Nutritional composition of some artisanal infant flours produced locally in Ivory Coast

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Abstract
Objective: This work aims to assess the nutritional composition of some Ivorian artisanal flours. Methodology: Five varieties of artisanal infant flours were collected. Flour 1 (corn, millet, rice, soybean); flour 2 (fermented millet, soya, tapioca); flour 3 (fermented millet, soy, tapioca); flour 4 (fermented corn, sprouted corn, Macrotermes subhyalinus); flour 5 (fermented millet, sprouted mil, Macrotermes subhyalinus). Moisture, ash, protein, lipid and fiber contents were determined according to AOAC standards. Minerals (calcium, magnesium, sodium, potassium, iron, copper, zinc and manganese) were determined by atomic absorption spectrophotometry and phosphorus by colorimetry. Results: The analyzes show that the composition of the various flours varies from one sample to another: moisture (4.82 - 6.82g / 100g); proteins (13.65 - 15.07 g / 100g); lipids (5.10-11.16 g / 100g) ash (0.99 - 2.26 g / 100g); fiber (2.12 - 3.98 g / 100g); carbohydrates (68.53 - 76.30 g / 100g) energy (402.58 - 434.26Kcal / 100g); potassium (510.34 - 976.38mg / 100g); phosphorus (100.21 - 334.85 mg / 100g); calcium (23.66-70.96 mg / 100g); magnesium (62.38 - 99.73 mg / 100g); sodium (56.80 - 389.56 mg / 100g); zinc (3.84 - 11.2 mg / 100g); manganese (9.6 - 107.67 mg / 100g); iron (5.01 - 9.60 mg / 100g); copper (4.25-13.1 mg / 100g). Macrotermes subhyalinus dried powder and soybeans significantly improve the protein and mineral content. Conclusion: All flours have a good protein content around 15%. The incorporation of Macrotermes subhyalinus dried powder has improved the lipid and mineral content of flours 4 and 5. The energy values of the flours analyzed are important. FAO / WHO recommends that weaning foods be energy rich. These data could be exploited for the choice of flours for a better feeding of children. Keywords: Local infant flour, Nutritional composition, Ivory Coast

Introduction
Protein and energy deficiency and mineral deficiency are public health problems in developing countries (FAO, 2010) [13]. Children are the most vulnerable layer. Malnutrition contributes to 35% of deaths of children under 5 in West and Central Africa. Currently, one million children in this age group die each year in this region because of malnutrition (UNICEF, 2010) [32]. Serious forms of malnutrition include marasmus, kwashiorkor and nutritional anemias (UNICEF, 2009) [33]. In Ivory Coast, despite an improvement due to the efforts made, the nutritional situation of the population, in particular that of children under five, is still worrying. Chronic malnutrition or stunting is 21.6% and global acute malnutrition is 6% (EDS III, 2012). According to the World Health Organization (WHO), the poor quality of food supplements given to children from 6 months in addition to breastfeeding and in particular, their low energy density is recognized as an etiological factor of the protein-energy malnutrition in young children. In fact, the health and well-being of each individual depends on a sufficient intake of good quality nutrients, such as fat, protein, carbohydrates, vitamins and minerals (Latham, 2001) [23]. According to, the work of Shankar, (2000) [27]; Shuichi and Masanobu, (2004) [28] foods modulate the immune system. One of the causes of this malnutrition is also the lack of nutritional data on locally produced infant flours. Thus, the present work aims to determine the nutritional composition of some artisanal infant flours of Ivory Coast.

Material and Methods
Preparation of the raw powder of Macrotermes subhyalinus
The termites once caught were immediately put in coolers containing ice (in order to preserve their freshness) and then were sent to the laboratory.
2 kilograms of termites were then cleaned, rinsed, drained, blanched, placed on trays and dried in an oven at 65 °C for 72 hours. The termites were subsequently removed from their wings and legs (figure 1), crushed in a blender and sieved to obtain the raw meal of *Macrotermes subhyalinus* (figure 2). The raw powder was put into cans and kept at + 4 °C.

