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Rheological and nutritional characteristics of infant flours prepared from mixed flours of taro (*Colocasia esculenta (L.) Schott*), soybean and baobab pulp

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Abstract

If, according to the UN, chronic hunger is declining, it still affects 795 million people worldwide. In sub-Saharan Africa, one in four people is undernourished. Malnutrition kills 3.1 million children under the age of five each year. This study aims to contribute to children's food security at complementary feeding age through taro valorization in Benin. Rheological and nutrient qualities of two infant flours formulated (FT^{25}, FT$^{35)}$ with a mixed flour of taro, soybean and baobab pulp were evaluated. These flours were analysed for their rheological, nutritional, microbiological and sensory profiles by standard methods. The result indicates that the rheological characteristic was 250.50, 345.50 and 353 cp respectively for FT^{25}, FT^{35} and commercial infant flour ''Beau bébé'' (FBB). The infant flours FT^{25}, FT^{35} and FBB had respectively 91.07±0.5; 91.65± 0.04 and 93.68 ± 0.007% for dry matter. The protein, fat and carbohydrate content were 14.97±0.01; 5.46±0.14 and68.41±0.46% for FT^{25}, 20.96±0.01; 7.31±1.06 and 60.30±1.73% for FT^{35} and 15.81±0.31; 7.34±0.05and 67.33±0.32% for commercial infant flour FBB. The ash content and energy value were respectively 2.23±0.05% and 382.23±2.53Kcal for FT^{25}; 2.58±0.08% and 390.85±2.67Kcal for FT^{35}; 3.21±0.05% and 399.12±0.25Kcal for commercial infant flour FBB. It then becomes important to promote the product developed in order to valorize taro and to contribute to children's food security in Benin. This goes through an industrial production and commercialization of taro based infant flours fortified with soybean.

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Introduction

Nutritionally adequate complementary foods are of high priority in developing countries. Adequate complementary feeding practices and appropriate quality and quantity of foods are essential components of optimal nutrition health and development for infants and young children from the age of 6 months, breast milk is no longer sufficient to meet infant nutritional needs according to WHO recommendations (WHO, 2003).Optimal nutrition in the first year of life is crucial in laying the foundation for good nutrition, health and development in later life (Mitchodigni *et al.*, 2017). Globally, 159 millions of children under five years are still affected by stunting with more than a third living in Africa (WHO, 2014).Malnutrition among infants in low-income countries is an important public health problem and can be related to the composition and formulation of the complementary foods introduced after the breastfeeding period and inadequate complementary feeding practice (Issaka *et al.*, 2015). Insufficient knowledge on infant feeding, poverty and cultural practices may affect the adequacy of the complementary feeding (Kulwa *et al.*, 2015; Kouton *et al.*, 2017). According to the UN, chronic hunger is declining but it still affects 795 million people worldwide. "Chronic hunger" means lack of sufficient food to lead a healthy and active life. The vast majority of hungry people live in developing countries, where 12.9% of the population is undernourished. In sub-Saharan Africa, one in four people suffer from malnutrition. Malnutrition kills 3.1 million children under the age of five a year. In francophone West African countries, malnutrition remains a pertinent problem and mothers are not well educated on how to provide the correct nutrition for their infant.

Indeed, complementary feeding period is the time when malnutrition starts in many infant and many factors contribute to the vulnerability of children during this period (Victora *et al.*, 2016). The complementary foods are often characterised by low nutritional quality and given to infant in insufficient amounts. When given too early or too frequently, they are likely to displace breast milk (Dolan *et al.*, 2015). It significantly contributes to the high prevalence of malnutrition in children under 5 years of age worldwide (WHO, 2012). Improved complementary feeding and breastfeeding practices with reduced morbidity are essential to achieving the Millennium Development Goals (MDGs) for child survival and prevention of malnutrition (Lutter, 2003). Complementary feeding improvement should be of highest priority for nutrition optimal of infant and young children because of it crucial role in preventing mortality and enhancing children development (Faber *et al.*, 2014).Over 70% of dietary protein in developing countries is supplied by cereals that are relatively poor sources of protein (Mitchodigni *et al.*, 2017). Formulation and development of nutritious complementary foods from local and readily available raw materials has received a lot of attention in many developing countries (Kouton *et al.*, 2017; Mitchodigni *et al.*, 2017).

