

Physicochemical Characterisation of Flours from Local Cereals and Powder from Cassava (*Manihot esculenta* Crantz) Leaves Varieties Cultivated in the Northern-Cameroon in Order to Supplement Infant Flours

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Abstract

The aim of the present study was to investigate on the inventory and determination of the nutritional value of cereals flour and cassava leaves powder in order to analyse their use in the production of infant flour. In this paper, a survey to identify the cereals used in the preparation of infant porridge in the Northern Cameroon was done by using 447 mothers having children between 06 and 59 months from areas (Gbakoungue, Sassa-Mbersi, Sanguere-Ngal and Kotkong-Wouldata) with high rate on malnourished children. Flour was prepared from the most preponderant cereals and Cassava leaves powder from varieties identified by the Regional Centre of Agricultural Research (CRRA) of Wakwa and local population. Flour and powder samples obtained were subjected to chemical composition analysis. Parameters analysed were crude proteins, total carbohydrates, ash, total fats, total phenols, total tannins, total carotenoids, vitamin C or cyanide. Also Iron, calcium and zinc were determined. The results revealed that white maize (62%) was the main cereal used in the preparation of infant porridge followed respectively by red sorghum, white rice and *muskwari*. Ten cassava varieties were identified: three (03) by CRRA (TME, 96/1/14 and IRAD 4115) and seven (south, *gambada*, sweet, Benin, six months, *M. glaziovii* and *grouna*) by local population. Amongst

cereals flour, those from white maize indicated high protein (10.09%), carbohydrates (84.46%) and total fat (7.46%) contents. The powder from 96/14/14 cassava variety showed high amount of iron (11.98 mg/100g), calcium (751.02 g/100g) and low cyanide content (1.21 ppm) amongst all the cassava leaves powder samples. The supplementation of white maize flour by cassava leaves powder from 96/14/14 variety could therefore be recommended for the preparation of infant flours.

Keywords

Infant Flour, Cereals Flour, Cassava Leaves Powder, Chemical Composition, Northern Cameroon

1. Introduction

The protein-energy malnutrition and micronutrients deficiency remain a major problem in both public health and socio-economic domains which affect rural and urban areas. In Cameroon, the nutritional and retrospective mortality in women, adolescents and infants surveys revealed that the prevalence of malnutrition in infants less than 05 years under their chronic, acute and moderate forms was 29%, 4% and 11%, respectively [1]. However, the Far North, the North and the Adamaoua regions are the most affected regions in Cameroon [2]. Although various foods are suggested for this purpose, infant flours are the most appropriate during weaning period [3] [4], critical period during which the breast milk or the household foods (traditional family dishes) are not sufficient enough to cover nutritional needs of babies. The market of infant flours is dominated by large industrials among which manufacture infant industrial complements. However, due to their relative high cost and irregularity on the market, these products remain inaccessible to families with low income or limited revenues [3]-[5].

The promotions of traditional homemade infant flours from local available agricultural products with high nutritive value are therefore recommended [6]-[8]. In that view, several findings were interested to available local resources such as fruit from plumb tree [3], moringa leaves [9], spirulin and cashew kernel [10].

Despite the noted availability and accessibility of these flours, malnutrition is persisting. This is confirmed by recent data obtained from surveys done in the Northern-Cameroon which revealed that in addition to protein-energy deficiency, they are also deficiency in iron, calcium, vitamin A and iodine [11]. Nevertheless, in this part of the country where infant malnutrition remains a major preoccupation, there is a high diversity of local resources with high nutritive value, able to satisfy the nutritional gap if they are used suitably. In addition to cereals, there are other local resources with low cost but under exploited such as cassava (*Manihot esculenta* Cranz) leaves which could represent an alterna-

tive against iron, calcium, vitamin A and iodine deficiencies. It is very urgent to achieve infant flour formulas from local resources in order to meet the nutritional needs of infants.

The aim of the present study therefore is to inventory and determine the nutritional value of cereals and cassava leaves in order to their use in the production of infant flour.

2. Material and Methods

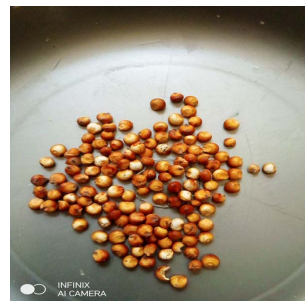
2.1. Material

2.1.1. Plant Material

Plant material consisted of major cereals used in the preparation of infant porridge (pap) by the women in the Northern Cameroon covering the North, Adamaoua and Far North regions. Also, the cassava leaves from varieties available were used from the production of cassava leaves powder samples (**Pictures 1-5**).



