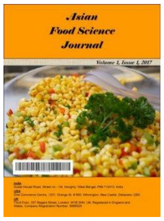

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Nutritional Quality of Food Supplements for Children from 6 to 59 Months Proposed to the Dietary Service of Regional Hospital of Daloa (Ivory Coast)

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Authors' contributions

This work was carried out in collaboration among all authors. Author BGAM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NKPV managed the analyses of the study. Author CAMM managed the analyses of the study. Author YNB managed the literature searches. Author GD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study aimed to evaluate the nutritional quality of the infant flours offered to mothers received in the dietary service of the CHR of Daloa.
Introduction: Ivory Coast's membership in Scaling up Nutrition (SUN) is a momentum in a collective effort to improve the nutrition and nutritional status of the population.
Method : For this purpose, analyses of biochemical compositions, in particular the levels of protein, fat and minerals in the proposed infant flours, were carried out.
Results: The formulations of the flours proposed have high nutritional values. The protein content

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of compound flours increases proportionally with the amount of soy incorporated. Indeed, for FC2 and FC3 formulations, these contents are 17.12 ± 0.19 g / 100 g (FC3) and 17.50 ± 0.56 g / 100 g (FC2) with a rate of incorporation of 25% soy. In addition, the FC1 flour formulation enriched with peanuts is low in protein with a value of 8.69 ± 0.11 g / 100 g. These flours also had mineral contents in accordance with WHO standards of calcium (> 125 mg / kg), iron (> 4 mg / kg) and zinc (> 0.8 mg / kg). In addition these formulations are highly digestible.

Conclusion: However, to use the proposed meal formulations as food for malnutrition, it would necessarily be necessary to supplement them with available local fruits and vegetables, rich in vitamins and minerals.

Keywords: Malnutrition; nutrition; nutritional quality; infant flour; formulation; soy.

1. INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO), malnutrition affects more than one billion people worldwide, 90% of them in developing countries. It mainly affects vulnerable groups such as children under 5, pregnant women and breastfeeding women [1]. For example, it contributes 33% of infant mortality, resulting in an estimated 128,354 deaths of children under five each year [2]. In Ivory Coast, acute malnutrition affected 8% of children under the age of five with 2% suffering from severe forms, 15% underweight and 30% stunted, of which 12% severe form [3]. Ivorian diets are generally poorly diversified, mainly based on tubers, roots and cereals that contribute more than 65% to energy inputs [4]. Also, in 2012, only 7% of children and infants received a minimum quality diet in terms of both diversity and frequency of meals [5]. In addition, the main causes of malnutrition are related to protein-energy deficiency and a deficiency in certain key micronutrients, namely calcium, iron and zinc [6].

Ivory Coast is experiencing the problem of the double burden of malnutrition marked by under-nutrition (stunting, acute malnutrition, underweight, and micronutrient deficiencies), the emergence of overnutrition (overweight and obesity) and nutrition-related non-communicable chronic diseases [7].

Faced with this situation, the promotion and production of infant flours from locally available food products of high energy density (cereals and vegetables) have been adopted to expand the range of staple foods, even food supplements.

Unfortunately, this situation also prevails in Daloa and little data is available. In the city of Daloa (Upper Sassandra Region, Ivory Coast), one of the densest in the country, the nutritional status of children from 6 to 59 months remains to be determined. The same applies to the nutritional quality of the complementary foods offered to mothers who come for consultation for their children. The purpose of this study is therefore to assess the nutritional quality of food supplements for children between 6 and 59 months of age offered at the regional hospital dietary service in Daloa (Ivory Coast).

2. MATERIALS AND METHODS

2.1 Plant Material

The plant material consists of millet, rice, maize, soy or peanut-enriched infant flour. These flours were purchased from the Daloa regional hospital dietary service and kept in jars.