In Benin, complementary feeding practices are not optimal. Complementary foods introduced by the mothers are mostly simple maize porridge and / or whether or not fermented sorghum porridge obtained from recycled maize dough. Porridge is slightly enriched with protein materials and daily distribution frequency is low (Atègbo, 1993; Kouton *et al.*, 2017). Poor feeding practices and shortfall in food intake are the most important direct factors responsible of malnutrition and illness among children in Benin (Amoussa Hounkpatin, 2011). These practices, which are the use of poor quality complementary foods and inappropriate conduct of complementary feeding practices, partly explain the prevalence of 34% of stunting observed in Benin preschool children (INSAE, 2015).

It is then necessary to propose to mothers, the high energy and minerals dense foods which will cover nutritional and energy needs for infant and young children (Kouassi *et al.*, 2015; Zannou-Tchoco *et al.*, 2011).In order to reach these goals and to promote the forsaken agro-resources, poorly or little used, we chose to use taro tuber as a carbohydrate source to improve the nutritional and organoleptic characteristics of complementary foods. Although, they are ample information on complementary foods from cereals, the potential of roots and tubers crops such as taro (*Colocasia esculenta* L.) to serve in the formulation of infant flours, has not yet explored by researchers in Benin. Le taro est l'un des tubercules délaissés, mal et/ou peu utilisés réservé seulement à la production et à la consommation domestique (FAO, 2009). Originally from malaysia, taro (*Colocasia esculenta* L. SCHOTT) is a monocotyledonous plant belonging to the family of araceae and asian origin. This culture developed towards Polynesia from where it comes to it the name of Taro (Himeda *et al.*, 2012). In Benin, the lack of diversified technologies for processing, especially in the producing or non-producing regions and the lack of valorisation efforts could explain the drop in taro production which went from 2475 tons in 2007 at 700 tons in 2011 (FAO, 2011).

Taro (*Colocasia esculenta* L.) is widely cultivated worldwide mainly for its edible roots rich in calories, dietary fiber (3,6 et 3,8%) and some biologically active phytochemicals such as essential amino acids, polyphenols, ascorbic acid (Himeda *et al.*, 2012). Taro (*Colocasia esculenta* L.) is a food who containing60 to 90% of carbohydrates, 0.4 to 0.7% of lipid and 1 to 4.5% of protein. The level of starch is 66 to 86% (Huang *et al.*, 2007). Taro contains a high levels of minerals, so potassium is principal mineral of tuber of taro with a level of 1% (Contreras-Padilla *et al.*, 2011). Taro flour has particles of very small sizes ranging from 1 to 4 µm which gives it a great digestibility to its starch (Himeda*et al.*, 2012). But, this flour is of limited use for the industry. In west Africa, especially in Benin, taro is almost exclusively consumed in boiled or fried form (Houngbo *et al.*, 2015). In fact, it is a good basis in the preparation of infant complementary foods, which can be enriched with protein-rich foods such as soybean and pulp of baobab who contains high protein, minerals and vitamins (Contreras-Padilla *et al.*, 2011).The objective of this study is to formulate new complementary infant flours, by combining a local product such as Taro flour with soybean flours and baobab pulp and to assess their nutritional, rheological, microbiological and sensory properties.

Materials and methods

The raw material is consisted of tuber such as: Taro (*Colocasia esculenta L.),* grains of soybean (Glycine max; yellow grains) and baobab pulp (*Adansonia digitata*). Raw material was obtained from local market at Ouando also located in southern Benin.

Infant flours preparation

The raw tubers of Taro were washed in tap water to remove dirt and soil peeled with a kitchen knife and sliced into pieces following Sanoussi *et al.* (2013). This method includes a boiling step which is among the most effective treatment that drastically reduced the anti-nutritional load of the tuber. Tuber peeled were cut small pieces about 0.5 cm thick and kept submerged in a water tank. The small pieces have been cooked during 5 minutes at 60°C and then dried in an incubator at 40°C during 72 hours. Then, the dried pieces of taro were crushed by the method of Elenga *et al.* (2012). Soybean seeds are sorted washed roasted and then crushed.

The infant flour has been prepared by mixing, in varied proportions, the taro flour, soybeans flour and ''baobab pulp''. The mixture was placed in polyethylene bag at room temperature to simulate the storage conditions in developing countries.

Infant flours formulation

Two complementary foods were elaborated. For the optimized and fortified formulation (FT25 and FT35), complementary foods (infant flours) were processed by mixing in varied proportions the taro and soybeans flours with baobab pulp as specified by FAO and WHO Commission (2006) recommendations for infant complementary food for older infants and young children (Table 1).Nutritional, microbiological, rheological analysis and sensory profiles of infant flours were assessed following multiple comparison test carried and infant flours in comparison to ''Beau-Bébé'' (FBB) commercial infant flour in Benin.