Picture 1. White corn.



Picture 2. Red sorghum.



Picture 3. *Muskwari*.



Picture 4. White rice.



Picture 5. Cassava (96/14/14 variety).

2.1.2. Inventory of Cereals Used by Household Women

The inventory of cereals used during infant pap (porridges) preparation was done through interview using 447 mothers whose babies were aged between 06 and 59 months. They were identified by focal points of vaccination-nutrition and the community health agents of health centres of Gbakoungue (Meiganga), Sassa-Mbersi (Mbe), Sanguere-Ngal (Garoua) and Kotkong-Wouldata (Yagoua). The choice of studied areas was motivated by the high rate on malnourished children (**Table 1**) and their production zone status according to the Regional Centre of Agricultural Research (CARRA) of Wakwa-Ngaoundere classification

Table 1. Malnourished infants recorded in the health centre.

Integrated health centre	Malnourished infants recorded in vaccination-nutrition
Gbakoungue	145
Sassa-Mbersi	112
Sanguere-Ngal	117
Kotkong-Wouldata	129

2.1.3. Identification of Cassava Varieties Cultivated in the Northern Cameroon

Cassava varieties present in the different production areas were identified by the CRRRA of Wakwa. Local populations were associated for the varieties available but not recognised by CRRRA-Wakwa.

2.2. Methods

2.2.1. Production of Cereal Flours

Cereals were obtained at the cereal section of the Polyvalent Research Station (SPRA) of Garoua and the flours produced according to a standard process [12]. The grains were previously washed and dried at 45°C in an oven for 24 h and roasted in a mini-roaster (REBUNE 2-029) at 150°C during 30 min. After cooling at room temperature, the roasted cereal grains were grinded in a crusher (*POLYMIX, KINETICA*) with a sieve of meshes less than 250 µm. The obtained flours were then stored in plastic bags at 4°C prior to utilisation.

2.2.2. Preparation of Powder from Cassava Leaves

The harvested cassava leaves were stored separately according to the variety in polyethylene bags and brought to the food laboratory of SPRA-Garoua. They were then processed into powder according to the method described by [13]. The leaves were washed with potable and rinsed with demineralised water. They were then dry in the shade at 27°C - 31°C and grinded using a mini grinder (JANKE & KANKEL, Typ RH). The powder obtained was sieved using a sieve of pore size less than 160 µm and stored in plastic bags at 4°C prior to utilisation (Picture 6, Picture 7).



Picture 6. Cereals flours.



Picture 7. Cassava leaves powder.

2.2.3. Chemical Analysis of Cereal Flours and Cassava Leave Powders

Chemical analysis consisted of determination of water, crude proteins, carbohydrates, total fats, ash, iron, zinc, calcium, total phenols and tannins contents for flours. In addition, vitamin C, total carotenoids, and total cyanide contents were also achieved with cassava leave powders.

Water content was determined according to the standard Association of Official Analytical Chemists [14]. The crude proteins were obtained by determination of nitrogen content using Kjeldahl method and the nitrogen value multiplied by a factor of 6.25. Total fats were achieved by extraction method [15]. Iron, Calcium and Zinc contents were obtained after incineration [16] [17]. The method prescribed by [18] and colorimetric method of [19] were used for total carbohydrates and carotenoids determination, respectively. Vitamin C dosage was done by the oxido-reduction reaction using N-Bromosuccinimide [20] and that of total phenols by using after extraction Folin-Ciocalteu reagent [21]. Total cyanide was achieved by the colorimetric method [22].

2.2.4. Statistical Analysis

The results were analysed by IBM/SPSS 20.0 for Windows using the ANOVA test followed by a post-hoc Tukey test for surveys. Data obtained were expressed as mean \pm SD. They were subjected to analysis of variance (oneway ANOVA) using the Statgraphics Plus, version 5.0 statistical software package. Separation of means was completed using the least significant difference test at 95% confidence level.

3. Results and Discussion

3.1. Cereals Used in Pap (Porridge) Preparation

From the interview, 04 local cereals (white corn, red sorghum, rice and *muskwari*) as indicated in **Figure 1** were generally used for infant pap preparation. The most abundant was white corn used by 62.78% of women. It might be due to its easy cooking compare to other cereals and white colour of the obtained pap [23] [24] [25].