2.2 Technical Equipment

The laboratory equipment consisted of a centrifuge (SIGMA-2-16P), beakers, graduated burettes, a precision scale (Denver, model ABT 320 - 4M), an oven (Memmert, allement, loading model 30-1060), porcelain capsules, a heating plate, a muffle oven (VELP Scientifica, Spain), graduated test tubes, matras, jars with lid, pipettes, a pH meter (pHs -36w Micro Processor Ph/mv/ Temperature METER, Belgium), aluminium crucibles; a water bath (Fisher Scientific model TW 8), a Soxhlet (Unid Tecator, System HT2 1045, Sweden), an atomic absorption spectrophotometer (Zuzi: model 4211/50), and test tubes...

2. METHODS

2.1 Preparation of Flours

Three types of infant flours have been formulated. The different formulations are as follows:

FC1 = 25% Mil + 25% Rice + 25% Maize + 25% Peanut;

FC2 = 25% Mil+ 25% Rice + 25% Maize + 25% Soy;
FC3 = 35% Corn + 35% Rice + 5% Sugar + 25% Soy.

This information was given by the producers of these different flour formulations. The bio-chemical, physico-chemical, functional and rheological analyses were carried out on these three formulations with one sample per type of flour.

2.2 Biochemical Analyses of Composite Flours

2.2.1 Determination of dry matter content [8]

A quantity of 0,5 g of sample was placed in a perfectly dry M0 aluminium crucible. This crucible is then placed in an oven (MEMMERT 854 SCHWABACH, Germany) at 105°C for 24 hours. After cooling, the sample is weighed. The dry matter content (MS) is given by the following expression :

$$\% \, MS = \frac{M_2 - M_0}{M_1 - M_0} \times 100$$

% MS: percentage dry matter
M0: Empty crucible mass
M1: Empty crucible mass + fresh sample
M2: Empty crucible mass + dried sample

2.2.2 Determination of protein content [9]

Total nitrogen was determined using the Kjeldahl method after sulphuric mineralization in the presence of selenium catalysts. The nitrogen content was multiplied by 6.25 (nitrogen-to-protein conversion coefficient) and divided by the dry matter content.

2.2.3 Determination of ash content [10]

Ash is the total amount of mineral material obtained after samples are incinerated at 550°C for 8 hours. 1 g of sample is placed in a M0 porcelain crucible. The set is placed in the muffler oven at 550°C for 8 hours. The sample is then removed from the oven and weighed after cooling.

2.2.4 Determination of lipid content [11]

The extraction was made by hexane in a Soxhlet type extractor (Unid Tecator, System HT2 1045, Sweden). After evaporation of the solvent and drying of the capsule in the oven at 105°C for 30 minutes; the difference in weight gave the lipid content of the sample.

2.2.5 Determination of fibre content [10]

The raw fibre content of the samples was determined using the AOAC method. This method consists of treating the sample at boiling with concentrated sulphuric acid and then with soda. The residue obtained is dried, burned and weighed.

2.2.6 Determination of carbohydrate content

The carbohydrate content (expressed as % of the dry matter) was estimated using the formula presented below [12].

% G = 100 – (% Protein + % Lipid + % Ash + % Fibers)

2.2.7 Determination of energy value

The energy value was calculated using the specific coefficients of [13] for proteins, lipids and carbohydrates.

Fig. 1. Different flour formulations

2.2.8 Physico-chemical analyses of compound flours Determination of minerals (Fe, Ca, and Zn)

The method used is that proposed by [14]. For extraction, 1 g of sample is calcined until complete mineralization at 525°C. All ash is transferred by 10 ml of HNO_3 (1 N) into a 100 ml beaker. The mixture is digested in a soft boil on a hot plate for 30 min. The mixture is then filtered in a 50 ml flask and, after cooling, the distilled water is filled up to the mark. This extract is used to measure the different minerals using an atomic absorption spectrophotometer (UNICAM 929 A Spectrometer) according to the following wavelengths: 248.3 nm (Fe); 422.7 nm (Ca), 213.9 nm (Zn).

