained in peel of varieties Kent (Ouollo), Mademoiselle and Amelie (Natio), followed by peel of varieties Palmer produced in Natio, Kent produced in Torgo and Keitt produced in Natio. The sample with the lowest ash content was obtained from pulp of Kent variety grown at Klokakaha. The peel is richer in ash than almond and pulp respectively. Ash represents all minerals contained in a sample [20]. The mango peel and almond would therefore be richer in minerals than the pulp. Ash contents in this study are higher than those found by Kanté-Traoré [21]. Indeed, he worked on valorization of mango varieties produced in Burkina Faso and obtained rates varying from 0.37% to 1.41%. The highest rate was recorded for the Brooks variety, while the lowest rates were recorded for the Amélie (0.37 ± 0.02) and Lippens ($0.39\% \pm 0.00\%$) varieties. Bamba *et al.* [20] obtained $3.82\% \pm 0.15\%$ for cashew apple, 3.11% and $1.53\% \pm 0.19\%$ for mango peel and almond respectively. Touré *et al.* [26] obtained 5.67% and 1.87%, respectively for cashew apple and mango almond. In contrast, the ash content determined by Sempore *et al.* [27] on 14 accessions of cashew almonds from Burkina Faso averaged $2.74\% \pm 0.39\%$. These differences in values could be due to climatic, pedological conditions and the treatments applied in the areas from which the mangoes originate [28]. It should be noted that ash content of all samples studied is higher than that of maize, which stands at 1.2% [29]. Mango almond and peel (especially those from Korhogo) could represent a good source of mineral matter for healthy body function and animal growth [20].

Vitamin C content ranged from 4.33 ± 0.07 mg/100 g to 18.33 ± 0.03 mg/100 g. The highest levels were found in pulp of Kent variety (Donnonnakaha) and in almond of palmer variety. The lowest content was found in almond of Kent variety produced in Natio (Korhogo). In terms

TABLE II: NUTRITIONAL VALUE OF THE ALMOND, PEEL AND PULP OF DIFFERENT MANGO VARIETIES

Samples	Mango organs	Proteins (%)	Carbo-hydrates (%)	Energy value (%)
Kent Klokakaha (Korhogo)	Almond	5.38 ± 0.05 ^a	71.96 ^c	399.83 ^a
	Peel	4.16 ± 0.05 ^a	76.01 ^b	323.45 ^b
	Pulp	3.72 ± 0.05 ^a	75.34 ^b	318.34 ^c
Kent Torgo (Korhogo)	Almond	4.24 ± 0.05 ^a	64.98 ^d	367.83 ^a
	Peel	5.03 ± 0.05 ^a	75.64 ^b	324.50 ^b
	Pulp	3.89 ± 0.05 ^a	71.48 ^c	304.71 ^c
Kent Natio (Korhogo)	Almond	4.55 ± 0.10 ^a	69.40 ^c	412.88 ^a
	Peel	2.32 ± 0.05 ^b	83.87 ^a	345.87 ^a
	Pulp	4.07 ± 0.05 ^a	82.43 ^a	347.81 ^a
Palmer Natio (Korhogo)	Almond	5.56 ± 0.05 ^a	67.24 ^d	401.13 ^a
	Peel	3.89 ± 0.05 ^a	77.73 ^b	328.59 ^b
	Pulp	4.24 ± 0.05 ^a	74.78 ^c	318.24 ^c
Keitt Natio (Korhogo)	Almond	2.84 ± 0.05 ^b	70.52 ^c	422.07 ^a
	Peel	5.43 ± 0.10 ^a	75.69 ^b	325.69 ^b
	Pulp	2.32 ± 0.05 ^b	73.68 ^c	307.25 ^c
Zill Natio (Korhogo)	Almond	3.76 ± 0.00 ^a	68.39 ^d	424.95 ^a
	Peel	5.56 ± 0.05 ^a	77.92 ^b	336.15 ^a
	Pulp	3.81 ± 0.05 ^a	78.34 ^b	330.98 ^b
Mademoiselle Natio (Korhogo)	Almond	5.51 ± 0.10 ^a	65.84 ^d	427.81 ^a
	Peel	4.07 ± 0.05 ^a	79.61 ^a	337.90 ^a
	Pulp	4.33 ± 0.05 ^a	73.51 ^c	313.98 ^c
Amélie Natio (Korhogo)	Almond	4.55 ± 0.10 ^a	68.71 ^d	401.62 ^a
	Peel	3.46 ± 0.05 ^a	79.55 ^a	334.85 ^a
	Pulp	2.32 ± 0.05 ^b	77.69 ^b	322.48 ^b
Cameroun Natio (Korhogo)	Almond	5.21 ± 0.05 ^a	71.76 ^c	386.68 ^a
	Peel	4.16 ± 0.05 ^a	78.36 ^b	332.92 ^a
	Pulp	3.98 ± 0.00 ^a	74.81 ^c	316.79 ^c
Kent Donnonnakaha (Sinématiali)	Almond	4.03 ± 0.10 ^a	71.48 ^c	408.86 ^a
	Peel	4.33 ± 0.05 ^a	77.86 ^b	332.74 ^a
	Pulp	5.25 ± 0.10 ^a	72.44 ^c	312.20 ^c
Kent Camonnon (Sinématiali)	Almond	2.84 ± 0.05 ^b	66.50 ^d	371.38 ^a
	Peel	3.46 ± 0.15 ^a	77.93 ^b	327.79 ^b
	Pulp	4.00 ± 0.03 ^a	73.38 ^c	311.09 ^c
Kent Ouollo (Sinématiali)	Almond	4.68 ± 0.05 ^a	69.11 ^c	418.12 ^a
	Peel	5.03 ± 0.05 ^a	75.32 ^b	324.14 ^b
	Pulp	4.42 ± 0.05 ^a	73.98 ^c	315.35 ^c
Average	Almond	4.43 ± 0.94 ^a	68.83 ^d	403.60 ^a
	Peel	4.24 ± 0.93 ^a	77.08 ^b	331.22 ^b
	Pulp	3.86 ± 0.82 ^a	74.35 ^c	318.27 ^c