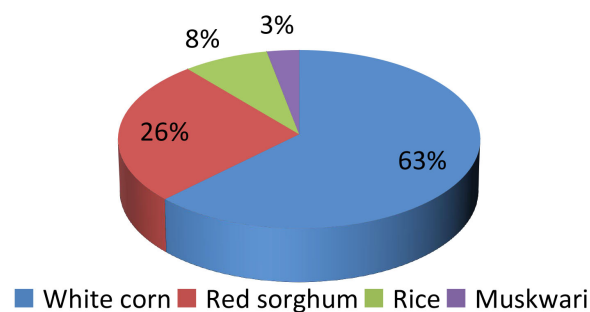


Figure 1. Cereals used in pap (porridge) preparation.

3.2. Cassava Varieties Inventoried in Different Production Areas

Ten (10) cassava varieties were obtained in the study area (Northern Cameroon).

Three (03) were clearly identified by the CRRA of Wakwa: *TME*, 96/1/14, and IRAD 4115. The other seven (07) varieties were acquired with the contribution of the local population: two (02) at Gbakoungue (Meiganga) known as “south cassava and *gambada*”; two (02) at Sassa-Mbersi (Mbé) with common name “sweet cassava and Benin cassava”; two (02) at Sanguere-Ngal (Garoua) locally called “six months and *M. glaziovii*” and one (01) from Kotkong-wouldata (Yagoua) named “*grouma*”.

3.3. Chemical Properties of Cereal Flours

3.3.1. Global Composition of Cereal Flours

The global composition of flours obtained from cereals is presented in **Table 2**.

Table 2. Global composition (g/100g) of cereal flours.

Flour samples	Water	Carbohydrates	Crude proteins	Total fat	Ash
White corn (<i>CMS 8501</i>)	7.10 ± 0.20 ^a	84.46 ± 3.11 ^a	10.09 ± 0.12 ^a	7.46 ± 0.02 ^a	4.47 ± 0.03 ^a
Red sorghum (<i>Zouaye</i>)	6.31 ± 0.29 ^a	79.57 ± 2.67 ^b	5.10 ± 0.49 ^b	4.03 ± 0.55 ^b	5.42 ± 0.11 ^a
White rice (<i>Nerica L 36</i>)	6.00 ± 1.73 ^a	83.44 ± 2.66 ^a	5.05 ± 0.35 ^b	3.97 ± 0.04 ^b	5.43 ± 0.52 ^a
<i>Muskwari (safrari)</i>	5.92 ± 0.14 ^a	72.24 ± 2.24 ^c	4.94 ± 0.21 ^b	4.11 ± 0.24 ^b	4.51 ± 0.18 ^a

(a, b, c): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$).

The water contents of all the flour samples were not significantly different ($p > 0.05$). They varied from 5.92 ± 0.14 g/100g (*muskwari* flour) to 7.10 ± 0.20 g/100g (white corn flour). These values seemed to be lower than previous results obtained by [26] from sorghum (*CE 180-33* and *CE 145-66*) flour at Bambey (Senegal) which were between 8.5 and 9.0 g/100g. This might be related to the combined action of drying and roasting of cereal grains. However, low water content could contribute to improve on storage period due to low water availability which is not favoured enzymatic reactions and spoilage microorganisms development [27] [28].

Rice flour and white corn flour showed the highest ($p < 0.05$) amount of total sugars (83.44 ± 2.66 g/100g and 84.46 ± 3.11 g/100g) and *muskwari* flour the lowest ($p < 0.05$). Except *muskwari* flour, the values of other ones appeared higher than that revealed by with maize (corn) [29] vulgarised in Benin and Ivory Coast. The total carbohydrates content $> 70\%$ is indicating that they are the flour main component and flour, energy providing food. Equally, carbohydrates are involved in protein anabolism and are constitutive element of fundamental tissues of the body such as nucleic acids, mucus, antigenic substances and cartilages [30].

White corn flour significantly ($p < 0.05$) indicated the high amount of crude proteins (10.09 ± 0.12 g/100g) and might be explained by the fact that its grains contain a germ, important protein source in maize [29]. Other flours had similar values ($p > 0.05$). All the values achieved were similar to previous results ac-

quired with corn flour produced in Senegal and Benin respectively [26] [31].

Flour obtained from white corn led significantly ($p < 0.05$) to the high total fat content (7.49%). Flours produced from rice, sorghum and *muskwari* showed the same ($p > 0.05$) total fat contents which were similar to values achieved with flours from corn and sorghum cultivated in Benin and Burkina-Faso [24] [29]. The high fat content in corn flour could be associated to the presence of a germ rich in fat [32].