2.2.9 Determination of acidity [15]

The titrable acidity was determined by titrimetric assay. The assay consisted of determining the total natural acid content of the product. At ten millilitres (10 mL) of the previously obtained supernatant were added 2 drops of a coloured indicator (phenolphthalein). The mixture was dosed with 0.1 N sodium hydroxide solution until the light pink turn. Acidity expressed in milliequivalents per 100 g of sample (mesh/100 g) was calculated:

Acidity (mesh/100 g) = (N1 x 105) / m; With N1 = (N2 x V2) / V1; V1 = Volume of the solution taken;
V2 = volume of soda (NaOH) poured; N1 = normality of the solution taken;
N2 = soda normality (0.1 N); m = sample mass (in grams).

2.2.10 Determination of pH

The pH was measured using the method [10]. 10 g of the sample was weighed in a beaker and 20 ml of distilled water was added. The assembly was homogenized and 10 ml of the supernatant was removed and the pH was measured by dipping the electrode into the 10 ml sample and the pH value was read on the pH meter screen.

2.2.11 Rheological properties and in vitro digestibility of compound flours Swelling and Solubility

Swelling and solubility tests were performed using [16] method. A solution of 10 ml to 1% (w/v) of dry flour is prepared and put in a double boiler at various temperatures (50°C to 95°C) at intervals of 5°C under maximum agitation for 30 min. After cooling at room temperature, the gel is centrifuged at 4000 revolutions/min for 19 min. The two separate phases of the gel (pellet and supernatant) were immediately poured into known crucibles and placed in the oven (MEMMERT 854 SCHWABACH) at 120°C for 4 hours. After cooling in a desiccator, the mass of the dried material is determined.

2.2.12 *In vitro* digestibility

The reaction medium consists of 100 µl of acetate buffer (100 mM, pH 5), 20 µl of amylase and 80 µl of flour gel (1%). The medium is incubated in a 37°C bain marie over a period of 160 min. The sugars released are quantified by the method [17] using DNS.

2.2.13 Functional properties of compound flours

Water Absorption Capacity [18]: 3 g of sample is dispersed in 25 ml of distilled water and placed in pre-weighed centrifuge tubes. Dispersions were occasionally agitated by hand for 30 min, then centrifuged at 3000 rpm for 25 min. Excess moisture is removed by flow at 50°C for 25 min, and the sample is repelled.

Oil Absorption Capacity [19]: 0,5 g of each sample was mixed with 6 ml of soybean oil in pre-weighed centrifuge tubes. After a hand shaking time of 30 min, the mixtures are centrifuged to 3000 rpm for 25 min. The decanted oil was then removed with a pipette and the tubes were spilled for 25 min to drain the remaining oil, then repelled.

3. RESULTS

3.1 Analysis of the Compound Flours Biochemical Characteristics

The biochemical analyses showed that the formulated flours (FC1, FC2 and FC3) have dry matter of 92 ,00± 0,01 %, 93,00± 0,10% and 93.00± 0.04%. The ash proportions of these flour formulations were 1.16 ±0.15%, 1.51± 0.51% and 1.71 ±0.57% respectively for FC1, FC2 and FC3. However, the one-factor variance analysis did not reveal a significant difference between the average dry matter values and the ash content of the three flour formulations at the 5% threshold. Protein levels in flour increased with the percentage of soybeans in the flour. Thus, 8.69 ± 0.11% for FC1, 17.50± 0.56% for FC2 and 17.12± 0.19% for FC3. The FC1 formulation had a significantly low protein content compared to the FC2 and FC3 formulations. The lipid content gradually varied according to the rate of intake of soybeans and peanuts. Values were 10.47 ±2.49% for FC1, 8.73 ±4.23% for FC2, and 8.03 ±1.02% for FC3, respectively. However, the one-factor variance analysis did not reveal a significant difference (P<0.05) between the different flour formulations. The carbohydrate content varied according to the rate of intake of soybeans and peanuts. Formulation FC1 had the highest content (75.32± 3.16%) of flour. The proportions of carbohydrates FC2 (66.48 ±3.41%), FC3 (67.74 ±1.37%) are not significantly different (P<0.05). The fibre content of the FC1, FC2 and FC3 flour formulations was 2.83 ±0.14%, 4.04± 0.05% and 5.40 ±0.30%, respectively. The one-factor variance analysis revealed a significant difference (P<0.05) between different flour formulations. The calorific energy was very high in the different flours. There were 445.50 ±16.78 kcal/100 g for FC1, 430.15± 11.14 kcal/100 g for FC2 and 411.69± 4.71 kcal/100 g for FC3. The one-factor variance analysis showed a significant difference at the 5% threshold between the different flour formulations.

