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Effect of the consumption of fermented sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the nutritional status of children aged 6 to 59 months in northern Benin

By:

AGOSSADOU Julienne Olawolé

Supervisors

Prof. Dr. Ir. D. Joseph HOUNHOUIGAN
Full Professor in Biochemistry and Food Technology

Dr. Ir. Flora CHADARE
Senior lecturer in Nutrition and Food sciences

Composition of the jury

Presidente: Dr. Anita LiNNEMANN

Rapporteur: Dr. Ir. Flora Josiane CHADARE

1st Examiner : Dr. Ir. Fernande HONFO

2nd Examiner : Dr. Ir. Waliou AMOUSSA HOUNKPATIN

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Spécialité: Nutrition Humaine et Sécurité Alimentaire

Effet de la consommation de la bouillie fermentée de sorgho fortifiée avec la poudre de feuille de moringa et la pulpe de fruit de baobab sur l'état nutritionnel des enfants âgés de 6 à 59 mois au Nord du

Par :

AGOSSADOU Julienne Olawolé

Superviseurs

Prof. Dr. Ir. D. Joseph HOUNHOUIGAN
Professeur Titulaire de Biochimie et Technologie Alimentaire

Dr. Ir. Flora Josiane CHADARE
Maître Assistant de Nutrition – Sciences des Aliments

Composition du jury

Présidente : Dr. Ir. Anita LINNEMANN

Rapporteur : Dr. Ir. Flora Josiane CHADARE

1er Examinateur : Dr. Ir. Fernande HONFO

2e Examinateur : Dr. Ir. Waliou AMOUSSA HOUNKPATIN

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CERTIFICATION

We certify that this research entitled "Effect of the consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the nutritional status of children aged 6 to 59 months in northern Benin" was carried out, by AGOSSADOU Julienne Olawolé, Student in the Faculty of Agronomic Sciences, University of Abomey-Calavi (FSA/ UAC), as partial fulfilment for the degree of Master in Agronomic Sciences, Specialty Human Nutrition and Food Security.

Supervisor

Prof. Joseph D. HOUNHOUIGAN

Full Professor in Biochemistry and Food Technology

Co-Supervisor

Dr. Ir. Flora Josiane CHADARE

Senior Lecturer in Nutrition and Food Sciences

DEDICATION

- I would like to thank the Almighty God for seeing me throughout the course of my studies.
- This thesis is lovingly dedicated to my parents Honorine SOUDE, Martine Alikpa, Aristide SOUDE, Renaud AGOSSADOU and Michel AGOSSADOU who have been my constant source of inspiration. These people have made indemonstrable contribution towards my education. Without their love and support I would not have made it that far. God bless you!

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SIGLES

AGVSA	**:**	Analyse Globale de la Vulnérabilité et de la Sécurité Alimentaire
BFP	**:**	Baobab Fruit Pulp
DSME	**:**	Direction de la Santé de la Mère et de l'Enfant
DW	**:**	Dry Weight
FAO	**:**	Food and Agriculture Organization
G	**:**	Gramme
INSAE	**:**	Institut National de la Statistique et de l'Analyse Economique
KAP	**:**	Knowledge Attitude and Practices
Kg	**:**	Kilogramme
MLP	**:**	Moringa Leaf Powder
PFB	**:**	Pulpe de Fruit de Baobab
PFM	**:**	Poudre de Feuille de Moringa
UNICEF	**:**	United Nation International Children's Emergency Fund
WHO	**:**	World Health Organization