3.3.2. Iron, Calcium and Zinc Contents of Cereal Flours

The iron, calcium and zinc contents of flours samples are presented in **Table 3**.

Table 3. Iron, zinc and calcium contents (mg/100g) of flour samples.

Flour samples	Iron	Zinc	Calcium
White corn (<i>CMS 8501</i>)	4.61 ± 0.14^{ab}	2.20 ± 0.21^a	36.31 ± 0.44^c
Red sorghum (<i>Zouaye</i>)	4.80 ± 0.07^a	1.64 ± 0.11^b	45.29 ± 0.71^b
White rice (<i>Nerica L 36</i>)	3.43 ± 0.48^b	2.09 ± 0.18^a	51.71 ± 0.71^a
<i>Muskwari (safrari)</i>	3.29 ± 0.09^b	2.27 ± 0.20^a	35.01 ± 0.65^c

(a, b, c): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$).

The sorghum flour revealed the highest iron content (4.80 ± 0.07 mg/100g). However, this value was similar ($p > 0.05$) to that of white corn flour. White rice, white corn and *muskwari* presented comparable ($p > 0.05$) iron content values. Values obtained are greater than 0.62 - 1.24 mg/100g acquired by [29] with corn from flour cultivated in Benin and lower than 4.90 mg/100g achieved with maize varieties from Nigeria [33].

With respect to the zinc content, the flour from red sorghum showed the lowest ($p < 0.05$) value (1.64 ± 0.11 mg/100g) while other flour samples had the same ($p > 0.05$) values. Previous finding also indicated similar results obtained by [24]. Zinc has an important role in the body. In fact, it acts as cofactor of about 100 metalloenzymes. Transcription factors such as metal response element transcription factor (MTF) need its presence for their activity. In addition, zinc is regulating several cellular activities including apoptosis and synaptic signals [34] [35].

White rice flour sample was significantly ($p < 0.05$) more rich in calcium while white corn flour and *muskwari* flour samples indicated similar ($p > 0.05$) values and the lowest ($p < 0.05$). Other authors obtained lower calcium content values (8.1 - 15.9 mg/100g) with corn flour [29]. On the other hand, flour obtained from corn cultivated in Guatemala indicated comparable result (48.3 mg/100g).

3.3.3. Total Phenols and Tannins Contents

Muskwari and red sorghum flour samples indicated similar ($p > 0.05$) values of total phenols and significantly ($p < 0.05$) the highest (**Table 4**). Other flour sam-

samples had < 0.25 mg/100g as total phenols content although white corn flour samples indicated the lowest ($p < 0.05$) value. Results acquired with red sorghum flour sample are very higher than results (0.22 and 0.57 mg/100g) from other findings [27] by using white sorghum from Senegal. This difference observed could be associated to the variety; the environmental or agro-climatic conditions.

Table 4. Total phenols and total tannins contents (mg/100g) of flour samples.

Flour samples	Total phenols	Tannins
White corn (<i>CMS 8501</i>)	0.10 ± 0.01 ^c	0.12 ± 0.05 ^b
Red sorghum (<i>Zouaye</i>)	32.34 ± 1.11 ^a	0.25 ± 0.05 ^b
White rice (<i>Nerica L 36</i>)	0.22 ± 0.01 ^b	0.03 ± 0.01 ^b
<i>Muskwari (safrari)</i>	31.56 ± 1.03 ^a	5.40 ± 0.24 ^a

(a, b, c): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$).

The high total tannins content was significantly ($p < 0.05$) achieved with *muskwari* flour sample while other ones presented comparable ($p > 0.05$) values. Results obtained from this study are similar to that acquired by [26] which were 0.12 à 0.19 mg/100g. High total tannins in *muskwari* flour could reduce its protein digestibility and absorption and/or that of other nutrients. In fact, they have the capacity to form an insoluble complex with some minerals (Fe, Mn, Cu, etc.) in physiological conditions (pH 7-7.4) which could lead to the reduction of their availability [36].

3.4. Chemical Characteristics of Cassava Leaves Powder

3.4.1. Global Composition of Cassava Leaves Powder

The results in Table 5 shows that the water contents of cassava leaves powder samples varied from 4.38 ± 0.20 g/100g (96/14/14 variety) to 7.74 ± 0.70 g/100g (*M. glaziovii* variety). However, powders from six months, *M. glaziovii* and Benin varieties did not indicate significant ($p > 0.05$) difference. Equally, other samples presented similar ($p > 0.05$) values. Values obtained seem to be lower than 9.9% - 11.6% obtained with powders from varieties *TMS 30572* and *TMS 30555*, respectively [37]. Differences observed could be due to many factors including environmental factors and cassava varieties.