3.2 Physico-chemical Characteristics

The different flours had a high starch content. The values were 73.77± 0.45%, 51.92± 1.56% and 69.40± 0.85% respectively for flour FC1, FC2 and FC3. These values differ significantly (P<0.05) from one flour to another. Thus, FC1 contained much more starch than the other two flours. The total sugar content was significantly lower in the composite flours. It was 2.39± 0.05% for FC1, 3.55 ±0.23% for FC2 and 3.18± 0.26% for FC3. The one-factor variance analysis revealed a significant difference (P<0.05) between the three flour formulations. Also, the different flours had significantly different reducing sugar content (P<0.05). In addition, the flour formulations had low reducing sugars of 0.87± 0.04 g/L for FC1, 1.98 ±0.13 g/L for FC2, and flour FC3 with 2,20± 0.12 g/L. The titrable acidity of flour varied with the rate of intake of soybeans and peanuts. It ranged from 2.50 ±0.50 meq/100g of flour, for the FC1 formulation, 5.50± 0.50 mg/100 g of flour, for the FC2 formulation, to 3.50± 0.50 mg/100g of flour, for the FC3 formulation. There is a significant difference between the titrable acidities of these flours. For the three meal formulations, it appears that the FC2 formulation had the highest mean value, followed by FC3 and FC1 formulations. The respective values were 6.43 ±0.01, 6.33 ±0.01 and 6.21± 0.01. Alternatively, the different formulations were rich in calcium and zinc with levels of 645.09± 0.19 mg/kg (FC1), 679.73 ±0.54 mg/kg (FC2) and 626.05± 0.96 mg/kg (FC3) for calcium, 5.34± 0.01 mg/kg (FC1), 5.74 ±0.01 mg/kg (FC2) and 6.28± 0.00 mg/kg (F3) for zinc. For iron, the levels varied according to the formulations and are 7.50 ±0.01 mg/kg (FC1), 5.99 ±0.02 mg/kg (FC2) and 6.43± 0.03 mg/kg (FC3). Duncan's POSTHOC test revealed a significant difference in the iron content of these formulations.

3.3 Functional Properties

Flour FC1 has a water absorption capacity (EAC) of 119.33 ±5.69% and an oil absorption capacity (ACH) of 89.33 ±10.07%. Flour FC2 has a EAC of 132.00 ±3.60% and an ACH of 84.67 ±3.05%. Flour FC3 has a CAE of 118.67 ±4.04% and a CAH of 86.00± 8.00%. There is no significant difference in oil absorption capacity as opposed to water absorption capacity (P<5%). In terms of foaming capacity, flour FC3 with 2.09± 0.01% had the lowest value than flour FC2 (8.49± 0.01%) and FC1 (6.06 ±0.06%). These different foams are not stable. The different flours had emulsifying activities of 33.93± 0.10% for FC1, 36.36 ±0.09% for FC2, and FC3 flour with 35.09 ±0.20%. These values are significantly different at the 5% threshold by Duncan's POSTHOC test.

