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Caractérisation physico-chimique et sanitaire des aliments de complément à base d'ignames (*Dioscorea rotundata, Dioscorea cayenensis et Dioscorea alata*) consommés dans la région du Haut Sassandra (Côte d'Ivoire)

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Abstract
This study assessed the nutritional and health quality of complementary foods for infants and young children produced from yam starch, allowing the preparation of porridge. To carry it out, the nutritional and health characteristics of yam starches were studied, as well as the physicochemical characteristics of the starchy mushrooms. The starches concerned are: *Dioscorea cayenensis* (variety "*Krenglè"); Dioscorea rotundata* (*Kponan* variety) and Dioscorea alata (Bètè-bètè variety). The results revealed, respectively, for starches *Pkonan, Krenglè* and *Bètè-Bètè;* a carbohydrate content of 86.58 ± 0.06%; 85.92 ± 2.83% and 81.18 ± 4.18%, a lipid level of 0.19 ± 0.03%; 0.52 ± 0.12% and 0.74 ± 0.06% and a protein content of 5.3 ± 0.1%; 5.56 ± 0.6% and 6.125 ± 0.6%. The starches of *pkonan, krenglè* and *beté-bétè* have an energy density of 60; 63 and 41 kcal / 100 g of dry matter, a fluidity of 100; 105 and 98 mm / 30 sec and do not contain pathogenic germs that may affect the health of the infant.
These infant flours do not contain pathogenic germs that can affect the health of the infant. Local yams produced from yams are low in protein. They have low nutritional values.

Keywords: yam starch, starch porridges, supplementary food, nutritional quality, sanitary quality

1. Introduction

At the level of children, malnutrition usually occurs during the period that corresponds to the introduction of breast milk supplemental food in infants [1]. Infants are particularly vulnerable during the transition period when supplement feeding begins [2, 3]. This period is a high-risk phase in the life of infants, because poorly conducted supplementary feeding increases multi-malnutrition malnutrition among critical health issues in infants [4, 5]. The complementary food is specially designed to enable them to meet their nutritional needs because after 6 months, breast milk is no longer sufficient to fully provide the nutritional needs of the infant energy and protein [6, 7, 8]. These diets primarily based on plant-based foods provide insufficient amounts of some key nutrients, such as iron, zinc, calcium and iodine, to cover the recommended nutrient requirements between 6 and 24 months [9].

During the weaning period, the mother introduces into the child's diet, porridges that are generally based on starchy meals. These traditional porridges consumed in developing countries have low energy densities in the range of 40 to 48 kilocalories per 100 g of preparation [10]. Bearing the WHO criteria for a good slurry are at least 30% dry matter, an energy density of 100 to 120 kcal / 100 g of slurry and a protein content of 12 to 15g / 100g [11]. However, because of its reduced gastric capacity, infants from 4 to 6 months ingest a small amount of porridge. It can not consume in a single take, more than 200 ml of food. Also, because of the low energy density of traditional porridges, the child will be satiated before he has been able to ingest sufficient amounts of energy and nutrients. The child will not be able to cover his energy needs unless at least 4 daily meals are offered.

In developing countries, however, no more than 3 porridges are usually distributed per day due to lack of time for field work, commercial and household activities, lack of knowledge about infant feeding and poverty of the farm. population. As a result, many young children suffer from malnutrition. Porridges containing the best nutrient and micronutrient contents are prepared from commercial infant flours, which costs are high compared to the low purchasing power of the majority of the population. Faced with this situation, the promotion and production of infant flours from locally available food products is desired in order to improve the traditional complementary foods used by mothers. In terms of the range of local raw materials available, we have yam, which is a starch-rich tuber and important for both its high food consumption and its cultural value in West Africa. It is commonly used in production areas in the form of kneaded starch in the diet of children.

The general objective of this study is to evaluate the nutritional and health quality of complementary foods produced from yam starch. It is specifically about:

- to determine the physicochemical composition of three varieties of yam;
- evaluate their sanitary quality;
- Determine the physicochemical characteristics of the slurry prepared from these yam starches.