Physico-chemical and rheological analysis of the infant flours

The physico-chemical compositions and rheological of infant flours were determined using recommended methods (AOAC, 2000). The samples were analysed for Moisture, pH and titratable acidity. The viscosities of infant flours were determined by method of Analyser Rapid RVA modèle-super4.

Nutritional and microbiological analysis of the infant flours

Proximate composition of protein, fat, and ash contents of the samples were determined following AOAC (2000) and the process described by Soro *et al.*(2013). Total available carbohydrate was calculated as 100% minus the sum of moisture, protein, fat and ash contents obtained as described above. Energy Value (EV) was calculated according to equation of Atwater and Benedict (1902). EV = (9 x Fat (%) + 4 x Proteins (%) + 4 x Carbohydrates (%)) according to the method of Zannou-Tchoko *et al.* (2011).

Mineral element (Fe, Ca, Zn and Mg) concentrations were obtained using Atomic Absorption Spectrophotometer. Microbiological analysis was determined using the method described by Sanoussi *et al.* (2013). Micro-organisms research included total aerobics, yeasts and molds, faecal coliforms, *Escherichia coli* bacteria and staphylococcus. All the results were carried out in triplicates.

Sensory profiles assessment

Sensory profiles of porridges of infant flours formulated were assessed following multiple comparison test carried out in comparison. Color, aroma, taste, consistency, overall acceptability and preference were appreciated by 30 mothers of children at complementary feeding period (Amagloh *et al.*, 2013). For evaluate overall acceptability, 5-point hedonic scale with 1 as least acceptable/dislike extremely and 5 as highly acceptable/ like extremely were used. Samples were simultaneously presented to tasters in cup and tap water was provided for rinsing the mouth between samples.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) and the t test of Students, Newman Keuls procedures Statistica 7.1 were used to perform descriptive analysis and compare the means of triplicate measurements of physico-chemical, nutritional, and rheological parameters.

Let's notify that the means were considered to be significantly different when $p < 0.05$. The least significant difference test was used to separate the means when the difference was significant.

Results

Physico-chemical and rheological analysis of the infant flours

The physico-chemical and rheological characteristics for the infant flours (FT25, FT35 and commercial infant flour FBB) were showed in Table 2.

The moisture of infant flours FT25 (8.92%) and FT35 (8.84%) was higher than recommended value (6.31%) by FAO/OMS (2006).

Table 1. Infant flours formulation.

Infant flours	Material (%)		
	Taro flour	Roasted soybean flour	''Baobab'' pulp
FT25	70	25	5
FT35	60	35	5

The viscosities of infant flours FT25 (345.50±0.71cp) and FBB (353±11.31cp) were significantly higher than those of infant flour FT35 (250.50±0.71cp) and the pH of commercial infant flour FBB was significantly higher than that of infant flours formulated. The titratable acidities values range from 0.80 ± 0.05 (FBB) to 1.06 ± 0.14 (FT35) %eq lactic acid and the pH values range from 5.05 ± 0.04 to 6.14 ± 0.01.

Table 2. Physico-chemical and rheological characteristics of infant flours.

Infant flours	Characteristics of infant flours			
	Moisture (%)	pH	Titrable acidity (% eq as lactic acid)	Viscosities (cp)
FT25	8.92±0.57[a]	5.05±0.04[c]	1.02±0.09[a]	345.50±0.71[a]
FT35	8.84±0.67[a]	5.30±0.02[b]	1.06±0.14[a]	250.50±0.71[b]
FBB	6.31±0.01[b]	6.14±0.01[a]	0.80±0.05[a]	353±11.31[a]
Standard infant flour FAO/OMS (2006)	5[c]	-	-	-

-: not specify.

Values in the same row with different superscripts are significantly different (p <0.05).

Nutritional and microbiological analysis of the infant flours

These nutritional characteristics of infant flours, were summarized in Table 3. FT25 (containing taro flour, roasted soybean flour and baobab pulp in ratio 70/25/5) and FT35 (containing taro flour, roasted soybean flour and baobab pulp in ratio 60/35/5) infant flours revealed dry matter, carbohydrates, protein, fat, and ash which were statistically different (P<0.05) to the rates of each nutrient taken independently. FT25 has 91.07% dry matter, the protein ratio 14.98%, 5.46% of fat, 2.23% of ash and energy value was 382.23 kcal/100g. The protein content (14.98%) was conforming to recommended value (15%). Formulation FT35 present 91.65% of dry matter content, 20.96% of protein, 7.31% of fat, 2.58% of ash content and 390.85 kcal/100g for energy value. This formulation has a dry matter (91.07%), lipid content (5.46%) and ash content (2.23%).