Table 5. Global composition (g/100g) cassava leaves powder samples.

Cassava leaves powders samples	Water	Crude proteins	Total carbohydrates	Total fat	Total Ash
<i>TME</i>	4.99 ± 0.19 ^b	25.14 ± 0.15 ^{bc}	72.29 ± 2.11 ^a	3.33 ± 0.60 ^c	6.02 ± 0.48 ^a
96/14/14	4.38 ± 0.20 ^b	17.59 ± 0.65 ^d	70.61 ± 1.14 ^b	6.79 ± 0.65 ^a	5.94 ± 0.25 ^a
IRAD 4115	5.03 ± 0.66 ^b	28.19 ± 0.44 ^a	60.02 ± 1.24 ^{ef}	5.42 ± 0.13 ^b	6.20 ± 0.70 ^a
south	5.11 ± 0.84 ^b	24.86 ± 1.40 ^c	64.35 ± 1.34 ^{cde}	5.09 ± 0.69 ^b	5.87 ± 0.56 ^a

Continued

<i>ganbada</i>	4.70 ± 0.35 ^b	13.71 ± 0.21 ^e	57.57 ± 1.32 ^f	7.42 ± 1.15 ^a	5.19 ± 0.14 ^b
sweet	4.59 ± 0.15 ^b	24.67 ± 0.97 ^c	67.47 ± 1.57 ^{bc}	6.67 ± 0.64 ^a	5.02 ± 0.14 ^b
Benin	6.97 ± 0.59 ^a	18.39 ± 0.34 ^d	61.67 ± 1.02 ^{def}	5.20 ± 0.41 ^b	5.99 ± 0.69 ^a
<i>M. glaziovii</i>	7.74 ± 0.70 ^a	25.83 ± 1.62 ^{abc}	63.58 ± 0.97 ^{cde}	6.75 ± 0.27 ^a	6.00 ± 0.38 ^a
six months	7.06 ± 0.25 ^a	27.95 ± 0.43 ^{ab}	59.12 ± 1.02 ^{ef}	5.23 ± 1.01 ^b	5.24 ± 0.24 ^b
<i>grouma</i>	4.61 ± 0.17 ^b	18.23 ± 0.11 ^d	66.29 ± 2.04 ^{bcd}	5.17 ± 0.97 ^b	5.01 ± 0.30 ^b

(a, b, c): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$); TME: Tropical Manihot Expensive; IRAD: Institute of Agricultural Research for Development.

A crude proteins content of cassava leaves powder samples was between 13.7 ± 0.21 g/100g (*ganbada*) and 28.19 ± 0.44 g/100g (IRAD 4115). The obtained values were significantly ($p < 0.05$) different from one variety to another except between *grouma*, Benin and 96/14/14 where they were comparable ($p > 0.05$). Other study indicated also similar values (17.7 to 31.1 g/100g) [37] or higher values (33.8 g/100g and 37.4 g/100g) for cassava leaves powders from *TMS 30572* and *TME1* varieties, respectively) in Nigeria [38]. The differences perceived could be related to cassava variety and environmental factors [39]. Values are indicating that cassava leaves are rich proteins source and supplementation of infant flour from cereal by their powder that might have positive effects on nutritive value and particularly protein content.

Carbohydrates are the main component of cassava leaves powder and its content values obtained varied from 57.57 ± 1.32 g/100g for *ganbada* variety to 72.29 ± 2.11 g/100g for *TME* variety. All the cassava leaves powder samples showed significant ($p < 0.05$) different values of total carbohydrates except samples from IRAD 4115 and six months varieties. These values are greater than 43.6 g/100g, data reported by Ravindran and Ravindran with H-165 cassava variety [40]. The variations in total carbohydrates content could be due to the cassava variety used, environmental and agro-climatic factors [41].

Cassava leaves powder samples from varieties *ganbada* (7.42 ± 1.15 g/100g), sweet (6.37 ± 0.64 g/100g), *M. glaziovii* (6.45 ± 0.27 g/100g) and 96/14/14 (6.49 ± 0.65 g/100g) had similar ($p > 0.05$) total fat content which were significantly ($p < 0.05$) the highest. The *TME* variety resulted to powder with the lowest ($p < 0.05$) total fat content (3.33 ± 0.60 g/100g) which is similar to 3.5 g/100g achieved in Nigeria [38].