2. Material and Methods

2.1 Biological material

Three (3) varieties of yam were used for the production of starch, they are: the variety *Kponan* ((*Dioscorea rotundata)* figure 1), the variety *Krenglè* ((*Dioscorea cayenensis)* figure 2) and the variety *Bètè Bètè* (*Dioscorea alata)* Figure

3. These yams were purchased at the small market and the large market of Daloa, the markets of Issia, Vavoua and Zoukougbeu (Ivory Coast). Tubers attacked by rodents, insects and microorganisms have been eliminated.

A B

Echelle: 1 cm

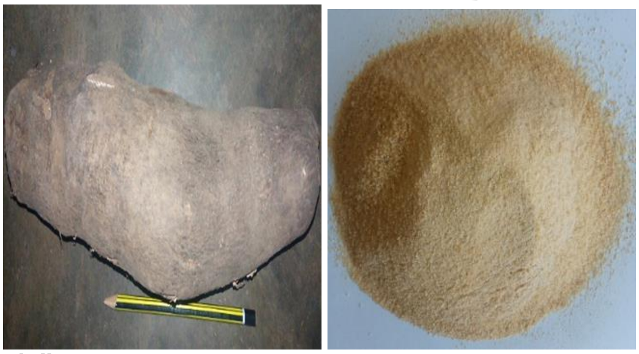
Fig 1: Photograph showing tubers (A) and starch (B) of *kponan* yam (*D. rotundata).*

A B

Echelle: 1 cm

Fig 2: Photograph showing tuber (A) and starch (B) of *krenglè* (*D. cayenensis*) yam.

A B



Echelle: 1 cm

Fig 3: Photograph showing the tuber (A) and the starch (B) of the *bètè-bètè yam (D. alata).*

2.2 Methods

2.2.2 Preparation of starches

The purchased yam tubers were peeled with a knife, cut into slices and washed in a tub of water. The slices of yam were then precooked in a saucepan containing boiling water over a gas fire. After 5 minutes of pre-cooking, the cooking water was removed and the yam slices were then oven dried at 65 ° C for 5 days and then ground by hand and the starch obtained was sieved through a sieve. 300 µm in diameter.

2.2.3 Preparation of the porridges

In an aluminum saucepan, the proportions of 10, 20, 30 and 40g of yam starch were diluted in 100 ml of water according to the method of [12].

2.2.4 Physico-chemical characterization of starches

2.2.4.1 Dry matter content

Dry matter determination was carried out by drying in an oven at 105 ° C for 24 hours [13].

2.2.4.2 Content of carbohydrates

The carbohydrate content (expressed in% of dry matter) was estimated according to the formula presented below [14].

2.2.4.3 Protein content [15]

The method used is that of KJELDAHL. The sample is wet-mineralized. The acidic solution is alkalised with the sodium hydroxide solution. The ammonia released is distilled off and collected in a determined amount of sulfuric acid from which the extract is drawn by a solution of sodium hydroxide.

2.2.4.4 Fat content

The determination of lipid content is by the standardized Soxhlet method [13] which is a method that uses a reflux extraction in a generally glass fitting.

2.2.4.5 Ash content

The determination of the ash content was carried out by incineration in a muffle furnace at 500 ° C. for 5 hours.

2.2.3.6 Mineral content

The magnesium, potassium, calcium and iron contents are measured by atomic absorption spectrometry, Perkin-Elmer, Model 110 [15].

2.2.4.7 Health characterization of starches

The health characterization of the starch was the preparation of the stock solution, the enumeration of mesophilic aerobic germs (GAM), the enumeration of faecal coliforms, the enumeration of yeasts and molds and the search for salmonella.

2.2.4.8 Physicochemical characterization of the porridge

2.2.4.8.1 Fluidity of the weaning porridge

The consistency of the slurry is measured at the flow rate using the BOSTWICK Consistometer [16].

2.2.4.8.2 Energy density of the weaning porridge

The energy density (ED) is calculated from the content of carbohydrates, lipids and proteins and their energy equivalence according to the caloric coefficients (9 kcal / g lipids, 4 kcal / g carbohydrates and 4 kcal / g proteins) of [17].