Note: Values in the same column with the same letter show no significant difference at risk $p < 0.05$.

of pulp, Kent from Donnonnakaha contains the most vitamin C, followed by Keitt from Natio and Kent from Camonnon. Zill pulp is the least rich in vitamin C. On average, pulp contains as much vitamin C as almond and peel. Samples from Sinématiali department contain more vitamin C than those from Korhogo department. Vitamin C is recognized for its antioxidant properties, which protect cells and tissues of human body against free radicals [30]. It acts indirectly on activity of polyphenol oxidases (PPO) by reducing O-quinones formed from diphenols, resulting in inhibition of enzymatic browning [31], [32]. Ma *et al.* [30] obtained vitamin C contents ranging from 19.79 ± 3.71 to 34.59 ± 4.41 mg/100 g fresh pulp in 8 mango varieties. These values are higher than ours, which could be explained by the fact that our samples were sun-dried, as the sun's radiation would oxidize vitamin C [22]. They are also unripe. In fact, Kaméni *et al.* [22] evaluated the suitability for drying of several varieties of mango grown in Cameroon: Amélie, Zill, Irwin and Horé Wandou. They

found that sun-dried mango strips were lower in vitamin C content than those dried in electric driers. Wills *et al.* [13] worked on the Springfield variety. They demonstrated that vitamin C levels are 3 mg/100 g when the mango is green, rising to 13 mg/100 g as the mango ripens.

Lipids contents of peels and almonds of samples were ranging from 0.13 ± 0.01 to $0.44 \pm 0.04\%$, with the lowest values in peels of Kent and Keitt varieties produced in Natio, and the highest in peel of Kent variety produced in Donnonnakaha, followed by pulp of Keitt variety produced in Natio. Except almonds, which show high values ranging from $8.76\% \pm 0.89\%$ (Cameroon) to $15.82\% \pm 0.89\%$ (Mademoiselle), mango almonds from Sinématiali department contain more lipids than those from Korhogo department. The lipid contents of mango almonds and peels in this study agree with those found by Kiendrebeogo *et al.* [33], for mango almond (7.87%–14.80%) and mango peel (0.37%) respectively. The fat content of pulp is similar to that obtained in mango pulp in general, which is

0.2% [34], [35]. Wills *et al.* [13] obtained 0.1% for unripe Springfield and 1.8% after ripening. Bamba *et al.* [20] obtained $1.36\% \pm 0.13\%$ and $9.15\% \pm 0.07\%$ for mango peel and almond, $3.76\% \pm 0.24\%$ for cashew apple and $10.53\% \pm 0.23\%$ for cottonseed cake. Generally speaking, mango pulp and peel contain very little fat. The almond is a significant source of lipids, essential for boosting the energy value of a food.