**Preparation of delipidated *Macrotermes subhyalinus* powder:** To the raw flour of *Macrotermes subhyalinus* was added hexane at the rate of 3 g of flour per 10 ml of hexane. The mixture was stirred magnetically for 6 hours. The cakes from this extraction were desolventized first in the open air for 1 hour and then in an oven at 45 °C for 2 hours before being ground again. After drying, the delipidated residue of *Macrotermes subhyalinus* was put in a box and stored at + 4 °C.

**Production of simple flours**
The production of artisanal flour requires many steps; thus several unitary operations enter into the manufacture of these flours. This involves sorting, roasting, pulping, grinding, sieving, mixing and packaging.

**Plant and biological material**
Five varieties of artisanal infant flours were collected in the production structure in Yaoundé. These are: Flour 1 (corn, millet, rice, soybean); flour 2 (fermented millet, soya, tapioca); flour 3 (fermented millet, soy, tapioca); flour 4 (fermented corn, sprouted corn, *Macrotermes subhyalinus*); flour 5 (fermented millet, sprouted mil, *Macrotermes subhyalinus*). The percentage of each ingredient used in the formulation of each flour is shown in Table 1.

**Table 1: Flour composition**

| Flour  | Compositions (%) | Scientific names of major ingredients |
|--------|------------------|---------------------------------------|
| Flour 1| Maize (25%); Mil (25%); Rice (25%); Soy (25%) | Zea mays; Glycine max. |
| Flour 2| Fermented millet (50%); Soy (20%); Tapioca (30%) | Pennisetum glaucum; Glycine max. |
| Flour 3| Fermented millet (50%); Soy (30%); Tapioca (20%) | Pennisetum glaucum; Glycine max. |
| Flour 4| Fermented maize (65%); Maize sprouted (10%), *Macrotermes subhyalinus* defatted (25%). | *Zea mays* ; *Macrotermes subhyalinus* |
| Flour 5| Fermented Mil (67,5%); Mil sprouted (10%); *Macrotermes subhyalinus* defatted (22,5%) | Pennisetum glaucum; *Macrotermes subhyalinus* |

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Fig 1: *Macrotermes subhyalinus* dried  
Fig 2: *Macrotermes subhyalinus* crushed  
Fig 3: delipid *Macrotermes subhyalinus* powder  
Fig 4: Flour 1  
Fig 5: Flour 2  
Fig 6: Flour 3

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Methods

**Moisture, ash, protein, fat, fiber, and carbohydrates**

Levels of water, ash, protein, fat and crude fiber were determined according to AOAC (2000) [9]. All analyzes were done in triplicate. The carbohydrate content was calculated by difference.

**Mineral Content:** The mineral contents: calcium, magnesium, sodium, potassium, iron, copper, zinc were determined according to the Benton and Vernon method, (1990) [7] using the atomic absorption spectrophotometer: Perkin-Elmer Analyst 700 spectrophotometer (Norwalk, CT, USA). Phosphorus was colorimetrically determined using the vanado molybdate method (AOAC, 1999) [4]. All analyzes were done in triplicate.

**Statistical analysis:** The results of the analyzes are presented as mean ± standard deviation. The results were processed by analysis of the variances (ANOVA) at the significance level $P<0.05$. These tests were performed using SPSS for Windows software version 17.0.

**Results and Discussion**

**A) Nutritional value**

### Table 2: Moisture, fat, protein, crude fiber, carbohydrate (g / 100g dry matter) and energy value (Kcal / 100g dry matter) contents of flours

| Flour | Fours 1 | Fours 2 | Fours 3 | Fours 4 | Fours 5 |
|-------|---------|---------|---------|---------|---------|
| Humidity | 5.83±0.11 | 6.82±0.09 | 6.23±0.07 | 4.82±0.01 | 4.97±0.91 |
| Protein | 14.65±1.02 | 13.65±0.44 | 15.07±0.17 | 14.86±1.76 | 14.35±1.12 |
| Lipids | 5.10±1.21 | 6.99±0.25 | 8.47±0.29 | 11.02±1.41 | 11.16±1.21 |
| Ashes | 2.26±0.77 | 0.99±0.01 | 1.17±0.03 | 2.14±0.39 | 2.04±0.86 |
| Raw fibers | 2.93±0.23 | 2.12±3.21 | 2.24±0.12 | 3.07±0.70 | 3.98±0.52 |
| carbohydrates | 75.07±2.31 | 76.30±0.3 | 73.09±0.11 | 68.91±1.80 | 68.53±1.74 |
| Value energy | 404.58±2.1 | 422.89±1.55 | 429.05±1.66 | 434.26±4.21 | 431.96±4.81 |

The results are presented as mean ± standard deviation; averages with different letters exhibiting within the same column are significantly different ($P<0.05$).