3. Results and discussion

3.1 Results

3.1.2 Physico-chemical characteristics of starches

The physico-chemical characteristics (chemical composition and mineral content) of starches are presented in Tables I and II. The results indicate that starch carbohydrate levels are respectively 86.58 ± 0.06 (*pkonan*), 85.92 ± 2.83

(*krenglè*), and 81.18 ± 4.18 (*bètè-bètè*). The lipid contents are equal to 0.19 ± 0.03% for *pkonan* starch, 0.52 ± 0.12% for *krenglé* starch and 0.74 ± 0.06% for starchy starch. The protein contents are 5.3 ± 0.1% and 5.56 ± 0.6% in the starch of *pkonan* and *krenglè.* The Bètè-bètè contains 6.125 ± 0.6%. The dry matter content of yam starches is 16.1 ± 1.14% *(pkonan*); 17.03 ± 0.01% (*krenglè*) and 11.6 ± 0.01% (*Bètè-bètè*). The ash content is in this order 1.21 ± 0.04%; 2.02 ± 0.04% and 1.71 ± 0.02 % those of the starch *pkonan, bètè-bètè and krenglè*. Phosphorus content of yam starch is 21 ± 1.41 mg / 100g MS (*bètè-bètè*), 34 ± 0.02 mg / 100g DM (*krenglè*) and 35 ± 1.12 mg / 100g DM (*pkonan*)). Starchy starch contains respectively potassium (75.9 ± 0.14 mg / 100g DM), calcium (61.5 ± 0.14 mg / 100g DM) and magnesium (10 ± 0.06 mg). / 100g MS) and iron (0.01 ± 0.03 mg / 100g MS) while that of *krenglè* gives at the potassium level (74 ± 0.04 mg / 100g MS), in calcium (76 ± 0.14 mg / 100g MS) to magnesium (13 ± 0.01 mg / 100g MS) and iron (0.03 ± 0.01 mg / 100g MS). As for the starch of pkonan, it gives contents of potassium (79 ± 0.2 mg / 100g MS), in calcium (85 ± 0.21 mg / 100g MS) in magnesium (15 ± 0.01 mg / 100g MS) and iron (0.03 ± 0.00 mg / 100g MS).

Table 1: Nutritional value of the three yams studied (g / 100 MS)

Nutrients (%)	variety		
	Pkonan	***Krenglè***	***Bètè-bètè***
Dry matter	16,1±1,14	17,03±0,01	11,6±0,01
Carbohydrates	86,58±0,06	85,92±2,83	81,18±4,18
Protein	5,3±0,1	5,56±0,6	6,125±0,6
Lipids	0,19±0,03	0,52±0,12	0,74±0,06
Ashes	1,21±0,04	1,71±0,02	2,02±0,04

Table 2: Mineral content of starch ingredients (g / 100 MS)

Minerals (mg)	Variétés		
	Pkonan	***Krenglè***	***Bètè-bètè***
Potassium	79±0,2	74±0,04	75,9±0,14
Calcium	85±0,21	76±0,14	61,5±0,14
Phosphorus	35±2,12	34±0,02	21±1,41
Magnesium	15±0,01	13±0,01	10±0,06
Iron	0,032±0,002	0,03±0,01	0,009±0,03

3.1.3 Sanitary quality of starches

Germs that have been counted in starches are: total flora, faecal coliforms, yeasts and molds, and Escherichia coli (Table III). The results obtained give a total number of flora respecting the standard. There were 104; 103 and 102 germs / g of food respectively in the *pkonan, krenglè* and *bètè-bètè* while the criterion is 105 germs / g of food. As for fecal coliforms, 10 germs were counted in the *pkonan*, 3 in the *krenglè* and 5 in the *beté-bètè* (criterion less than 10 germs). The same is true of yeasts and molds, of which there are 102; 30 and 15 germs in pkonan, krenglè, *beté-bète* and no salmonella was. At the level of Escherichia coli, no germ was counted respectively in *pkonan, krenglè, bétè-bètè* (load 10 germ / g) of the flora.

