

Evaluation of the physico-chemical and antioxidant activity properties of attieke flour deshydrate enriched with cashew kernel (*Anacardium Occidentale I.*) and moringa (*moringa oleifera I.*) powders

ABSTRACT

The objective of this study is to produce an infant flour based on attiéké enriched with moringa oleifera and cashew kernel (*Anacardium Occidentale L.*) powders. For this purpose, moringa oleifera powder is incorporated in proportions of 10%, 15% and 20% into two types of composite flours (attiéké / unfermented cashew kernel and attiéké / fermented cashew kernel). Mineralogical, physico-chemical and antioxidant activity are performed. The results of the mineralogical analyzes showed potassium is the majority in composite flours. In addition, the calcium, magnesium, copper and zinc contents in the composite flours conformity with the standards. The fortification of attiéké flour with moringa oleifera and cashew kernel powders resulted in an increase in phenolic compounds, antioxidant activity, as well as protein contents which vary from 11.59 ± 0.10 g / 100 g of 16.59 ± 0.26 g / 100 g. Moringa and cashew kernel powders have increased the nutritional quality of attiéké flour.

Key words: nutritional quality, attiéké, *Anacardium occidentale L.*, *Moringa oleifera*, fortification

1. INTRODUCTION

Cassava (*Manihot esculenta*, Crantz) is an important staple food crop for millions of people in the tropics of the world. Cassava roots provide up to a third of daily calories [1], and contain mainly carbohydrates, of which 80% is starch [2]. Traditionally, cassava roots are processed by several methods, according to local customs and preferences [3] such as attiéké, gari, fufu, flour, fries, starch, syrups, dextrins and alcohol [4].

In Ivory Coast, attiéké is the most widely consumed cassava by-product in urban areas [5] (Koffi-Nevry et al., 2007). It constitutes approximately 5% of the food expenses of many Ivorian populations including those of the Abidjan coastal region recognized as major producers and consumers. Attiéké is the main source of income generating activity [6]. Thus, the annual production of fresh attiéké is estimated between 18,965 tons and 40,000 tons. Annual consumption varies between 28 kg and 30 kg per inhabitant [7, 8]. Despite its great socio-economic importance, this product has a low nutritional value. To overcome this nutritional problem, strategies for improving local products are put in place. For example, fortification of staple foods with other foods rich in micronutrients and macronutrients such as oilseeds and legumes (cashew kernels and moringa leaves) to form a balanced diet remains an important route for the fight against malnutrition.

In addition, the exceptional nutritional value of oilseeds and legumes (cashew kernel and moringa) is a factor that makes it a potential asset in the fight against malnutrition in Ivory Coast. In fact, oilseeds and legumes contribute to satisfying the need for protein, fiber, lipids, minerals and vitamins, as well as the contribution of functional constituents for the well-being of children. In addition, the exceptional nutritional value of oilseeds and legumes (cashew kernel and moringa) is a factor that makes it a potential asset in the fight against malnutrition in Ivory Coast. In fact, oilseeds and legumes contribute to satisfying the need for protein, fiber, lipids, minerals and vitamins, as well as the contribution of functional constituents for the well-being of children. Thus, they play an essential role in the strategy of children's food security and contribute to nutritional balance. Among oilseeds and legumes, cashew kernels and moringa, which are known to be very nutritious [9], are increasingly used to improve the nutritional content of cereal-based energy foods (corn, rice, millet), tubers (yam, potato) and roots (cassava) low in protein, fat and micronutrients.

50 In view of all the above, this study aims to enrich dehydrated attiéké flour with cashew kernel and
51 Moringa powders by determining physicochemical characteristics and antioxidant activities in order to
52 contribute to the fight against malnutrition.

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54 **2. Material and Methods**

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56 **2.1 Vegetable material**

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58 The Vegetable material used in this study consists of cassava semolina (attiéké) bought in Djahakro,
59 a village located on the outskirts of Yamoussoukro town in three producers, the cashew kernel flour
60 obtained after various treatments of cashew nuts and the powder of the leaves of Moringa Oleifera.

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62 **2.2 Production of attiéké flour**

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64 The attieke collected from the producers is dried in an oven at 60 °C for 24 hours and crushed using a
65 grinder. The flour obtained was stored in polyethylene bags.