Table 1. Biochemical characteristics of flour

Parameters	FC1	FC2	FC3
Dry matter (%)	92,00± 0,01^{a}	93,00 ± 0,10^{a}	93,00 ± 0,04^{a}
protein (%)	8,69 ± 0,11^{a}	17,50 ± 0,56^{b}	17,12 ± 0,19^{b}
Lipid (%)	8,73 ± 0,423^{a}	10,47± 2,49^{a}	8,03 ± 1,02^{a}
Ash (%)	1,16 ± 0,15^{a}	1,51± 0,51^{a}	1,71 ± 0,57^{a}
Fiber (%)	2,83 ± 0,14^{a}	4,05 ± 0,05^{b}	5,40 ± 0,30^{c}
Carbohydrate (%)	75,32± 3,16 ^{b}	66,48 ± 3,41^{a}	67,74 ± 1,37^{a}
Energy value (kcal/100 g)	445,50 ± 16,78^{b}	430,15± 11,14^{ab}	411,69 ± 4,71^{a}

The values are the average standard deviation of three measurements (n = 3). The same index letter in the same line indicates that there is no significant difference between the samples for the parameter concerned (P<0,05). FC1 = Compound Flour 1, FC2 = Compound Flour 2 and FC3 = Compound Flour 3

Table 2. Physico-chemical characteristics of flour

Parameters	FC1	FC2	FC3
Starch (%)	73,77 ± 0,45[a]	51,92 ±1,56[b]	69,40 ± 0,85[c]
Total sugar (%)	2,39 ± 0,05[a]	3,55±0,23[b]	3,18 ± 0,26[b]
Reducing sugar (g/l)	0,87 ± 0,04[a]	1,98 ± 0,13[b]	2,20 ± 0,12[c]
Acidity méqg/100 gMS	2,50 ± 0,50[a]	5,50 ± 0,50[c]	3,50 ± 0,50[b]
Ph	6,21 ± 0,01[a]	6,43 ± 0,01[c]	6,33 ± 0,01[b]
Calcium (mg/kg) > 125 mg/kg	645,09 ± 0,19[b]	679,73 ± 0,54[c]	626,05 ± 0,96[a]
Iron (mg/kg) > 4 mg/kg	7,50 ± 0,01[c]	5,99 ± 0,02[a]	6,43 ± 0,03[b]
Zinc (mg/kg) > 0,8 mg/kg	5,34 ± 0,01[a]	5,76 ± 0,01[b]	6,28 ± 0,00[c]

The values are the average standard deviation of three measurements (n = 3). The same index letter in the same line indicates that there is no significant difference between the samples for the parameter concerned (P<0,05). FC1 = Compound Flour 1, FC2 = Compound Flour 2 and FC3 = Compound Flour 3

3.4 Rheological Properties and *in vitro* Digestibility of Flour

Inflation values ranged from 3.67 to 14.00 g/g for FC1, 3.50 to 15.00 g/g for FC2, and 3.33 to 17.00 g/g for FC3. Flour swelling progresses from 50°C to 85°C. From 85°C, the swelling of the flour became greater up to 95°C. The percentages of solubility of the different flours also increased with temperature. Values ranged from 10% to 75% FC1, from 10% to 81.67% for FC2 and from 10% to 83.33% for FC3 flour. The percentage solubility varied progressively between 55°C and 65°C. Starting at 70°C, the solubility of flour becomes more important. In addition, digestibility increased over time and then stabilized after 105 min. It is higher for flour FC1 (0 - 130%) and lower for flour FC3 (0 - 80%).