The moisture of the flours analyzed varied from 4.97 (flour 5) to 6.82 g / 100 g (flour 2) and showed significant differences ($P<0.05$). This low water content is due to the fact that these flours come from dried seeds (corn, soybean, millet, tapioca) and other dry products such as dried and delipidated *Macrotermes subhyalinus* termite powder. A large quantity of water in these flours would compromise their preservability; in fact, water promotes the proliferation of microorganisms capable of using their amylases, to hydrolyze the starch contained in the flours and thus to facilitate the acidification of the latter (Sall, 1998) [29].

These flours have water contents close to those of cassava + soy flour (5 g / 100 g) and attiéké + soy flour (5 g / 100 g) produced by Zannou *et al.* (2011) [34] in Côte d'Ivoire and below the moisture content of maize (12.38g / 100g) and millet (19.71g / 100g) flours found by Sall (1998) [29] in Senegal. The protein contents of the flours analyzed varied from 13.65 (flour 2) to 15.07 g / 100 g (flour 3) and did not show significant differences ($P<0.05$). The presence of dried *Macrotermes subhyalinus* termite powder and soy in flours may explain these high levels. Indeed, according to Niaba, (2011) [22], dried *Macrotermes subhyalinus* termite powder is a great source of animal protein (16.5g / 100g), unlike cornmeal which contains only 7g / 100g. ACC/SCN (2001) [1] demonstrated that when locally available cereals, legumes and / or animal products are mixed, the resulting protein content is improved. In addition, Ibeanu (2009) [20] noted that the use of compound flours could help improve the quality of weaning foods in developing countries. These protein contents are higher than that found by Ukegbu and Anyika (2012) [31] (2.17 g / 100 g) in the maize porridge prepared in Nigeria, especially in Ngor-okpala in the state Imo and comparable to those found by Ponka *et al.* (2015) [9] (8.91-13.69 g / 100 g) in the porridges consumed in the Far North of Cameroon more specifically in the city of Maroua. All flours have a protein value in accordance with the standards recommended by FAO/WHO (2008) for weaning foods (11-21 g / 100g).

Proteins play a role in the defense of the body and cover the nitrogen expenditure caused by the renewal of tissues and the synthesis of certain compounds involved in the proper functioning of the body (enzymes, hormones) (Sguera, 2008) [26]. The lipid contents of the flours show significant differences ($P<0.05$).

The lowest content (5.1 g / 100g) is found in flour 1 while the highest content is found in flour 4 and 5. These last levels (11.16 and 11.02 g / 100g) could explain by adding in flour 4 and 5 dried termite *Macrotermes subhyalinus* termite powder. These levels are higher than the values of 1.66 and 2.2 g / 100 g respectively found in corn and millet porridge prepared in Kaduna State, Nigeria (Amigbo et al., 2010) [2].