Table 3. Nutritional characteristics of infant flours.

Infant flours	Characteristics of infant flours					
	Dry matter (%)	Protein (%)	Fat (%)	Carbohydrates (%)	Ash (%)	Energy value (kcal/ 100 g)
FT25	91.07±0.57 [c]	14.98±0.01 [c]	5.46±0.14[c]	68.41±0.46[a]	2.23±0.05[d]	382.23±2.53[b]
FT35	91.65±0.04c	20.96±0.01[a]	7.31±1.07[b]	60.0±1.73[c]	2.58±0.08[c]	390.85±2.67[ab]
FBB	93.69±0.01[b]	15.81±0.31[b]	7.34 ±0.05[b]	67.33±0.32[b]	3.21±0.05[a]	399.12±0.25[a]
Standard infant flour FAO/OMS (2006)	95[a]	15c	8[a]	68[a]	2,9b	400a

Values in the same row with different superscripts are significantly different (p <0.05).

The dry matter, fat, ash contents and energies values of formulation FT25 and FT35 were lower than recommended values (8% for fat, 2.9% for ash content and 400 kcal/100g for energy value). The dry matter, protein, Fats, ash content and energy value of the FT35 infant flour was higher than FT25 infant flour but still in accordance with the complementary food standard recommended by FAO/ WHO (2006). So the carbohydrates content of FT35 (60.30%) was lower than that of FT25 (68.41%) infant flour. The nutritional characteristics of commercial infant flour FBB was conforms to recommended value of the FAO / WHO (2006) for infant flour using as a complementary food. Only FT25 flour containing 60% taro flour, 35% roasted soybean flour, 5% of baobab pulp allowed to prepare a complementary food having 382.23 kcal energy value. But the energy value of FT25 (382.23 kcal) infant flour was lower than energy value recommended (400 kcal) by FAO / WHO (2006). This is energy value don't could cover the infant energy requirements (400 kcal).

Mineral contents of the infant flour FT25 were lower than recommended value by FAO and WHO (2006) (Table 4) for complementary infant flours. But the magnesium content (83.6541mg) of FT25 was higher than the recommended value (48.7mg). The mean counts of organisms were presented in Table 4 in the formulated complementary foods with significantly (p < 0.05). FT25 infant flour had significantly higher (p < 0.05) E. coli count, yeast and molds, faecal coliforms and staphylococcal than formulation FT35

(Table 5). But the formulation FT25 has a lower mean count of total aerobics. According to Codex Stan 74-1981 of *Codex alimentarius* recommendations (1981) related to the microbiological qualities of infant flours intended for cooking, the total number of total aerobes, faecal coliforms, E. coli, yeasts and moulds and Staphylococcal should be less than 10^5,10^2,10, 10^3 and 10 cfu/g respectively.

Table 4. Mineral content of infant flour FT25.

Infant flour	Iron	Calcium	Zinc	Magnesium
FT25	6.6139 ± 0.56^b	207.2637 ± 1.16^b	2.0890 ± 0.14 ^{b}	83.6541 ± 0.95^a
Suitable composition (mg/100g) FAO/OMS (2006)	8.5 ± 0.66^a	341.2 ^{a}± 1.06a	3.7 ± 0.22 ^{a}	48.7 ± 1.30^b

Values in the same row with different superscripts are significantly different ($p < 0.05$).

Sensory profiles assessment

The results of the sensory profiles evaluation by panel members for various attributes (acceptability, aroma, consistency, color and taste) of the porridges made with the different infant flours (Table 6) showed that all the developed taro tuber base flour porridges were more appreciated than the commercial infant flour ''Beau bébé'' used in Benin.

The formulation FT35 was more appreciated than FT25. However, FT25 infant flour has obtained higher levels (90%) of preference by mothers.

Table 5. Mean count of organisms (cfu/g) in infant flours FT25.

Infant flours	Total aerobic	Faecal coliforms	Escherichia coli	Yeast and molds	Staphylococcal
FT25	2.51 10^3 ± 0.21^b	50 ± 0.00^a	5± 0.00 ^{a}	10 ± 0.14 ^{a}	5 ± 0.25^a
FT35	10^4 ± 0.30 ^{a}	25 ± 0.00 ^{b}	2 ± 0.00^b	5 ± 0.16 ^{b}	4 ± 0.12^b
Standards	<10^5	<100	<10	<10^3	<10

Values in the same row with different superscripts are significantly different ($p < 0.05$).