Table 3. Functional properties of flour

Parameters	FC1	FC2	FC3
Water Absorption Capacity (%)	119,33 ± 5,69[a]	132.00±3,60[b]	118,67 ± 4,04[a]
Oil absorption capacity (%)	89,33 ± 10,07[a]	84,67 ± 3,05[a]	86,00 ± 8,00[a]
Foaming capacity (%)	6,06 ± 0,06[b]	8,49 ± 0,01[c]	2,09± 0,01[a]
Stability of foam (%)	0	0	0
Emulsifying activity (%)	33,93 ± 0,10[a]	36,36 ± 0,09[c]	35,09 ± 0,20[b]

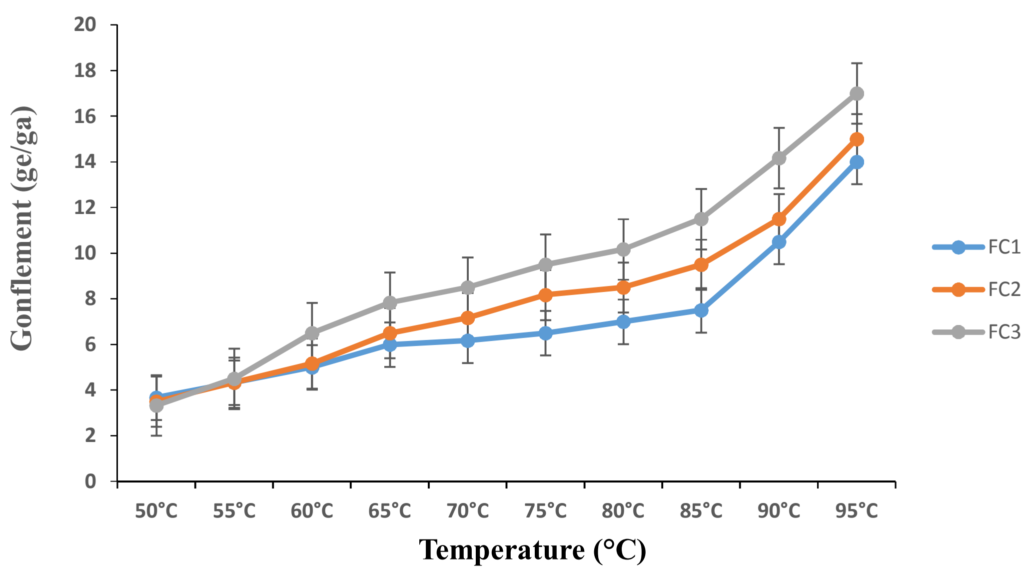

Fig. 2. Evolution of flour swelling as a function of temperature

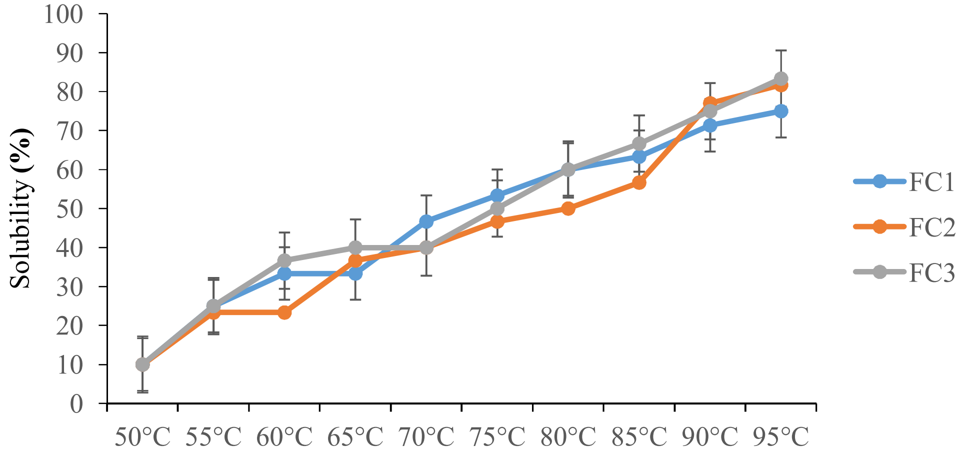

Fig. 3. Temperature-dependent solubility of flour

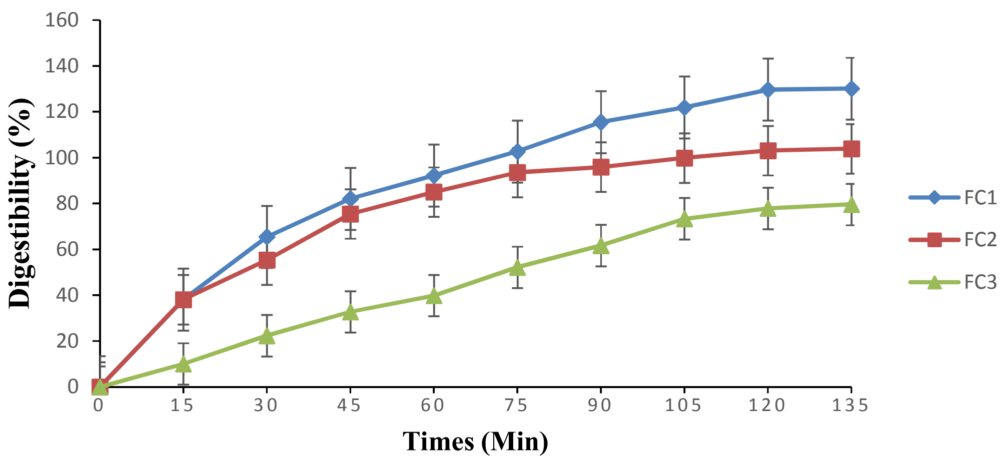

Fig. 4. Evolution of *in vitro* digestibility of flour over time

4. DISCUSSION

4.1 Analysis of Composite Flours Biochemical Characteristics

To remedy this nutritional situation, several formulations of infant flour are offered to mothers in health centres. Three samples of these flours were collected to assess their nutritional values. Biochemical analyses showed that all flour produced from the different formulations had high dry matter contents (92.00± 0.01% FC1, 93.00± 0.10% FC2 and 93.00 ±0.04% FC3) and low humidity. According to Okezie and Bello [15], a low moisture content (7-8%) of less than 12% would allow better preservation of flour. Protein content is important in flour formulations FC2 and FC3 in relation to flour formulation FC1. This could be explained by the presence of soybeans in these two formulations. The protein levels of the FC2 and FC3 formulations are higher than those of Viviane et al. [20] for their formulations