Flour 1 has the highest content (2.26 g / 100g) of ash while flour 2 has the lowest value (0.99 g / 100g). These different levels do not differ significantly ($P<0.05$). However, the high ash content of the flours could be explained by the presence of soy and termite powder in the latter. These levels are lower than that found by Ponka *et al.* (2015) [9] (1.35 g / 100 g) in...
Potassium and phosphorus are the most abundant minerals in flours. The potassium and phosphorus contents range from 510.34 (flour 2) to 976.38 mg/100g (flour 5). The other minerals and their contents are: calcium, 23.66 mg/100g (flour 5) to 99,73 mg/100g (flour 3); magnesium, 62,38 mg/100g (flour 2); iron, 11,2 mg/100g (flour 5); and copper with grades that vary of (4,25-13,1 mg/100g). A significant difference is observed between the distribution of all minerals (P<0,05). Potassium levels (> 250 mg/100g) are higher than the potassium content (217,78 mg/100g) of cornmeal prepared in northwestern Nigeria (Anigo et al. 2010) [2]. Potassium is needed for the regulation of the water balance of cells, the use of carbohydrates and the construction of proteins. It acts against disturbances of the cardiac rhythm and intervenes in the regulation of the osmotic pressure of the cell. Potassium participates in membrane transport and enzyme activation and plays a role in muscle contraction (increased neuromuscular excitability) (EUFIC, 2016) [11]. Phosphorus levels of Flours 1, 2 and 3 analyzed (100,21-141,17 mg/100g) were lower than those of cornmeal (171,32 mg/100g) consumed in northwestern Nigeria (Anigo et al., 2010) [2]. Phosphorus combines with calcium in the form of calcium phosphate, a hard substance that gives the body its rigidity. Phosphorus is necessary for the production and use of energy, the preservation of bones and teeth (FAO, 2001) [17]. In

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**Table 3: Mineral content of flours (mg/100g)**

| Minerals (mg/100 g of MS) | Flour 1 | Flour 2 | Flour 3 | Flour 4 | Flour 5 |
|---------------------------|--------|--------|--------|--------|--------|
| Sodium                    | 56,8±0,4 | 89,53±3,7 | 104,63±3,2 | 389,56±0,89 | 225,52±0,55 |
| Potassium                 | 525,31±0,4 | 510,34±1,1 | 599,36±1,9 | 830,61±1,01 | 976,38±1,23 |
| Calcium                   | 70,96±0,4 | 40,59±3,1 | 47,39±2,4 | 29,60±0,87 | 23,66±1,12 |
| Magnesium                 | 94,75±0,4 | 62,38±1,1 | 99,73±12 | 85,47±0,36 | 78,03±0,42 |
| Phosphorus                | 100,21±0,5 | 105,68±5 | 141,17±2,5 | 334,85±1,33 | 286,32±1,31 |
| Iron                      | 9,60±0,4 | 5,01±0,4 | 7,70±0,01 | 7,77±0,27 | 6,41±0,57 |
| Copper                    | 09,61±0,4 | 10,23±0,7 | 13,1±0,4 | 9,25±0,08 | 4,25±0,06 |
| Zinc                      | 03,84±0,4 | 9,19±0,1 | 11,2±0,5 | 10,73±0,27 | 8,83±0,05 |
| Manganese                 | 11,20±0,4 | 9,6±0,10 | 11,17±0,1 | 107,67±0,33 | 90,40±0,41 |

The results are presented as mean ± standard deviation; averages with different letters exhibiting within the same line are significantly different (P<0,05).
humans, calcium plays a major role in the constitution of the skeleton, but also in various metabolic functions such as muscle activity, nerve stimuli, enzymatic and hormonal activities, and oxygen transport (FAO, 2001) [17].

The magnesium contents of the flours analyzed (62.38 - 99.73 mg / 100 g) are comparable to the levels of (49.35-80.56 mg / 100 g) found in the slurries consumed at Maroua in the far north. of Cameroon (Ponka et al., 2015) [9]. Magnesium is found mainly in the bones, but also in most of the tissues of the body. Most diets contain enough magnesium, but in case of diarrhea for example, wastage is important and can induce weakness, behavioral problems and sometimes convulsions (FAO, 2001) [17].

The sodium contents of the flours analyzed (56.8-389.56 mg / 100 g) are higher than those (2.10-2.75 mg / 100 g) found in corn-based slurries containing other elements such as soy, shrimp, peanut or milk eaten in Ngor-okpala, Nigeria (Ukegbu and Anyika, 2012) [31]. Sodium is involved in the acid-base balance and body moisture balance. It promotes nerve function and muscle contraction. Sodium salts are very common in foods and are easily absorbed by the digestive tract and major cations of body fluids (EUFIC, 2006) [11].