Discussion

Physicochemical characteristics of the produced flours

Lack of nutrient-dense complementary foods is one of the common factors accounting for decline in satisfactory growth pattern in children (Anigo *et al.*, 2010). Kouton *et al.* (2017) reported that appropriate number of feeding by children depends on the energy density of the local foods and the usual amount consumed at each feedings. The physico-chemical characteristics of infant flours have revealed that have revealed that formulation FT25 who contains taro flour (70%), roasted soybeans flour (25%) and "baobab pulp" (5%) has 91.07% of dry matter and moisture of 8.92%. Moisture of FT35 was 8.84%. These moistures of infant flours were higher than the recommended value (5%) by FAO/WHO (2006). The higher moisture of infant flours was due to insufficient dried conditions (temperature and times) of pieces of taro tubers. But the higher moisture can have developed the undesirable modifications of nutritional and organoleptic characteristics of infant flour during the storage. Dry matter, fat, ash and energy value levels are lower than 95% for dry matter, value recommended by the FAO/WHO for standard complementary infant flour. Our result was higher than Sanoussi *et al.* (2013) who indicated 5.20% as moisture of infant flours based on sweet potatoes (75%) and roasted soybeans flours (25%). The moisture of formulation FT25 of the formulated complementary foods was higher with 4.5% founded by Gnahé *et al.* (2009) in complementary food based taro (74%) and pigeon pea flours.

Rheological characteristics of the flours produced

The viscosities of infant flours FT25 (345.50±0.71cp) was significantly higher than those of infant flour FT35 (250.50±0.71cp).The result showed that higher incorporation of roasted soybeans flour in formulation infant flour increase the viscosities of complementary infant flours. These results were close to those found by Soro *et al.* (2013), which showed that, with the exception of 10% of soybean flour fortified, the viscosity of infant flour based yam and soybean flours decrease with the rate of the incorporation of soybeans. Kouton *et al.* (2017) revealed that the viscosities (mm/30sec) of infant flours decreased from traditional to fortified formulations based on soybeans flour (from 0; 26 to 31%).

Table 6. Sensory profiles of infant flours.

Infant flours	Percent (% ± ET) of sensory characteristics					
	Colour	Aroma	Taste	Consistency	Acceptability	Preference
FT25	83.3± 0.4[a]	53.3± 0.51[a]	96.66± 0.57[a]	86.66± 0.25[b]	36.67± 0.10[b]	90± 0.54[a]
FT35	83.3± 0.38[a]	54.3± 0.25[a]	93.33± 0.23[b]	96.66± 0.32[a]	46.67± 0.35[a]	85± 0.52[b]
FBB	76.66± 0.3[b]	43.33± 0.1[b]	96.66± 0.51[a]	16.66± 0.4[c]	36.37± 0.11[b]	90± 0.4[a]

Values in the same row with different superscripts are significantly different ($p < 0.05$).

Nutritional value of the produced flours

The nutritional value of infant flours have revealed that formulation FT25 who contains taro flour (70%), roasted soybeans flour (25%) and "baobab pulp" (5%) has 68.41% of carbohydrate, 14.98% of protein ratio, 5.46% of fat, 2.23% of ash and energy value was 382.23 kcal/100g. In the two formulations FT25 and FT35, only FT25 was the best formulation of infant flour that the formulation respected the recommended value (15% and 68%) respectively of protein and carbohydrate values by the FAO/WHO. However, these dry matter, fat, ash and energy value levels are lower than 95% for dry matter, 8% for fat, 2.9% for ash and 400 kcal for recommended energy value by the FAO/WHO for standard complementary infant flour. *FT25 was the best formulation of infant flour that the formulation respected the recommended value (15% and 68%) respectively of protein and carbohydrate values by the FAO/WHO.*