3.4.2. Iron, Zinc and Calcium Contents of Cassava Leaves Powder

Data presented in Table 6 show that cassava leaves powder from *TME*, sweet, *M. glaziovii* and *grouma* varieties indicated similar ($p > 0.05$) values in term of iron content. However, Benin and 96/14/14 varieties had significantly ($p < 0.05$) the lowest and the highest values respectively. Iron content values achieved are higher than 0.03 mg/100g reported by [42] and [43] in Congo-Brazzaville. On the

other hand, they were lower than previous results; 20 - 21 mg/100g [38] and 15 - 27 mg/100g [44]. The observed differences could be attributed to the cassava variety, agro-climatic and environmental factors [41]. Cassava leaves powder samples indicated high amount of iron content that cereals flour samples and could then be used at supplement for its iron fortification. However, Iron intervenes in haemoglobin, myoglobin and enzymes constitution which play an important role in various metabolic reactions [45].

Table 6. Iron, zinc and calcium contents (mg/100g) of powder samples.

Cassava leaves powders samples	Iron	Zinc	Calcium
<i>TME</i>	6.31 ± 0.70 ^{cd}	07.56 ± 0.49 ^{bcd}	751.02 ± 25.12 ^a
96/14/14	11.98 ± 0.24 ^a	08.56 ± 0.66 ^{bc}	748.41 ± 21.79 ^a
IRAD 4115	5.78 ± 0.99 ^f	06.31 ± 0.63 ^d	340.79 ± 11.28 ^d
south	5.27 ± 0.23 ^g	05.59 ± 0.44 ^d	563.54 ± 14.43 ^b
<i>ganbada</i>	5.56 ± 0.11 ^f	03.22 ± 0.31 ^e	319.21 ± 10.12 ^e
sweet	6.11 ± 0.11 ^{de}	09.00 ± 0.68 ^{ab}	327.17 ± 14.10 ^{de}
Benin	5.09 ± 0.77 ^h	07.04 ± 0.45 ^{cd}	446.98 ± 15.28 ^c
<i>M. glaziovii</i>	6.62 ± 0.88 ^c	10.50 ± 0.78 ^a	312.52 ± 13.32 ^e
six months	7.91 ± 0.59 ^b	09.29 ± 0.65 ^{ab}	741.77 ± 19.27 ^a
<i>grouma</i>	6.37 ± 0.25 ^{cd}	06.60 ± 0.32 ^d	575.07 ± 17.31 ^b

(a, b, c, d, e): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$); TME: Tropical Manihot Expensive; IRAD: Institute of Agricultural Research for Development.

Powder from *M. glaziovii* variety had the highest value of zinc content which was comparable ($p > 0.05$) to those from six months and sweet varieties. *Ganbada* variety had significantly ($p < 0.05$) the lowest value. Sweet, south and *grouma* varieties also led to similar ($p > 0.05$) zinc contents. Other authors from their studies achieved higher values (12 - 15 mg/100g) [38] [40] or lower ones (1.56 - 2.95 mg/100g) [46]. In the body, Zinc plays a role during proteins synthesis and cellular growth, interacts with several enzymes such as DNA and RNA-polymerase. It also contributes to maintain fertility and testosterone level in blood [47].

Cassava varieties *TME*, 96/14/14 and six months led to the same ($p > 0.05$) level of calcium in their leaves powder and the highest ($p < 0.05$). Powders from *M. glaziovii* and *ganbada* varieties had equally similar ($p > 0.05$) values but the lowest ($p < 0.05$). Cassava leaves powder from H-165 variety indicated higher values of calcium content (1140 mg/100g) as reported in Madagascar [40]. This could be explained by agro-climatic and environmental factors [41]. Cassavas leaves powder showed high calcium content than cereals flour and could then serve as a supplement for its calcium fortification. Calcium is the major bone constitutive element that has a major role in skeletal constitution. In addition, it

intervenes in several metabolic functions such as muscular activity, nervous stimulation, enzymatic and hormonal activities and oxygen transport [48] [49].

3.4.3. Total Carotenoids and Vitamin C Contents of Cassava Leaves Powder

In **Table 7** are presented total carotenoids and vitamin C contents of different powder samples prepared.

Table 7. Total carotenoids ($\mu\text{g}/100\text{g DM}$) and vitamin C ($\text{mg}/100\text{g FW}$) of cassava leaves powder samples.