The zinc contents of the flours analyzed (03.84-11.20 mg / 100 g) are higher than those (0.17-0.30 mg / 100 g) found in the cornmeal consumed in Nigeria (Obinnaoye, 2012) [22]. Zinc is present in many enzymes essential for metabolism (FAO, 2001) [17]. The manganese contents of the flours analyzed (9.6-107.67 mg / 100 g) are higher than that (4.41 mg / 100 g) found in the corn meal consumed in Nigeria, in particular at Jos plateau (Solomon et al., 2000) [28].

Manganese is involved in bone and tendon growth, and plays an important role in the synthesis of complex carbohydrates and proteins (EUFIC, 2006) [11]. The iron contents of the flours analyzed (5.01-9.60 mg / 100 g) are greater than the 2.49 mg / 100 g value contained in the maize porridge produced at Umua-hia Abia in Nigeria (Unaeze, 2011) [19]. Iron is also involved in the formation of hemoglobin, myoglobin and enzymes that play a key role in many metabolic reactions (Badham et al., 2007) [6]. The copper contents of the flours analyzed (4.25-13.1 mg / 100 g) are higher than the values of (0.17-0.30 mg / 100 g) found in the slurries consumed in Maroua in the far north. of Cameroon (Ponka et al., 2015) [9]. Copper is involved in the absorption of iron, metabolism and the formation of elastic and connective tissues. It also has an enzymatic function because it acts as a cofactor in certain enzymatic reactions of the body (EUFIC, 2006) [11].

Conclusion and application of results
This work made it possible to determine the nutritional composition of 5 varieties of Ivorian artisanal infant flours. Analyzes show that the composition varies from one flour to another. All flours have a good protein content around 15%. The incorporation of dried Macrotomus subhyalinus termite powder has improved the lipid and mineral content of Flours 4 and 5. The energy values of the flours analyzed are important, FAO / WHO recommends that weaning foods be energy rich. These data could be exploited for the choice of flours for a better feeding of children.

References
1. ACC/SCN. A review of the efficacy and effectiveness of nutrition interventions Allen, L.H. and Gillespie, S.R. (eds). Geneva, WHO, 2001.
2. Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS. Nutrient composition of complementary Food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. African Journal of Food Science. 2010; 4:65-72.
3. Ansnes. Table de composition nutritionnelle Cigail réalisée par l'Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (Ansnes). 2013.
4. AOAC. Official methods of analysis; 21st Edition, Association of official analytical chemists. Washington D.C. USA, 1999.
5. AOAC. Official methods of analysis international, 17th ed. Association of Official Analytical Chemists, Washington DC, 2000.
6. Badham J, Zimmermann MB, et Kramer K. Le guide de l'anémie nutritionnelle. Suisse : Sigh and Life, 2007.
7. Benton JJ, Vernon CJW. Sampling, handling and analyzing plant tissue samples. In : RL Westerman, Eds. Soil testing and plant Analysis; 3rd ed. SSSA Book Series : No. 3, 1990.
8. Brown KH. The importance of dietary quality versus quantity for weaning in less developed countries: a framework for discussion. In Food and Nutrition Bulletin. 1991; 13(2):86-94.
9. Ponka R, Abdou Bouba A, Fokou E, Beauchere E, Piot M, Leonil J et al. Nutritional composition of five varieties of pap commonly consumed in Maroua (Far-North, Cameroon). Polish Journal of Food and Nutrition Sciences. 2015; 65:183-19.
10. EDSC-III. Enquête Démographique et de Santé en Côte d’ivoire (EDS-III). Rapport final, MINSANTE (Côte d’Ivoire), 2012, 334.
11. EUFIC. Les minéraux: quel est leur rôle ? Où les trouve-t-on? 2006. http://www.eufic.org/article/fr/expid/mineraux/ consulté le 10 janvier 2016 à 22h 42min
12. FAO/OMS. Programme mixte FAO/OMS sur les normes alimentaires. Commission du Codex Alimentarius : Rapport de la 30èmesession du comité du codex sur la nutrition et les aliments diéétiques ou de régime. Rome (Italie), 2008, 1-223.
13. FAO. The State of Food Insecurity in the World. Rome, Italy: Addressing Food Insecurity in Protracted Crisis, 2010.
14. FAO/WHO. Lignes directrices pour la mise au point des préparations alimentaires complémentaires destinées aux nourrissons du deuxième âge et aux enfants en bas âge (CAC/GL, 08-1991). Rome (Italie), 1991, 11.
15. FAO/WHO. Energy and protein requirements. WHO Technical Report Series. No 724. World Health Organization, Geneva, 1985.
16. FAO. Nutrition et développement : une évaluation d’ensemble. Conférence internationale sur la nutrition. Rome, Italie, 1992, 2.
17. FAO. Improving nutrition through home gardening. A training package for preparing field workers in Africa. FAO Rome, 2001.
18. Henauer J, et Frei J. Alimentation riche en fibres : L’importance des fibres pour les personnes souffrantes de paralysie; Paraplegiker zentrum Uniklinik Balgrist traduction française AG & CBA, 2008; (3):1-9.
19. Henry-Unaenze HN. A comparative study of micronutrients content of complementary food used by
Igbo and Hausa mother in Umuahia, Abia State, Nigeria. Pakistan Journal of Nutrition. 2011; 10:322-324.