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67 **2.3 Production of deoiled and unfermented cashew kernel flour**

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69 The cashew kernel flour are obtained after dehulling, drying and pruning nuts. The cashew kernel flour
70 is produced according to the method described by [10] modified. The dried cashew kernel are crushed
71 using a semi-artisanal grinder and placed in a stainless steel tank. Hexane is added 1: 1 (w / v) to the
72 flakes for oil extraction. The mixture is macerated for 30 minutes before being heated at 130 ° C for 50
73 minutes and allowed to stand for 24 hours at room temperature. Then the pellet is separated from the
74 supernatant (oil and hexane). The operation is performed twice. The cakes are pressed for 24 hours to
75 extract the rest of the oil. The deoiled cake is oven dried at 70 °C for 12 hours. They are milled in a
76 mill and the flour obtained is stored in polyethylene bags.

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78 **2.4 Production of fermented deoiled cashew kernel flour**

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80 The cashew kernels are fermented according to the method of [11] modified. The cashew kernel are
81 boiled at 100 ° C for 1 hour. The boiled almonds are wrapped in the plantain leaf for 72 hours for
82 fermentation. The fermented seeds are oven dried 60 °C for 48 hours. The fermented cashew kernel
83 are crushed and the hexane is added (confers the production of unfermented flour). The cakes are
84 milled in a grinder and packaged in polyethylene bags.

85

86 **2.5 Production of moringa powder**

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88 The leaflets of M. oleifera leaves are detached from their petioles, sorted to remove damaged leaves
89 and sanitized for 5 minutes in chlorinated water. After rinsing with distilled water and then draining for
90 30 minutes, the leaflets are soaked for 12 hours and dried out of the sun in an airy room for three
91 weeks and ground in a hammer mill.

92

93 **2.6 Formulation of infant flours: attiéké / cashew kernel**

94

95 Attiéké / cashew kernel / moringa composite flours are obtained by incorporating respective
96 proportions of 10, 15 and 20% moringa flours into the two most preferred composite flours in the study
97 by [12], (FAFCF15: 85 % Attiéké flour / 15% fermented cashew kernel, FAFCNF10: 90 % Atiéké flour /
98 10 % unfermented cashew kernel). Each formulation is thoroughly mixed in a blender and stored for
99 analysis.

100

101 **The formulations and their abbreviations**

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103 **A** : 90% FAFCF15 + 10% moringa

104 **B** : 85% FAFCF15 + 15% moringa

105 C : 80% FAFCF15 + 20% moringa

106 D : 90% FAFCNF10 + 10% moringa

107 E : 85% FAFCNF10 + 15% moringa

108 F : 80% FAFCNF10 + 20% moringa

109 2.7 Physico-chemical composition

110 The moisture content is determined by the method described in [13] based on oven drying dehydration
111 of samples until a constant weight is obtained. The determination of the ash content is done
112 according to the method [13]. It consists in mineralizing a sample of 5 g (m) at 600 ° C. for 6 h in a
113 muffle furnace (NABERTERM, GmbH Babnhofstrasse 20,28865 Lilienthal / Bremen, Germany), until
114 destruction of all organic matter contained in the sample.
115 About 0.1 g of attiéké-cashew kernel composite flour is used to determine the crude protein content
116 from the total nitrogen assay using the Kjeldhal method [13]. The protein level is obtained by
117 multiplying the total nitrogen content by a factor of 6.25 convention. The determination of lipid content
118 is by the soxhlet method [13]. The fat is extracted by boiling with pure hexane. The latter is then
119 removed by evaporation and the residue is dried and weighed. The raw fibers include cellulose, some
120 hemicelluloses and lignin. The raw fiber contents of flours are determined by the method of [14] For
121 this, one gram of flour (m) was boiled in 50 ml of sulfuric acid (1.25 N) and then in 50 ml of sodium
122 hydroxide (1.25 N) for one hour (30 minutes x 2). The resulting residue is dried at 105 °C for eight
123 hours (m1) and then incinerated at 550 ° C for three hours (m2). The total crude fiber (Fb) content,
124 expressed as percentage dry matter.