Table 3: Enumeration of sprouts in yam starch

Bacteria counted	*Pkonan*	*Krenglè*	*Bètè-bètè*	Criteria FAO/OMS)
Total flora	10^4 / g	10^5 / g	10^4 / g	10^5 / g
Fecal coliform	10 / g	3 / g	5 / g	10^2 / g
E. coli	0 / g	0 / g	0 / g	10 / g
Yeasts and molds	10^2 / g	30 / g	15 / g	10^3 / g
Salmonella	Absence	Absence	Absence	Absence

3.1.4 Physicochemical characteristics of the weaning porridge

The characteristics of yam starch slurries are shown in Table IV. The higher the amounts of starch (*pkonan, krenglè* and *bètè-bètè)* (10, 20, 30 and 40 g) in the preparation of the slurry, the higher the viscosity of the slurry, in other words the fluidity decreases to reach the minimum value of 0 mm / 30 seconds, ie a paste whose dry matter is 18.5; 17.9 and 16.5 g / 100 ml in this order *pkonan, krenglè* and *bètè-bètè*. These dry materials and this fluidity are obtained when 40 g of ponchon, *krenglè* and *bétè-bètè starch* are supplied. However, at 10 g of starch of the three varieties, the fluidity is acceptable (100 mm / 30 seconds (*pkonan),* 105 mm / 30 seconds (*krenglè)* and 115 mm / 30 seconds (*Bétè-Bètè*) but the dry matter of the There is a shortage of porridge (4.7, 4.4 and 3.9 g / 100 ml respectively in *pkonan, krenglè* and *bétè-bètè).* The energy density of the yams porridge (*pkonan, krenglè* and *bètè-bètè)* is insufficient for 100 ml of slurry (Table IV).

Table 4: Physico-chemical characteristics of yam starch slurries

	Variétés		
Quantity of starch (g)	***Pkonan***	***Krenglè***	***Bètè-bètè***
10	MS = 4,7 % Fluidity = 100 mm /30 s Protein = 5,3 % DE = 19 kcal / 100 ml	MS = 4,4 % Fluidity = 105 mm /30 s Protein = 5,56 % DE = 18 kcal / 100 ml	MS: 3,9 % Fluidity = 115 mm /30s Protein = 6,125 % DE = 16 kcal / 100 ml
20	MS = 9 % Fluidity = 60 mm / 30 s Protein = 5,3 % DE = 36 kcal / 100 ml	MS = 8,5 % Fluidity = 64 mm / 30 s Protein = 5,56 % DE = 34 kcal / 100 ml	MS = 8 % Fluidity = 70 mm / 30 s Protein = 6,125 % DE = 32 kcal / 100 ml
30	MS = 14 % Fluidity = 4 mm / 30 s Protein = 5,3 % DE = 56 kcal / 100 ml	MS = 13 % Fluidity = 5 mm / 30 s Protein = 5,56 % DE = 52 kcal / 100 ml	MS = 12,5 % Fluidity = 7 mm / 30 s Protein = 6,125 % DE = 50 kcal / 100 ml
40	MS = 18,5 % Fluidity = 0 mm / 30 s Protein 5,3 % DE = 74 kcal / 100 ml	MS = 17,9 % Fluidity = 0 mm / 30 s Protein = 5,56 % DE = 72 kcal / 100 ml	MS = 16,5 % Fluidity = 0 mm / 30 s Protein = 6,125 % DE = 66 kcal / 100 ml

3.2. Discussion

The protein content of yam starch [6.125 ± 0.6 g / 100 g of Bètè-bètè yam; 5.3 ± 0.1 g / 100 g *Kponan* yam and 5.56 ± 0.6 g / 100 *krenglè* yam are comparable to those found in [18]. This author has reported that the protein content of D. alata yams ranges from 6.12 g / 100 g to 7.07 g / 100 g of starch. That of D. cayenensis yams is 5.7 g / 100 g. The slurries made with yam starch have dry matter contents of 16.1 ± 1.14 g / 100 g (*pkonan*); 17.03 ± 0.01 g / 100g (*krenglè*) and 11.6 ± 0.01 g / 100 g (*Bètè-bètè)* and an energy density of 60; 63 and 41 Kcal / 100g of porridge. But this content remains below the recommended value (110 kcal / 100 g of slurry). Several authors have shown that the energy density of traditional porridges is generally low and is around an average of 50-60 Kcal / 100g of porridge [19, 20, 21]. Such slurries, taking into account, on the one hand, the small volume of the stomach of the order of 30 g (ml) / kg of body weight [22] and, on the other hand, the low estimated daily consumption frequency, at 2 times / day, are not able to effectively cover the nutritional needs of infants and young children in addition to breast milk.