Cassava leaves powders samples	Total carotenoids	Vitamin C
<i>TME</i>	$3330 \pm 100^{\text{d}}$	$440.41 \pm 3.41^{\text{b}}$
96/14/14	$4500 \pm 510^{\text{b}}$	$597.21 \pm 5.13^{\text{a}}$
IRAD 4115	$2970 \pm 120^{\text{e}}$	$370.19 \pm 0.99^{\text{c}}$
south	$5100 \pm 710^{\text{a}}$	$310.01 \pm 2.56^{\text{e}}$
<i>ganbada</i>	$3410 \pm 100^{\text{d}}$	$219.20 \pm 2.01^{\text{h}}$
Sweet	$2380 \pm 90^{\text{f}}$	$238.20 \pm 1.88^{\text{gh}}$
Benin	$4010 \pm 240^{\text{c}}$	$442.15 \pm 0.41^{\text{b}}$
<i>M. glaziovii</i>	$3420 \pm 220^{\text{d}}$	$339.24 \pm 2.81^{\text{d}}$
six months	$2910 \pm 100^{\text{e}}$	$241.15 \pm 3.14^{\text{g}}$
<i>grouma</i>	$2874 \pm 111^{\text{e}}$	$288.57 \pm 3.32^{\text{f}}$

(a, b, c, d, e, f, g, h): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$); TME: Tropical Manihot Expensive; IRAD: Institute of Agricultural Research for Development; DM: Dry matter; FW: Fresh Weight.

South variety of cassava permitted to have significantly ($p < 0.05$) the highest total carotenoids level in powder. Sweet variety led to the lowest ($p < 0.05$) followed by *grouma*, six months and IRAD 4115 which indicated the same values ($p > 0.05$). Values achieved are comparable to 3300 and 45,000 $\mu\text{g}/100\text{g}$ acquired in Nigeria [38] but lower than 41,300 and 46,300 $\mu\text{g}/100\text{g}$ reported from other findings [44]. The high content of total carotenoids, pro-vitamin A, in cassava leaves powder renders it suitable for the supplementation of cereals flour for vitamin A fortification. In fact, vitamin A intervenes in vision, growth, cellular differentiation, foetal and embryonic development, maintaining of epithelial and skin barrier and immunity [50].

The cassava leaves powder from 96/14/14 variety had significantly ($p < 0.05$) the highest amount of vitamin C. *ganbada* variety led to powder with the low vitamin C content which was different ($p > 0.05$) from that of sweet variety which was equally not different c from six months result. Other powder samples indicated significant difference ($p < 0.05$) except those from Benin and *TME* varieties. Vitamin C content from *ganbada* and sweet and six months varieties show a real significant difference with values achieved by other study [38]. In general, results obtained from prepared powder samples are rich in vitamin C. Supplementation of cereals flour with cassava leaves powder could therefore

positively affect its vitamin C content. It facilitates the iron absorption at the level of the gastro-duodenal mucosa [51]. In addition, it acts as antioxidant and plays many other roles in the organism such as participation in hydroxylation of steroid hormones and collagen formation and inhibition.

3.4.4. Cyanide and Total Phenols Contents of Cassava Leaves Powder

Table 8 is giving the cyanide and total phenols contents of cassava leaves powder samples.

Table 8. Cyanide and total phenols content of cassava leaves powder samples.

Cassava leaves powders samples	Cyanide (ppm)	Total phenols (mg/100g DM)
<i>TME</i>	1.19 ± 0.02 ^c	52.10 ± 2.38 ^g
96/14/14	1.21 ± 0.10 ^c	47.21 ± 3.02 ^h
IRAD 4115	1.52 ± 0.91 ^c	29.12 ± 1.99 ⁱ
south	153.10 ± 4.32 ^a	631.21 ± 6.38 ^b
<i>ganbada</i>	116.21 ± 7.02 ^b	742.10 ± 14.32 ^a
Sweet	1.27 ± 0.01 ^c	142.10 ± 5.30 ^d
Benin	109.23 ± 4.32 ^b	301.54 ± 2.51 ^c
<i>M. glaziovii</i>	1.49 ± 0.01 ^c	131.09 ± 2.32 ^e
Six months	1.54 ± 0.71 ^c	146.35 ± 3.81 ^d
<i>grouma</i>	1.34 ± 0.07 ^c	111.14 ± 3.09 ^f

(a, b, c, d, e, f, g, h): The values with the same superscript letter in the same column are not significantly different ($p > 0.05$); TME: Tropical Manihot Expensive; IRAD: Institute of Agricultural Research for Development; DM: Dry matter.