It would be necessary to incorporate in this formulation of infant flour other lipid raw material such as palm oil, roasted groundnut, pigeon pea flour, fruits and legumes to improve the fat and ash contents. The carbohydrate level (68.41%) of formulation FT25 was in lined with Soro *et al.* (2013) in Côte d'Ivoire who founded 68.90% of carbohydrate in infant flour based of fermented yam flour incorporated with 30% of soybean flour. Fat content (5.46%), protein level (14.98%) and ash (2.23%) of infant flour FT25 were comparable respectively to 5.42%, 14% and 2.28% with those reported by Kayodé *et al.* (2012) in Benin, Zannou-Tchoco *et al.* (2011) in Côte d'Ivoire and Anigo *et al.* (2010) in Nigeria. Energy value (382.23 kcal) of FT25 was lower than recommended energy value (400 kcal) by FAO/WHO (2006). It was necessary to incorporate in this infant flour a malted cereals flours to improve the dry matter and energy value concomitantly. The result of Kouton *et al.* (2017) in Benin and Kouassi *et al.* (2015) in Côte d'Ivoire also showed that the use of malted maize and sorghum flours improved the dry matter and energy value of composite infant flour. Traoré *et al.* (2004) in Burkina-Faso reported that in order to enhance energy value of infant flours in order to meet nutritional requirements of young children, malted cereal flour should be added to infant flour in rate depending on raw material. These observations were in lined with those found by Kayodé *et al.* (2006) in Benin who reported that the malted maize flour is a good base in the preparation of infant gruel with good energy value. Formulation FT35 present 91,65% of dry matter content, 20.96% of protein, 7.31% of fat, 2.58% of ash content and 390.85 kcal/100g for energy value. The dry matter, protein, fats, ash content and energy value of the FT35 infant flour was higher than FT25 infant flour. The result revealed that the incorporation of 35% of roasted soybean flour in infant flour improved the nutritional characteristics such as dry matter, protein, fat, ash content, energy value and viscosity of the infant flour. These results are in lined with Oniludé (2009) who showed that the protein content of the combined cereals and legumes combined was better than that produced from cereals alone. Iron, calcium and zinc levels of formulation FT25 were lower than recommended values by FAO/WHO (2006). But the magnesium content of FT25 (83.65) was higher than recommended value (48.7). Also, this low mineral content could be explained by infant flour processes and used raw materials (*Taro tuber, soybean and baobab pulp*). They might be fortified with mineral sources, in this case legumes and fruits, to cover the nutritional requirements of mineral contents in infant and young children. The calcium and magnesium contents (207.26 mg and 83.65 mg) of infant flour FT25 was higher than 13 mg and 70 mg respectively found by Gnahé *et al.* (2009) in infant flour based on Taro flour, pigeon pea, malted maize flour and sucrose. The iron content (6.61 mg) of FT25 was higher than 5.59 mg obtained by Soro *et al.* (2013) in complementary infant flour based on fermented yam and soybean flours. This is value was lower than 10 mg obtained by Gnahé *et al.* (2009) in infant flour based on Taro flour, pigeon pea, malted maize flour and sucrose. Soro *et al.* (2013) were founded 2.83 mg of zinc in complementary infant flour based on fermented yam and soybean flours and 2.08 mg have been found in formulation FT25. Gnahé *et al.* (2009) have founded 10 mg of zinc content in in infant flour based on Taro flour, pigeon pea, malted maize flour and sucrose. The microbiological analysis obtained, showed that all the infants flours produced were conformed to microbiological standard Codex Stan 74-1981 of *Codex alimentarius* recommendations (1981). It was observed that the infant flours have been produced to adequate conditions.The sensory profiles evaluation by panel members for various attributes (acceptability, aroma, consistency, color and taste) of the porridges made with the different flours showed that all the developed taro tuber base flour porridges were more appreciated than the commercial infant flour “Beau bébé” used in Benin. The infant flour FT25 has been more preference that infant flour FT35. This preference is explained by nutritional value of infant flour FT25. As reported by Gnahé *et al.* (2009), Amagloh (2013) and Sanoussi *et al.* (2013) the results indicated that root and tuber can serve as basis for nutritious infant flours. In terms of taste, tasters reported that porridge of taro tuber flour were sweeter that the commercial infant flour “Beau bébé”. The formulation FT25 and FT35 presents the high organoleptic characteristics and could be using as complementary food for cover the requirement nutritional needs of children in the age of complementary feeding.

Conclusion

This study showed that taro flour is a local available raw material, which present a good nutritional quality and not toxic for human consumption. When enriched with soybean flour in specific ratios. it can be used as complementary infant flour and a potential complementary food of high nutritional, microbiological and organoleptic qualities. Only the infant flours FT25 have presented good nutritional characteristics conforms to FAO/WHO recommendations. But, fat and mineral contents are lower than recommended value by the FAO/WHO for standard complementary infant flour. It would be necessary to incorporate in this formulation other lipid raw material, fruits and legumes to improve the fat and mineral contents of this formulation, while increasing the potential to overcome protein-energy malnutrition and mineral deficiencies within infants and young children.