of Attiéké + soybeans and cassava + soybeans. In addition, these values are substantially identical to those of 16.99± 0.41 and 21.88 ±1.09% recorded in formulations of soy-fortified yam flour [15]. The lipid levels determined in the different flours (10.47± 2.49% FC1, 8.73± 4.23% FC2, and 8.03 ±1.02% FC3) were lower than those found by some authors in the formulation of their respective flours. For example, [20] reported 10% lipid. The variation in carbohydrate content in flour is due to the amount of peanut in flour.

For example, flour FC1 has the highest carbohydrate content (75.32± 3.16%). These values are higher than those obtained by François et al. [21] who reported 61±2% carbohydrate in MISOLA flour. A 63 3% carbohydrate content was reported in BAMISA flour, composed of small millet + soy + peanut ( ). In addition, the various flours contained very low ash values (1.16 ±0.15% FC1, 1.51 ±0.51% FC2 and 1.71 ±0.57% FC3). These levels are lower than the 2% obtained by Viviane et al. [20]. However, they are close to the 1.88± 0.06% reported by Okezie and Bello [15]. The average fibre content values of the FC1, FC2 and FC3 flour formulations are relatively low (2.83±0.14% FC1, 4.04± 0.05% FC2 and 5.40± 0.30% FC3). Dietary fibre is a residue of non-digible carbohydrates that is essential for proper intestinal transit [22,23]. The flour obtained all have high energy values (448.50± 16.78 kcal/100 g FC1, 430.15±11.14 kcal/100 g FC2 and 411.69±4.71 kcal/100 g FC3), higher than WHO recommendations (400 Kcal/100 g) according to Mouquet-Rivier [24].