Protein levels in the samples analyzed ranged from 2.32 ± 0.05 to $5.56 \pm 0.05\%$. The lowest values were obtained in the peel of Kent and the pulps of Keitt and Amelie produced at Natio. On the other hand, the highest values were obtained in the almond of the Palmer variety (Natio) and the peel of the Zill variety (Natio). The proportion of protein in almond, peel and pulp was $4.43\% \pm 0.94\%$, $4.24\% \pm 0.93\%$ and $3.86\% \pm 0.82\%$, respectively. This difference in values is thought to be linked to the mango variety [20]. The protein content of mango organs is low, however, and these values fall within the range of protein contents (3% and 10%) of mango organs from various countries [33], [36], [37]. These values are lower than those obtained by Meité *et al.* [38] on wheat, with a value of 10.09 ± 0.09 g/100 g. This means that the various mango organs cannot be used as fortifiers for protein-poor foods. The recommended daily intake of protein for children is between 23.0 and 36.0 g, and for adults between 44 and 56 g [39]. Mango almond, peel and pulp are therefore a negligible source of vegetable protein.

Carbohydrate values ranged from 64.98% to 83.87%. The lowest value was obtained in almond of Kent (Torgo) variety. The highest value was obtained in peel of Kent (Natio) variety. Samples from Sinématiali department contain more carbohydrates. The almond is organ with the lowest carbohydrate content. This could be due to the fact that it contains more lipids. Bamba *et al.* [20] obtained 79.56 ± 0.32 g/100 g, 73.96 ± 1.59 g/100 g, and 69.33 ± 1.79 g/100 g for mango peel, almond and cashew apple respectively. Touré *et al.* [26] obtained 60.59% for cashew apple, 63.34% for mango almond and 62.86% for mango peel. Our values are higher than those for white corn (66.57%) and yellow corn (73.8%), with the exception of the almond [29]. The high carbohydrate content is linked to the cellulose walls of the various organs, where fibers and starch are found in abundance [20]. These by-products (almond and peel) could therefore be used to replace corn in broiler feeds.

Energy value varies between 304.71 kcal/100 g and 427.81 kcal/100 g, with the highest energy value recorded for Mademoiselle almond, followed by Zill variety. The lowest value was obtained in pulp of Kent variety produced at Torgo, followed by pulp of Keitt. On average, almond has a higher energy value than peel and pulp. These values are well above the 280 kcal/100 g recommended by INRA [40] for the choice of raw materials in poultry feed. The energy values of the present study corroborate those obtained by Bamba *et al.* [20]. Indeed, these authors obtained 402.71 ± 6.84 , 346.24 ± 3.22 , 388.41 ± 4.94 , 413.73 ± 1.38 , and 361.56 ± 5.36 , respectively for mango almond and peel, cotton and shea cakes and cashew apple.

5. CONCLUSION

The present study has made it possible to characterize the different mango varieties existing in the departments of Sinématiali and Korhogo in order to enable their appropriate use by mango industry stakeholders. In Sinématiali, all other varieties have disappeared in favor of the Kent variety for economic reasons. However, in Korhogo, precisely in Natio, there are still a few trees of the Amelie, Cameroun, Zill, Mademoiselle, Keitt and Palmer varieties in the orchards. Almonds are a significant source of lipids, essential for boosting a food's energy content. Mango almond and peel could represent a good source of minerals for healthy body function and animal growth. These by-products (almond and peel) have a high carbohydrate content and could be used to replace corn in broiler feeds. Their low crude fiber content could be beneficial for broilers. The pulp, as the main edible part, is packed with vitamin C for human nutrition and health, reinforcing its basic nutritional role. These results underline the importance of integrated valorization of the various mango organs, in particular to reduce post-harvest losses and transform by-products into economic resources. By promoting the transformation of agricultural waste into high value-added products, this approach could help boost local economies, while minimizing the environmental impact of mango production in production areas. This will optimize the value of mangoes and encourage more sustainable and innovative agriculture.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