125

126 The determination of carbohydrates is made by difference according to the following formula [13]:

127 $\% \text{ Carbohydrates} = 100 - (\% \text{ Moisture} + \% \text{ Protein} + \% \text{ Fat} + \% \text{ Ash}).$

128

129 The energy value is calculated using Atwater specific coefficients:

130 $(\% \text{ protein} \times 4) + \% \text{ carbohydrate} \times 4 + \% \text{ lipid} \times 9$

131

132 The total phenols are extracted according to Method [13] (Christensen, 1974), using the Folin
133 Ciocalteu reagent. For extraction, 1 g of flour is placed in a beaker into which are added 100 mL of
134 oxalic acid at 0.3% (g / v). The mixture is stirred with a magnetic stirrer for 30 minutes. The whole is
135 centrifuged at 3000 rpm for 15 minutes. Then the extract is filtered on Whatman paper No. 41. For the
136 assay, 1 mL of the extract diluted in 8 mL of distilled water is added to a tube, plus 0.5 mL of diluted
137 Folin Ciocalteu reagent (1/10), and 1.5 mL of sodium carbonate solution (7.5%). The mixture is left in
138 the dark for 1 hour at room temperature. The reading is made at an absorption of 765 nm at the
139 spectrophotometer. A standard range is made with gallic acid at different concentrations (0 to 1 mg /
140 mL).

141

142 The determination of the antioxidant activity is made according to the method described by [15] whose
143 principle is based on the fading of DPPH. This discoloration is proportional to the antioxidant activity of
144 the sample. A volume of 2.5 mL of methanolic extract is introduced into a test tube. To the contents of
145 the tube is added 1 mL of DPPH solution (3 mM in methanol). The tube is placed in the dark for 30 min
146 and the absorbance is read at 415 nm against the blank. A control tube (1 mL of DPPH + 2.5 mL of
147 methanol) is made and the absorbance of the tube is read under the same conditions as the test tube.
148 The mineral content is determined by atomic absorption spectrophotometry [13]. 0.5 g of ground
149 sample is weighed in a porcelain crucible and then baked at 600 ° C for six hours. After cooling, 5 ml
150 of 1 mol/L nitric acid are added to the ash obtained and then brought to total evaporation on a sand
151 bath. To the residue are added five milliliters of hydrochloric acid (0.1 mol / L) which is returned to the
152 oven at 400°C for 30 min. The final residue is recovered with 10 mL of hydrochloric acid (1 mol / L)
153 and then poured into a 50 ml flask. The crucible is rinsed twice with 10 ml of hydrochloric acid. The

154 flask is supplemented to 50 ml with hydrochloric acid. The content of the minerals was obtained by air-
155 acetylene flame atomic absorption spectrophotometer assay. The values were read in mg /L. The read
156 values were then converted to mg /100g.

157

158 3. RESULTS AND DISCUSSION

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160 3.1. *Physicochemical properties of composite flours*

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162 The various physico-chemical analyzes are presented in Table I. The pH of the various flours varies
163 from 4.80 ± 0.1 for the sample A and 5.23 ± 0.5 for the moringa powder. Titratable acidity amounts to
164 10 ± 1.73 meq /100 g (Moringa oleifera) and 13.33 ± 0.57 meq / 100 g (A). The addition of Moringa
165 oleifera powder increased the moisture content of the Attieke- cashew kernel Composite Flours.
166 However, these values remain below 12% ($7.13 \pm 0.11\%$ at $7.8 \pm 0.2\%$) and all these values do not
167 show significant differences ($P < 0.05$). As for the ash content, they vary from $1.66 \pm 0.57\%$ to $4.33 \pm$
168 0.57% .

169 The fortification of Attiéké-cashew kernel with Moringa oleifera composite flour resulted in an increase
170 in the protein content of composite flours. Moringa powder at a content of 24.63 ± 0.10 g /100 g of
171 protein. These contents vary significantly ($P < 0.05$) from 11.59 ± 0.10 g /100g to 16.59 ± 0.26 g / 100g.
172 The high protein levels of Moringa oleifera leaves have been demonstrated in several studies. The
173 contents of composite flours have increased with the incorporation rate of moringa powder and these
174 values are in line with the standards recommended by [16]. Proteins play a role in the defense of the
175 body and cover the nitrogen expenditure caused by the renewal of tissues and the synthesis of certain
176 compounds involved in the proper functioning of the body (enzymes, hormones) [17].

177 The fiber contents of the various flours enriched with Moringa oleifera are low (2 ± 0.50 g / 100g - 4.00
178 ± 0.50 g / 100g), however the Moringa powder has a high value ($10.66 \pm 1, 50$ g / 100g) in fibers. The
179 dietary fiber content of food supplements should not exceed 5 g / 100 g of product on a dry weight
180 basis according to [18]. The fibers regulate the intestinal transit; capture some of the fat and
181 carbohydrates and can also reduce the caloric density of complementary food preparations.