Low ash levels indicate low levels of yam starch in minerals. These respective contents of potassium, calcium, phosphorus, magnesium and iron (75.9, 61.5, 21, 10, 0.009 mg / 100 kcal) for the *bètè-bètè, pkonan* (79; 85; 35; 0.032 mg / 100 kcal) and *krenglè* (74; 76; 34; 13; 0.03 mg / 100 kcal) are lower than the respective recommendations (129; 125; 114; 19; 4 mg / 100 kcal). Also, this low mineral content could be explained by the nature of the basic material (Dioscorea alata, Dioscorea rotundata and Dioscorea cayenensis). These results are in agreement with those of [23] who reported that the mineral content of yam starches is very low compared to some products such as vegetables and fungi.

The results of the microbiological analysis indicate that infant meal does not contain any pathogenic germs that may affect the health of the infant. In addition, the counts of these stems give values lower than the criteria of [11], with the absence of Escherichia coli and Salmonella. The access of the infants to a porridge of good bacteriological quality and which can constitute one of the ways of improvement of the nutritional situations. Such a mixture can not cause diarrhea [12]. On the basis of the microbiological standards applicable to infant flours and instant flours, recommended by [11], these infant flours have a satisfactory quality.

Conclusion

This study showed that various complementary foods are consumed by young children and infants in the Upper Sassandra region. The main complementary food is porridge made from cereals, roots and tubers. Local yams made from yams (*pkonan, krenglè* and *bètè-bètè)* are low in protein. They have low nutritional values, often consumed twice a day can not meet the nutritional and energy needs of young children. This infant flour also provides insufficient mineral content to meet the physiological needs of the child. This complementary food is microbiologically acceptable because it does not contain pathogenic germs that can cause infections and diarrhea for children. Prepared as a slurry from yam starch, it has a fluid consistency and is appropriate for the infant because it meets the criteria of WHO and FAO. But the dry matter content of the slurry is insufficient. This porridge is not balanced in nutrients and micronutrients to cover the needs of children alone.

Studies should be carried out to better appreciate the ability of yam *Bètè-Bètè, Kponan* and *Krenglè* to produce better-quality infant flours nutritional and hygienic quality compared to those produced from cereals. However, to use yam starch as a control product against malnutrition, it would necessarily be necessary to supplement them with fruits and local vegetables available, rich in protein, vitamins and minerals. Then, the valorization of yam starch in the infant food will necessarily pass through good public awareness. Finally, the production of accessible and adequate local porridges to meet the nutritional and energy needs of young children should be encouraged.