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References

Amagloh FK, Hardacre AN, Mutukumira JL, Weber L, Brough, Coad J. 2013. Carbohydrate composition, viscosity, solubility, and sensory acceptance of sweet potato- and maize-based complementary foods. Food & Nutrition Research **57(1),** 18717.
https://doi.org/10.3402/fnr.v57i0.18717

Hounkpatin AW. 2011. Evaluation du potentiel de couverture des besoins en vitamines A des jeunes enfants à partir des sauces accompagnant les aliments de base consommés au Bénin. Thèse de Doctorat de l’Université Montpellier **2,** p 1-109.

https://doi.org/10.5897/AJFS

Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS. 2010. Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. African Journal of Food Science **4(3),** 65-72. https://doi.org/10.5897/AJFS

AOAC. 2000. Official Method of Analysis of the Association of Analytical Chemists International, 16th edn. Washington, DC.

Ategbo EA. 1993. Food and nutrition insecurity in northern Benin: impact on growth performance of children and on year to year nutritional status of adults. PhD Thesis Wageningen University, Netherlands. p 1-150.

Contreras-Padilla M, Pérez-Torrero E, Hernandez-Urbiola MI, Hernandez Quevedo G, Real A, Rivera-Munoz EM, Rodrıguez-Garcıa ME. 2011. Evaluation of oxalates and calcium in nopal pads (Opuntia ficusindica var. redonda) at different maturity stages. Journal of Food Composition and Analysis **24,** 38-43. https://doi.org/10.1016/j.jfca.2010.03.028

Dolan CM, Mwangome KT. 2015. Extent of stunting and wasting in the same children. Panel in global nutrition report 2015: Actions and accountability to advance nutrition and sustainable development. International Food Policy Research Institute: 102-108.

Elenga M. 2012. Amélioration de la qualité nutritionnelle et de la densité énergétique des bouilles de maïs fermenté et de la farine d"igname utilisée comme aliment de complément du nourrisson. Thèse de Doctorat de l"Université de Marien Ngouabi, p 104.

Faber M, Laubscher R, Berti C. 2016. Poor dietary diversity and low nutrient density of the complementary diet for 6-to 24-month-old children in urban and rural K wa Z ulu-N atal, S outh A frica. Maternal & child nutrition **12(3),** 528-545. https://doi.org/10.1111/mcn.12146

FAO/OMS. 2006. Programme mixte FAO/OMS sur les normes alimentaires. Rapport des vingt-septièmes sessions du comité du codex sur la nutrition et les aliments diététiques ou de régime. Alinom 06/29/26, 105.

FAO/OMS. 2009. Programme mixte FAO/OMS sur les normes alimentaires, Commission du Codex Alimentarus, 32ème session Rome (Italie), Rapport de la 30ème session du comité du codex sur la nutrition et les aliments diététiques ou de régime, p 223.

FAO. 2011. Profil Nutritionnel du Bénin. Division de la nutrition et de la protection des consommateurs, FAO. (Consulté le 08/06/2011). ftp://ftp.fao.org/ag/agn/nutrition/ncp/ben.pdf

Gnahé DA, Kouassi AAK, Gbogouri GA, Brou K, Gnahé D. 2009. Rheological and nutritional characteristic of weaning mush prepared from mixed flours Taro (Colocasia esculenta L Schott), Pigeon Pea (Cajanus cajan) and malted maize (Zea mays). Pakistan Journal of Nutrition **8(7),** 1032-1035.

Himeda M, Njintang YN, Gaiani C, Nguimbou RM, Facho B, Scher J, Mbofung CMF. 2012. Physico-chemical and thermal properties of sosso-taro (Colocasia esculentasp) powders as affected by state of maturity and drying method. Journal of Food Science and Technology. https://doi.org/10.1007/s13197-012-0697-9

Houngbo N, Abiola A, Adandonon A. 2015. Contraintes liées au développement de la culculture du taro (Colocasia esculenta) au sud- Bénin, International Journal of Neglected and Underutilized Species 1: Original Paper. **1-9**

Huang CC, Chiang PY, Chen Y Y, Wang CCR. 2007. Chemical compositions and enzyme activity

changes occurring in yam (Dioscorea alata L.) tubers during growth. Lebensmittel Wissenschaft & Technologie **40,** 1498–1506.
https://doi.org/10.1016/j.lwt.2006.12.006

INSAE. 2015. Enquête par grappes à indicateurs multiples (MICS): rapport de résultats clés-Bénin. p 4-15.