182 The energy values of the different composite flours are statistically different. The Moringa powder has
183 a value of 360.04 ± 1.47 kcal / 100g, while the energy values of the formulations are between $374.41 \pm$
184 1.39 kcal / 100g and 365.36 ± 1.58 kcal / 100g.

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186 3.2. *Mineral content of composite flours (attiéké- cashew kernel) enriched with* 187 *Moringa powder*

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189 Table II shows the contents of the different minerals observed in Moringa enriched composite flours.
190 The fortification of Moringa composite flours led to an increase in mineral content. Calcium and
191 potassium are the most abundant in the Moringa powder among the macroelements studied, with
192 respective contents of 1166.68 ± 2 mg / 100g and 1818.22 ± 0.22 mg / 100g. For the formulations the
193 calcium contents differ significantly ($P < 0.05$). Flour C has the highest content 394.54 ± 0.5 mg / 100g
194 and flour D has the lowest value 146.69 ± 0.55 mg / 100g. The increase in the contents of the various
195 composite mineral flours is due to the incorporation of the moringa powder. Moringa leaves are known
196 for their excellent mineral content [19, 20]. As regards the formulations, their calcium contents have
197 increased, however the flours C and F, have satisfactory contents according to the standard [21].
198 Calcium helps fortify bones, especially in the growing season. It plays a major role in muscle
199 contraction, vitamin B12 absorption and blood clotting [22].

200 **Table 1: Results of the physicochemical properties of attiéké / cashew kernel composite flours enriched with *Moringa oleifera* powder**
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Paramètres	A	B	C	D	E	F	M
pH	4.80±0.1 ^e	4.89±0.01 ^{cd}	4.93±0.05 ^b	4.88±0.3 ^d	4.90±0.2 ^c	4.94±0.25 ^b	5.23±0.5 ^a
Ac. Titrable méq/100 g	13.33±0.57 ^a	11.33±0.5 ^{ab}	10.66±0.55 ^{ab}	12±2 ^{ab}	11.66±1.5 ^{ab}	10.66±1,8 ^{ab}	10±1.73 ^b
Moisture %	7,8±0.2 ^a	7.6±00 ^a	7.2±0.2 ^a	7.6±0.11 ^a	7.5±0.11 ^a	7.6±0.2 ^a	7.13±0.11 ^a
Ash %	2.33±0.57 ^{bc}	2.66±0.57 ^{bc}	3.66±0.50 ^b	1.66±0.57 ^{cd}	2.66±0.20 ^{bc}	3.33±0.30 ^b	4.33±0.57 ^a
Protein %	12.87±0.30 ^d	14.20±0.50 ^c	16.59±0.26 ^b	11.59±0.10 ^e	12.86±0.10 ^d	14.96±0.20 ^c	24.63±0.10 ^a
Fiber %	2±0.50 ^{ef}	2.33±0.28 ^{def}	3.16±0.28 ^{bcd}	3.00±0.50 ^{cd}	3.3±0.50 ^{bc}	4.00±0.50 ^b	10.66±1.50 ^a
Fat %	2.35±0.05 ^a	2.02±0.02 ^a	1.86±0.02 ^{ab}	2.05±0.01 ^a	2.01±0.01 ^a	1.76±0.03 ^{ab}	1.20±00 ^{ab}
Carbohydrate %	78.64±0.61 ^a	77.51±0.2 ^b	73.77±0.80 ^d	79.02±0.58 ^a	77.25±0.4 ^b	76.01±0.5 ^c	62.70±0.61 ^e
Energy kcal/100g	374.41±1.39 ^a	373.05±1.42 ^{ab}	365.36±1.58 ^c	368.91±1.57 ^{bc}	366.58±0.4 ^c	367.76±1.17 ^c	360.04±1.47 ^d

202 *Averages with different letters in the same row are significantly different (P <0.05) according to Duncan's test.*
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204 **A** : 90 % FAFCF15 / 10 % Moringa; **B** : 85 % FAFCF15 / 15 % Moringa; **C** : 80 % FAFCF15 / 20 % Moringa; **D** : 90 % FAFCNF10 / 10 % Moringa ; **E**: 85 % FAFCNF10 / 15 %
 205 Moringa; **F**: 80 % FAFCNF10 / 20 % Moringa; **M**: Poudre de Moringa.
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217 **Table 2: Mineral Content of Attiéké-cashew kernel composite flours fortified with Moringa powder (mg / 100g)**