4.2 Physico-chemical Characteristics

All the flours produced from the different formulations have high starch contents. Starch is the major part of cereals and accounts for 70-85% of the weight of the dry matter ([25]). The quantities of starch are significantly lower in the FC2 and FC3 formulations than in the FC1 formulation. This could be due to the presence of peanuts in the FC1 formulation. In addition, the total sugar content is low and close to the values (2.97 and 5.55%) obtained by Mezajoug et al. [26] in cake.

Flours have small amounts of reducing sugars. In addition, the results show high levels of minerals in flour formulations.These levels are higher than [15], obtained in its different yam and soy formulations. In addition, the levels of calcium, iron and zinc in these flours comply with WHO recommended standards for calcium (>125 mg/kg), iron (>4 mg/kg) and zinc (>0.8 mg/kg) [15].

4.3 Functional Properties

Regarding the functional properties of flour, the FC2 is richer in protein with the highest water absorption capacity. Sefa-Dedeh and Afoakwa [27] indicated that the water absorption capacity of the product increases with the protein content of the flour. According to Hung and Sheng [28], residues of polar amino acids from proteins have an affinity for water molecules [29]. For the foaming capacity and stability of the foam, the results showed that the flours formed less foams and the foams from the flours were not stable. This could be explained by the denaturation of proteins during technological operations. In fact, native proteins give a high stability of the foam than denatured proteins [30]. But also, the low foaming capacity of some flours and its absence for others could influence this stability. As for the emulsifying capacity, the values are high. These values are lower than the values (63-87%) found in the protein aces of Mezajoug et al. [26].

4.4 Propriétés Rhéologiques et Digestibilité *in vitro* des Farines

The swelling of the different flour formulations changes with temperature. The behaviour of starch in water depends on temperature and concentration [31]. In general, it absorbs very little water at room temperature, hence its low inflating power. This absorption increases with temperature. This would explain the increase in the inflating power of the different flours with temperature. The solubility of flour also increases with temperature. Starch, with a crystalline structure is insoluble in cold water. During gelatinization, between 60-65°C, there is a destruction of the crystalline structure and a beginning of swelling. The swelling continues with the increase in temperature until the granules burst, releasing their contents, a part of which is solubilized [32]. A high temperature thus distorts the starch granules of the flour by improving solubility. In addition, solubility could involve the amount of amyloidosis (soluble starch fraction) released from starch pellets during bulging. Therefore, the increase in solubility could be explained by an increase in released amyloidosis [33]. The different flours formulated are suitable to be used as a supplement to breast milk because they contain nutrients that can cover the needs of children from 6 to 59 months. These flours can be used as infant flours since they are digestible with a high and very soluble starch swelling power.

5. CONCLUSION

The biochemical, physico-chemical, functional and rheological analyses of compound meal formulations have yielded important results to combat the scourge of child malnutrition. The proposed flour formulations have high nutritional values. The protein content of the compound flours increases in proportion to the amount of soybeans incorporated. For formulations FC2 and FC3, these levels are 17.12± 0.19 g / 100 g (FC3) and 17.50± 0.56 g / 100 g (FC2) with a 25% intake rate of soybeans. In addition, the formula of FC1 flour enriched with peanuts is low in protein with a value of 8.69± 0.11 g / 100 g. These flours also had mineral contents in accordance with WHO calcium standards (>125 mg/kg), iron (> 4 mg/kg) and zinc (> 0.8 mg/kg). In addition these formulations are highly digestible. However, these flours must be supplemented with local, vitamin-rich fruits and vegetables. This study should start with a survey to assess the prevalence of micronutrient deficiencies in the Daloa region to better understand the problem of malnutrition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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