Issaka AI, Agho KE, Page AN, Burns PL, Stevens GJ, Dibley MJ. 2015. Determinants of suboptimal complementary feeding practices among children aged 6-23 months in seven francophone West African countries. Maternal and Child Nutrition. **11,** 31-52.
https://doi.org/10.1111/mcn.12193

Kayodé APP, Hounhouigan DJ, Nout MJR, Niehof A. 2006. Household production of sorghum beer in Benin: technological and socio-economic aspects. International Journal of Consumer Studies **31(3),** 258-264.
https://doi.org/10.1111/j.1470-6431.2006.00546.x

Kayodé APP, Akogou FUG, Amoussa Hounkpatin W, Hounhouigan DJ. 2012. Effets des procédés de transformation sur la valeur nutritionnelle des formulations de bouillies de complément à base de sorgho. International Journal of Biological and Chemical Sciences **6(5),** 2192-2201.
http://dx.doi.org/10.4314/ijbcs.v6i5.25

Kouton SE, Amoussa Hounkpatin W, Ballogou VY, Lokonon JH, Soumanou MM. 2017.Caractérisation de l'alimentation des jeunes enfants âgés de 6 à 36 mois en milieu rural et urbain du Sud –Bénin. Journal of Applied Biosciences **110,** 10831-10840.
http://dx.doi.org/10.4314/jab.v110i1.13

Kulwa KBM, Mamiro PS, Kimanya ME, Mziray R, Kolsteren PW. 2015. Feeding practices and nutrient content of complementary meals in rural central Tanzania: implications for dietary adequacy and nutritional status. BMC Pediatrics **15(1),** 171.
https://doi.org/10.1186/s12887-015-0489-2

Kouassi AKA, Agbo EA, Dago AG, Gbogouri AG. BrouD K, Dago G. 2015. Comparaison des caractéristiques nutritionnelles et rhéologiques des bouillies infantiles préparées par les techniques de germination et de fermentation. International Journal of Biological and Chemical Sciences **9(2),** 944-953.
http://dx.doi.org/10.4314/ijbcs.v9i2.31

Lutter CK. 2003. Macrolevel approaches to improve the availability of complementary foods. Food and nutrition bulletin, **24(1),** 83-103.
https://doi.org/10.1177/156482650302400105

Mitchodigni IM, Amoussa Hounkpatin W, Ntandou-Bouzitou G, Termote C, Kennedy G, Hounhouigan DJ. 2017. Complementary Feeding Practices of Children Aged 6-23 Months in Rural Area, Southern-Benin: Challenges and Opportunities. International Journal of tropical disease & Health **24(2),** 1-12.
https://doi.org/10.9734/IJTDH/2017/33877

Sanoussi AA, Dansi I, Bokossa-Yaou M, Dansi M, Egounlety LO, Sanni A. 2013. Formulation and biochemical characterization of sweet potato (*Ipomoea batatas*) based infant flours fortified with soybean and sorghum flours. International .Journal of Current Microbiology and Applied Sciences **2(7),** 22-34.
https://doi.org/10.13140/2.1.2664.5121

Traoré C, Mouqu CC, Icard-Vreniere T, Traoré A, Trèche S. 2004. Change in nutrient composition, phytate and cyanide content and -amylase activity during cereal malting in small production unit in Ouagadougou (Burkina Faso). Food.Chemistry **88,** 105-114.

Victora CG, Bahl R, Barros AJ, Franca GV, Horton S, Krasevec J, Murch S, Sankar MJ, Walker N, Rollins NC. 2016. Breastfeeding in the 21s Century: Epidemiology, Mechanisms, and

Lifelong Effect. Lancet **387 (10017),** 475-490. https://doi.org/10.1016/S0140-6736(15)01024-7

WHO. 2003. Alimentation complémentaire des jeunes enfants dans les pays en development. OMS, Genève, 130131.

WHO. 2012. Maternel infant and young child nutrition: Draft comprehensive implementation plan. Geneva. http://apps.who.int/gb/ebwha/pdf_files.

WHO. Childhood stunting: Challenges and opportunities; Report of Colloquium. Geneva. WHO, 2014.

Zannou-Tchoko VJ, Ahui-bitty LB, Kouame K. Bouaffou KGM, Dally T. 2011. Utilisation de la farine de maïs germe source d‟alpha amylases pour augmenter la densité énergétique de bouillies de sevrage à base de manioc et son dérivé, l‟attiéké. Journal of Applied Biosciences **37,** 2477–2484.