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Echantillons	Calcium	Potassium	Sodium	Magnésium	Cooper	Iron	Manganèse	Zinc
A	154.54±1.1 ^f	274±0.4 ^f	12.43±0.25 ^f	92.07±1 ^f	4.6±0.15 ^c	3.41±0.2 ^c	1.45±0.35 ^c	2.60±0.4 ^f
B	231.43±0.35 ^d	416.03±1.52 ^d	14.98±0.4 ^{de}	125.17±1.5 ^d	5.65±0.26 ^c	3.84±0.1 ^c	1.55±0.36 ^c	3.63±0.3 ^{de}
C	394.54±0.5 ^b	588.38±0.8 ^b	16.39±1.21 ^b	166.56±0.39 ^b	8.5±1.00 ^b	5.36±0.85 ^b	3.22±0.25 ^b	4.40±0.25 ^{cd}
D	146.69±0.55 ^g	246.01±0.35 ^g	12.84±0.5 ^f	88.08±0.83 ^g	4.6±0.35 ^c	3.93±0.81 ^c	0.90±0.1 ^c	3.00±0.5 ^{ef}
E	223.10±2.1 ^e	399.04±0.8 ^e	14.4±0.2 ^e	123.23±1.52 ^e	5.82±0.75 ^c	4.59±0.57 ^{bc}	2.58±0.2 ^b	3.81±0.41 ^{cd}
F	353.78±0.6 ^c	512.12±1.32 ^c	15.71±0.25 ^{cd}	159.26±0.37 ^c	7.99±0.86 ^b	5.87±1 ^b	2.96±0.72 ^b	5.04±0.71 ^b
M	1166.68±2 ^a	1818.22±0.22 ^a	66.11±0.2 ^a	523.9±1.6 ^a	33.53±1.53 ^a	28.81±1.2 ^a	4.27±0.35 ^a	14.18±0.2 ^a
Standards (mg / 100g)	341.2	408.7	60	48.7	0.1	8.5	-	3.7
FAO/OMS (2006)								

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220 **Averages with different letters in the same row are significantly different ($P < 0.05$) according to Duncan's test.**221 **A : 90 % FAFCF15 / 10% Moringa; B : 85%FAFCF15 / 15% Moringa; C : 80%FAFCF15 / 20% Moringa; D : 90%FAFCNF10 / 10% Moringa ; E: 85%FAFCNF10 / 15% Moringa; F:**222 **80%FAFCNF10 / 20% Moringa; M: Poudre de feuille Moringa**

From 15% incorporation of moringa flour the potassium contents are suitable. Potassium acts against disturbances of the heart rhythm and intervenes in the regulation of the osmotic pressure of the cell through the Na^+ / K^+ pump. It also contributes to maintaining the acid-base balance of the body [23]. All formulations have satisfactory levels of magnesium and copper. Copper participates in the synthesis and maintenance of andas myelin [24]. Magnesium is important for the proper functioning of the body, it participates in the cohesion of proteins by activating enzymatic functions, prevention of muscle degeneration, growth retardation and congenital malformations [25]. Iron and zinc are important for the functioning of the body as their deficit poses real public health problems. Zinc is an essential component of many enzymes involved in the synthesis and degradation of proteins, lipids and carbohydrates, in the synthesis of prostaglandins and in the metabolism of other micronutrients [26]. In the human body, although present in very small quantities; iron plays vital roles in vital functions. It is also involved in the formation of hemoglobin, in its heme form, myoglobin and enzymes that play a key role in many metabolic reactions, allowing the transport of oxygen from the lungs to the tissues [27]. Moringa leaves, like leafy vegetables, can help fight micronutrient deficiencies to ensure growth for children under five.

3.3. Antioxidant property of composite flour enriched with Moringa powder

Table III shows the contents of vitamin C, phenolic compound and antioxidant activity. Moringa powder is a major source of total polyphenols 869.59 ± 0.3 mgEAG / 100g, as well as tannins 232.04 ± 1.06 mg / 100g. The compound flours have contents of between 434.78 ± 0.1 mgEAG / 100g for flour D and 609.31 ± 1.22 mgEAG / 100g for flour C total polyphenols. For tannin, flour F was 147.99 ± 1.26 mg / 100g the highest statistically ($P < 0.05$) of composite flours. Phenolic compounds are important antioxidants that protect biological macromolecules against degradation [28]. Thus, they effectively fight against aging and the occurrence of cancer cells [29, 30]. Moringa oleifera powder flour is an important source of total polyphenols, which leads to an increase in these contents in moringa-enriched composite flours.