20. Ibeanu VN. Proximate composition, sensory properties and acceptability of low viscous complementary gruels based on local staples. Nigeria Journal of Nutritional Science. 2009; 30(1):103-111.

21. Ogbonnaya JA, Ketiku AO, Mojekwu CN, Mojekwu JN, Ogbonnaya JA. Energy, iron and zinc densities of commonly consumed traditional complementary foods in Nigeria. British Journal of Applied Science and Technology. 2012; 2:48-57.

22. Niaba Koffi PV, Gbogouri Grodji A, Beugre Avit G, Ocho-Anin AL, Gnaki Dago. Potentialités nutritionnelles du reproducteur ailé du termite Macrotermes subhyalinus capturé à Abobo-doumé, Côte d’Ivoire. Journal of Applied Biosciences. 2011; 40:2706-2714.

23. Latham MC. La nutrition dans les pays en voie de développement. FAO, Rome, Italy, 2001.

24. Okeke EC, Eze C. Nutrient composition and nutritive cost of Igbo traditional vendor foods and recipes commonly eat-en in Nsukka. Journal of Tropical Agriculture, Food, Environnement and Extension. 2006; 5:36-44.

25. Solomon M, Aliyu R, Mohammed R. Nutrient composition of foodstuffs and dishes/foods of indigenous population of Jos Plateau, Nigeria. West African Journal of Food and Nutrition. 2000; 2:20-26.

26. Sguera S. Spirulina plantesis et ses constituants, intérêts nutritionnels et thérapeutiques. Thèse, université Henri Poincare-Nancy 1, 2008.

27. Shankar AR. Nutritional modulation of Malaria Morbidity and mortality. The American Journal of Infectious Diseases. 2000; 182:37-53.

28. Shuichi K, Masanobu N. Modulation of Immune Function by Foods Evidence-based Complementary and Alternative Medicine. 2004; 2503:241-250.

29. Sall K. Contrôle de qualité des farines céréalières mises sur le marché au Sénégal. Thèse pour obtenir le grade de docteur en pharmacie, université Cheikh Anta Diop de Dakar, faculté de médecine de pharmacie et d’odontostomatologie, 1998.

30. Sanogo M, Mouquet C, Trêche S. La production artisanale de farines infantiles, Expériences et Procédés. Gret, Paris, France, 1994, 11.

31. Ukegbu PO, Anyika JU. Chemical analysis and nutrient adequacy of maize gruel (pap) supplemented with other food sources in Ngor-Okpala Iga, Imo State, Nigeria. Journal of Biology, Agricultural and Healthcare. 2012; 2:13-21.

32. UNICEF. Overview of children in west and central Africa, 2010.

33. UNICEF Cameroon. Humanitarian action update. Silent emergency affecting children in Cameroon. Unicef, Yaoundé Cameroon, 2009.

34. Zannou TV, Bouaffou KG, Kouame KG, Konan BA. Etude de la valeur nutritive de farines infantiles à base de manioc et de soja pour enfant en âge de sevrage. Bulletin de la Société Royale des Sciences de Liège. 2011; 80:748-758.