REFERENCES

- [1] Grant W, Kadondi E, Mbaka M, Ochieng S. *Opportunities for Financing the Mango Value Chain: A Case Study of Lower Eastern Kenya*. Nairobi, Kenya: FSD Kenya; 2015. 52.
- [2] Gerbaud P. La mangue plus forte que la covid. *FruiTrop*. 2021;274:48–90.
- [3] Galán SV. Worldwide mango production and market: current situation and future prospects. *Acta Hort.* 2013;992:37–48.
- [4] Mieu B. Côte d'Ivoire: Le Gouvernement Veut Restructurer La Filière Mangue. 2017, pp. 12. Available from: www.Jeuneafrique.com.
- [5] Touré S. Etude nationale mangue-Côte d'Ivoire. Rapport d'analyse pour le Centre du Commerce Internationale, Genève, 2012, pp. 27.
- [6] Coulibaly SA, Toure A, Kablan RJF, N'Guessan OE, Yéo ND, Kablan ALC. Phytochemical and antioxidant properties of mangoes produced in Korhogo and Sinématiali departments, north of Côte d'Ivoire. *J Pharmacogn Phytochem*. 2025;14:408–15.
- [7] CBI. Analyse de la chaîne de valeur des fruits transformés au Burkina Faso, au Mali et en Côte d'Ivoire. Rapport d'analyse pour le Centre pour la Promotion des Importations, 2019, pp. 178.
- [8] Koffi. Estimation de la maturité physiologique de la mangue et du rendement du verger de manguier (*Mangifera indica* L., variété 'Kent') au nord de la Côte d'Ivoire : vers la mise en place d'un modèle de prévision de récolte. Thèse de doctorat : Agro-physiologie. Université Jean Lorougnon Guédé Côte d'Ivoire, 2021, pp. 162.
- [9] Lakshmi A, Sagadevan. Low power implementation of sequential circuits. *Int J Curr Eng Technol*. 2014;4(3):2108–11.
- [10] Arogba SS. Physical, chemical and functional properties of Nigerian mango (*Mangifera indica* L.) kernel and its processed flour. *J Sci Food Agric*. 1997;73:321–8.
- [11] Arogba SS. Mango (*Mangifera indica* L.) Kernel: Chromatographic analysis of the tannin, and stability study of the associated polyphenol oxidase activity. *J Food Compos Anal*. 2002;13:149–56.