Values in **Table 8** show that south variety gave significantly ($p < 0.05$) the highest cyanide content in leaves powder followed by *ganbada* and Benin which had the same values ($p > 0.05$). Other powder samples indicated similar results ($p > 0.05$). Values obtained are lower than 380 - 590 ppm and 1000 - 2000 ppm achieved respectively by [42] and [52]. Nevertheless cyanide content could depend on the cassava variety, harvesting period and growing stage or age [42] [53]. Drying method could also justify differences obtained. In fact, drying of cassava leaves under sun reduces up to 60% - 70% of cyanide. Recommended value for human consumption in product is ≤ 10 mg of HCN/kg in product [52] [54].

The powder from *ganbada* variety had significantly ($p < 0.05$) the great total phenols content while that from IRAD 4115 revealed the lowest ($p < 0.05$) quantity. Results acquired were lower than 6200 mg/100g reported by other authors [55]. It could be related to environmental conditions (soil, climate, and relief), cassava variety and plant age [56] [57].

3.5. Compare Analysis of Cassava Variety in Relation with Quality Indicators

As it can be seen on **Figure 2**, the principal component analysis (PCA) done

from 11 parameters analysed in powder samples from each variety permitted to have two (02) principal components (axis 1 and axis 2) which explained 58.00% of the total variance of data.

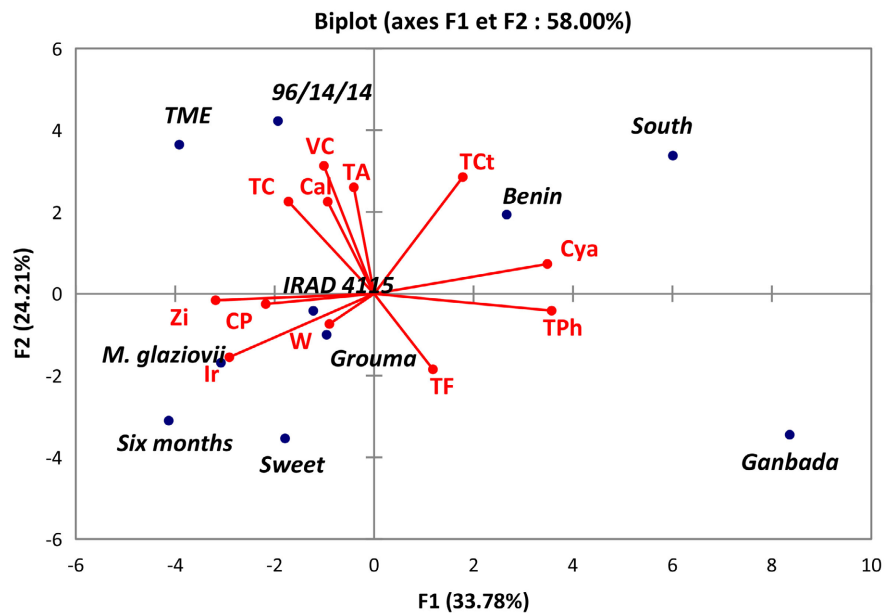


Figure 2. Between analysed parameters of cassava leaves powder samples and the varieties. W: water, CP: crude proteins, TC: total carbohydrates, TF: total fat, TA: total ash, TCt: total carotenoids, Zi: zinc, Cal: calcium, Cya: cyanide, VC: vitamin C, Ir: iron, TPh: total phenols.

The positive contribution in axis F1 was mainly done by total fat, total carotenoids, cyanide and total phenols. 94/14.14, Benin and sweet cassava varieties were positively correlated to total carbohydrates, calcium, vitamin C, ash, total carotenoids and Zinc. These parameters had higher contents and are very useful for the growth and prevention of infant of new born baby malnutrition. However, Benin and sweet varieties had high levels of cyanide and total phenols comparatively to 94/14/14 variety. For infant porridge or pap formulation, cassava leaves powder from 94/14/14 variety could be more appropriate.

4. Conclusion

From the results, cereals flour and cassava leaves powder samples composition depend on the types or varieties. The white corn is the main cereal used in infant pap preparation and it is rich in carbohydrates (84.46%), proteins (10.09%) and fat (10.09%). The cassava leaves powder from 94/14/14 variety represents an appropriate food for infants between 06 and 59 months and could then serve as supplement to cereals flour due to its acceptable amount of iron, zinc, carbohydrates, calcium and carotenoids coupled to its low cyanide content. Hence, it becomes judicious to define optimal operating conditions to obtain infants flour with high sensory quality and nutritive value in order to fight efficiently against malnutrition of infants from 06 to 59 months.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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