The vitamin C contents of the different formulations show significant differences ($P < 0.05$). Flour F at the highest content of the formulations 13.98 ± 0.74 mg / 100g. However, these values are lower than that of Moringa powder 19.81 ± 0.14 mg / 100g. The analysis of the ability to trap the free radical of 2,2-diphenyl-1-picrylhydrazyl (DPPH) of the various flours to show that the Moringa powder has a significant capacity to trap free radicals with a content of 141.47 ± 0.2 g / 100g. The antioxidant activity levels of the various flours show significant differences. They range from 71.67 ± 0.22 g / 100g (D) to 86.94 ± 0.2 g / 100g (C).

Table 3: Antioxidant Properties of Composite Flours fortified with Moringa Powder

Sample	Vit C mg/100g	Polyphenols mgEAG/100g	Flavonoids MgEAG/100g	Tannins mg/100g	Ac. antioxidant mg/100 g
A	11.74 ± 0.43^a	471.01 ± 1.75^{ab}	88.56 ± 1.48^{ab}	100.08 ± 1.98^a	76.35 ± 0.3^b
B	12.65 ± 0.14^b	543.48 ± 0.8^{bc}	102.65 ± 1.04^{cd}	131.05 ± 1.8^b	80.41 ± 0.5^d
C	13.48 ± 0.42^{cd}	609.31 ± 1.22^c	121.46 ± 1.89^e	143.49 ± 1.33^{bc}	86.94 ± 0.2^f
D	11.74 ± 0.45^a	434.78 ± 0.1^a	82.52 ± 1.96^a	104.24 ± 2.88^a	71.67 ± 0.22^a
E	12.73 ± 0.42^{bc}	471.01 ± 1.51^{ab}	94.59 ± 0.48^{bc}	111.44 ± 1.45^a	78.88 ± 0.11^c
F	13.98 ± 0.74^d	537.63 ± 0.25^{bc}	110.70 ± 1.97^d	147.99 ± 1.26^c	81.29 ± 0.34^e
M	19.81 ± 0.14^f	869.59 ± 0.3^d	221.02 ± 0.11^f	232.04 ± 1.06^d	141.47 ± 0.2^g

Averages with different letters in the same row are significantly different ($P < 0.05$) according to Duncan's test.

A : 90% FAFCF15 / 10% Moringa ; **B** : 85%FAFCF15 / 15% Moringa; **C** : 80%FAFCF15 / 20% Moringa; **D** : 90%FAFCNF10 / 10% Moringa ; **E**: 85%FAFCNF10 / 15% Moringa; **F**: 80%FAFCNF10 / 20% Moringa; **M**: Poudre de feuille Moringa.

268 Several authors have also reported that *Moringa oleifera* leaves are known to be an excellent source
269 of antioxidants and a significantly higher content compared to other fruits such as strawberries known
270 for their antioxidant content [31, 32]. The antioxidant properties of the methanolic extracts, although
271 variable, indicate that the flours studied are inhibitors of free radicals. The antioxidant efficacy of
272 polyphenols is mainly due to the ease with which a hydrogen atom of an aromatic hydroxyl group is
273 ceded to a free radical [33]. Furthermore, the affinity of polyphenols for free radicals makes it possible
274 to inhibit the oxidation of low-density lipoproteins, playing a positive role in the prevention of
275 cardiovascular diseases [34]. This antioxidant property is beneficial and helps prevent carcinogenesis
276 [35]. A diet based on these plants, in particular, *Moringa oleifera* with high polyphenolic levels could
277 strengthen the health of populations.

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279 4. CONCLUSION

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281 The fortification of composite flours (attiéké / unfermented cashew kernel and attiéké / fermented
282 cashew kernel) with the different proportions (10%, 15%, 20 %) of *Moringa oleifera* allowed an
283 increase in protein contents (11.59% - 16.59%). The contents of minerals, phenolic compounds and
284 oxidative activities have also increased. *Moringa Oleifera* powder would be a good source of
285 fortification for food for children.

286

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