- [12] Ajila CM, Aalami M, Leelavathi K, Prasada RUJS. Mango peel powder: a potential source of antioxidant and dietary fiber in macaroni preparations. *Innov Food Sci Emerg Technol*. 2010;11:219–24.
- [13] Wills R, Glasson MB, Graham D, Joyce D. *Postharvest: An introduction to the physiology and handling of fruit, vegetables and ornamentals*. 5th ed. Sydney: University of New South Wales; 2007, pp. 227.
- [14] Bendeck AM, Akakpo A, Aguayo V, Baker S, Mbaye DS, Lathen L, et al. *Les pratiques prometteuses et les leçons apprises dans la lutte contre la carence en vitamine A dans les pays de l'Afrique subsaharienne*. Arlington, VA, USA: Publié pour l'Agence des Etats Unis pour le développement international (USAID) par le projet Soutien à l'institutionnalisation de la survie de l'enfant (BASICS); 2000.
- [15] ISO 659 Graines oléagineuses-Détermination de la teneur en huile (méthode de référence). 2009; 13 p.
- [16] Elie BDN. Optimisation du broyage des mangues séchées (*Mangifera indica* var Kent): Influence sur les propriétés physicochimiques et fonctionnelles des poudres obtenues thèse présenté pour l'obtention du doctorat. 2006, pp. 7.
- [17] AOAC. *Official Methods of Analysis of the Association of Analytical Chemists*. 14th ed. Sydney Williams. Inc: USA; 1990, pp. 771.
- [18] Livesey G, Brown JC. D-tagatose is a bulk sweetener with zero energy determined in rat. *J Nutr*. 1995;126:1601–9.
- [19] Pongracz G. Neupotentiometrische Bestimmungen method für Ascorbinsäure und deren Verbindungen. *J Anal Chem*. 1971;253:271–4.
- [20] Bamba R, Toure N, Kone FMT, Toure A. Caractéristiques biochimiques de quelques sous-produits agricoles de Côte d'Ivoire en vue d'une valorisation en alimentation de volaille. *J Anim Plant Sci*. 2023;58:10701–12.
- [21] Kanté-Traore H. Valorisation des variétés de mangue produites au Burkina Faso: aspects biochimiques, biotechnologiques et nutritionnel. Biochimie-Technologie Alimentaire. Burkina Faso, Université Joseph Ki-Zerbo, Doctorat. 2019, pp. 170.
- [22] Kameni A, Mbofung CM, Ngnamtam Z, Doassem J, Hamadou L. *Aptitude au séchage de quelques variétés de mangue cultivées au Cameroun : Amélie, Zill, Irwin et Horé Wandou*. Actes du colloque. Garoua, Cameroun, 2002 mai 27–31. 10.
- [23] Ponka R, Goudoum A, Tchougouelieu AC, Fokou E. Evaluation nutritionnelle de quelques ingrédients entrant dans la formulation alimentaire des poules pondeuses et porcs d'une ferme d'élevage au Nord-Ouest Cameroun. *IJBACS*. 2016;10:2077–8.
- [24] Champ M, Langkilde AM, Brouns F, Kettlitz B, Le Bail CY. Advances in dietary fibre characterisation. 1. Definition of dietary fibre, physiological relevance, health benefits and analytical aspects. *Nutr Res Rev*. 2003;16:71–82.
- [25] Grundy MML, Edwards CH, Mackie AR, Gidley MJ, Butterworth PJ, Ellis PR. Re-evaluation of the mechanisms of dietary fiber and implications for macronutrient bioaccessibility, digestion and postprandial metabolism. *Br J Nutr*. 2016;116:816–33.
- [26] Touré A, Zoro AF, Touré N, Sall F, Soro YR, Coulibaly A. Phytochemical and nutritive properties of by-products flours from cashew (*Anacardium occidentale*) and mango (*Mangifera indica*) for ruminants feeding in Poro region (Northern Côte d'Ivoire). *EAS J Nutr Food Sci*. 2020;2:44–8.
- [27] Sempore JN, Ouattara-Songre LT, Tarpaga VW, Dicko MH. Caractérisation morphologique et potentialité nutritionnelle de quatorze accessions de noix de cajou (*Anacardium occidentale* L.) au Burkina Faso. *Revue Ivoirienne de Géographie des Savanes*. 2022;12:68–80.
- [28] N'guessan KA, Kouakou KE, Alui KA, Yao A. Stratégies et pratiques paysannes de gestion durable de la fertilité des sols dans le département de Korhogo au Nord de la Côte d'Ivoire. *Afrique Sci*. 2019;15:245–58.
- [29] Inoussa KY, Charles P, Marius KS, Bréhima D, Mamoudou HD. Caractéristiques physicochimiques de quelques matières premières utilisées dans la formulation des aliments pour volaille au Burkina Faso. *J Appl Biosci*. 2020;151:15598–604.
- [30] Ma X, Wu H, Liu L, Yao Q, Wang S, Zhan R, et al. Polyphenolic compounds and antioxidant properties in mango fruits. *Sci Hortic*. 2011;129:102–7.
- [31] Hu W, Jiang Y. Quality attributes and control of fresh-cut produce. *Stewart Postharvest Rev*. 2007;3:1–9.
- [32] Robles-Sánchez RM, Rojas-Graü MA, Odriozola-Serrano I, González-Aguilera GA, Martín-Belloso O. Effect of minimal processing on bioactive compounds and antioxidant activity of fresh-cut 'Kent' mango (*Mangifera indica* L.). *Postharvest Biol Technol*. 2009;51:384–90.
- [33] Kiendrebeogo T, Mopate LY, Ido G, Kaboré Z, Chantal Y. Procédés de production d'aliments non conventionnels pour porcs à base de déchets de mangues et détermination de leurs valeurs alimentaires au Burkina Faso. *J Appl Biosci*. 2013;67:5261–70.
- [34] De Laroussilhe F, Manguier L. Techniques agricoles et productions tropicales. In: *Ed Maisonneuve et Larose*. Paris, 1980, pp. 312.
- [35] Djioua T. Amélioration de la conservation des mangues 4ème gamme par application de traitements thermiques et utilisation d'une conservation sous atmosphère modifiée. Thèse de Doctorat: Sciences Agronomiques. Université d'Avignon et des Pays de Vaucluse. 2010, pp. 150.
- [36] Dakare MA, Danlade AA, Abel SA, Sunday EA. Effects of processing technique on nutritional and antinutritional contents of mango seed kernel. *W J Young Resear*. 2012;2:55–9.
- [37] Diarra SS. Potential of mango (*Mangifera indica* L.) seed kernel as a feed ingredient for poultry: A review. *Worlds Poult Sci J*. 2014;70:279–88.
- [38] Meité A, Kouame KG, Amani NG, Coulibaly KS, Offoumou A. Caractéristiques physico-chimiques et sensorielles des pains fortifiés avec les farines de graines de citrullus /anatus. *J Pharm Biol Sci*. 2008;9:32–43.
- [39] NRC (National Research Council). *Food and nutrition board recommended dietary allowances*. Washington, DC: National Academies Press; 2008, pp. 82.
- [40] Hervé J, Mathilde B, Léonie D, Fabrice M, Sophie P, Christel N, et al. *Alimentation des volailles en agriculture biologique*. Cahier Technique. 2015, 68 p. Available from: <https://www.bio-bretagne-ibb.fr/wp-content/uploads/Alimentation-Volailles-Bio-CahierTechnique-juin2015.pdf>.