References

1. Dewey KG, Brown KH. Update on technical issues concerning complementary feeding of young children in developing countries and applications for intervention programs. Food and Nutrition Bulletin, 2003; 24(1):5-28.
2. OMS. Maternel, Infant, and Young Child Nutrition: Draft Comprehensive Implementation Plan. Geneva, 2012. http://apps.who.int/gb/ebwha/pdf_files.
3. FAO, FIDA, OMS, PAM, UNICEF. L'État de la sécurité alimentaire et de la nutrition dans le monde 2017. Renforcer la résilience pour favoriser la paix et la sécurité alimentaire Rome, FAO. 2017; p.16.
4. Azagoh-KR, Enoh J, Niangue B, Cissé L, Oulai S, Andoh J. Connaissances et pratiques des mères d'enfants de 6 à 18 mois relatives à la conduite du sevrage: cas de l'hôpital général de Marcory. Mali médical. Tome, 2013; XXVIII:4.
5. Victora CG, Bahl R, Barros AJ, Franca GV, Horton S, Krasevec J, *et al*. Breastfeeding in the 21s Century: Epidemiology, Mechanisms, and Lifelong Effect. Lancet, 2016; 387(10017):475-490.
6. OMS. Recommandations relatives à l'allaitement maternel exclusif et l'alimentation complémentaire des jeunes enfants dans les pays en développement. OMS: Genève, 2003; 130-131.
7. Brown KH, Lutter CK. Petentiel of processed complementary food in the improvement of early childhood nutrition in, Nutrition Latina America bulletin, 2000; 21.
8. OMS. Analyse de la situation nutritionnelle en Côte d'Ivoire. Rapport juillet. 2014, 2015, 8p.
9. Camara F, Brou K, Assemand EF, Tano K, Gnahe D. Quantification of the energy, Iron Intake and the Promoter and Inhibitors Absorption in Rural and Urban Côte d'Ivoire. European Journal of Scientific Research. 2009; 35(1):130-141.
10. Trèche S. Techniques pour augmenter la densité énergétique des bouillies. In: L'alimentation de complément du jeune enfant. Actes d'un atelier OMS/ORSTOM inter-pays du 20 au 24 novembre 1994, à l'Université Senghor, Alexandrie (Égypte). 1995; p. 126-136.
11. FAO/OMS. Caractéristiques d'une bonne farine infantile. *Bulletin du réseau TPA*, mai. Norme Codex Stan 74-1981 du *codex alimentarius*. Programme mixte FAO/OMS sur les normes alimentaires. (CAC/RCP 21-1979). 1998; 8p.
12. Mouquet C. Les farines infantiles. Bulletin du réseau Technologique et Partenariat en Agro-alimentation (TPA), numéro du 15 Mai 1998, Pp 9-20. programs. Food and Nutrition Bulletin, 1998; 24(1):5-28.
13. AOAC. *Official Methods of Analysis* (Vol. 2, 15th ed). Washington, DC: Association of Official Analytical Chemists, 1990.
14. Soro S, Konan G, Elleingand E, N'guessan D, Koffi E. Formulation d'aliments infantiles à base de farines

d’igname enrichies au soja. Volume 13 N°. 5 December 2013. African Journal of Food, Agriculture. Nutrition. And Development. 2013; 8320 p.
15. BIPEA. Recueil des méthodes d’analyses des communautés européennes. Bureau interprofessionnel d’études analytiques: Gennevilliers. France, 1976; 140p.
16. Vieu MC, Traore TS. Effects of energy density and sweetness of gruels on Burkinabe infant energy intakes in free living condition. Journal of Food Sciences and Nutrition. 2001; 52:213-218.
17. Atwater. The American Journal of Clinical Nutrition. 1986, 1987; 45(5):896-897.
18. Comoé KB. Evolution de la matière sèche chez deux cultivars améliorés d'igname (*Diosocorea* spp) dans deux zones agroécologiques sous l'effet de la fumure minérale. Mémoire DAA. Ecole Supérieure d'Agronomie (ESA). 2002; 44p.
19. Trèche S. Techniques for increasing the energy of gruel. In: M.C. Dop, D. Benbouzid, S. Trèche, B. De Benoist, A. Verster, F. Delpeuch eds. Complementary feeding of young children in Africa and the middle East. Geneva: World Heath Organization, 1999, 101-119.
20. Elenga M, Massamba J, Kobawila SC, Makosso VG, Silou T. Évaluation et amélioration de la qualité nutritionnelle des pâtes et des bouillies de maïs fermenté au Congo. International Journal of Biological and Chemical Sciences. 2009; 3(6):1274-1285.
21. Zannou-Tchoko VJ, Ahui-Bitty LB, Kouame K, Bouaffou KGM, Dally T. Utilisation de la farine de maïs germé source d’alpha-amylases pour augmenter la densité énergétique de bouillies de sevrage à base de manioc et de son dérivé, l’attiéké. Journal of Applied Biosciences. 2011; 37:2477-2484.
22. Sanchez-Grinan MI, Peerson J, Brown KH. Effect of dietary energy density on total ad libitum energy consumption by recovering malnourished children. European journal of clinical nutrition. 1992; 46:197-204.
23. Oboh G, Akindahunsi AA. Biochemical changes in cassava produits (flour and gari) Subjected to saccharomyces cerevisea solid media fermentation. Food Chemistry, 2003; 82:599-602.