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ABSTRACT

Malnutrition in all its forms remains one of the most serious and neglected health problems. Benin is facing many challenges; the most important ones are to ensure food production and food and nutrition security for its 10 million people. The present study aimed at (i) assessing the determinants of the consumption of foods containing the moringa leaf powder and baobab fruit pulp by children in Benin and (ii) testing the effect of the consumption of sorghum porridge fortified with moringa leaf powder (MLP) and baobab fruit pulp (BFP) on the nutritional status of children aged 6 to 59 months in northern Benin. Indeed, a focus group discussion was carried out among mothers to assess the determinants of the consumption of food containing moringa leaf powder and baobab fruit pulp such as economic and physical determinants whereas knowledge, attitudes and practices survey was conducted to get information related to mother's knowledge, practices and perceptions about MLP and BFP in the three biogeographic zones of Benin. Then a nutritional intervention was performed in the northern Benin among children aged 6 to 59 months with fruste and moderate acute malnutrition. The case group consumed daily 400g of sorghum porridge fortified with 10g of MLP and 5g of BFP in the nutritional rehabilitation hearth for two weeks whereas the control group consumed common foods from the study area. Anthropometric measurements such as weight, height as well as age were taken. Results from the study showed that MLP and BFP were more available, accessible and more consumed in the Sudanian zone than in the others. In addition, mothers have high level of knowledge in terms of nutritional and medicinal importance about the two resources. As for the intervention, the daily consumption of the food formula by children for two weeks improved significantly the children weight at the end of the trial but did not improve significantly their z-score. The average weight gain and recovery rate were respectively 9.85 g/kg/day and 62.50%. Therefore it can be concluded that the sorghum porridge fortified with MLP and BFP may contribute to fight against children malnutrition in Benin.

Keywords: Malnutrition, determinants of food consumption, biogeographic zones, food formula, nutritional rehabilitation hearth

RESUME

La malnutrition sous toutes ses formes reste l'un des problèmes de santé les plus sérieux et négligés. Le Bénin est confronté à de nombreux défis; les plus importants sont d'assurer la production et la sécurité alimentaire et nutritionnelle pour ses 10 millions d'habitants. Cette étude a pour objectifs (i) d'évaluer les déterminants de la consommation des aliments contenant la poudre de feuille de moringa et la pulpe de fruit de baobab et (ii) de tester l'effet de la consommation de la bouillie de sorgho fortifiée avec la poudre de feuille de moringa (PFM) et la pulpe de fruit de baobab (PFB) sur l'état nutritionnel des enfants. Un groupe de discussion dirigée a été effectuée parmi les mères d'enfants pour évaluer les déterminants de la consommation des aliments contenant la poudre de feuille de moringa et la pulpe de fruit de baobab tels que les déterminants physiques et économiques pendant que l'enquête connaissance, attitudes et pratiques (KAP) a été conduite pour accéder aux informations sur les connaissances, pratiques et perceptions des mères concernant la poudre de feuille de moringa et la pulpe de fruit de baobab dans les trois zones biogéographiques du Bénin. Une intervention nutritionnelle a été effectuée au nord du Bénin chez les enfants âgés de 6 à 59 mois souffrant de la malnutrition aiguë modérée et fruste. Le groupe d'intervention a consommé quotidiennement 400g de bouillie fermentée de sorgho enrichie avec 10g de PFM et 5g de PFB dans un foyer de récupération nutritionnelle pendant deux semaines tandis que le groupe témoin a consommé des aliments habituellement consommés dans la zone d'étude. Les mesures anthropométriques telles que le poids, la taille ainsi que l'âge ont été prises. Les résultats de l'étude ont montré que la PFM et la PFB sont plus disponibles, accessibles et plus consommés dans la zone soudanienne que dans les autres zones. En outre, les mères ont un niveau élevé de connaissances en termes d'importance nutritionnelle et médicinale sur les deux ressources alimentaires. En ce qui concerne l'intervention, la consommation quotidienne de la formule d'aliment par les enfants pendant deux semaines a amélioré significativement le poids des enfants à la fin de l'essai, mais n'a pas amélioré de façon significative leur z-score. Le gain de poids moyen et le taux de récupération nutritionnelle étaient respectivement de 9,85 g/kg/jour et de 62,50%. On peut donc conclure que la bouillie fermentée de sorgho fortifiée avec la PFM et la PFB pourrait contribuer à lutter contre la malnutrition infantile au Bénin.

Mots-clés: Malnutrition, déterminants de la consommation d'aliment, zones biogéographiques, formule alimentaire, foyer de récupération nutritionnelle

INTRODUCTION

I. INTRODUCTION

1.1. Context and justification

Malnutrition in all its forms remains one of the most serious and neglected health problems. Indeed, millions of women and children under five years die from malnutrition every year in Low- and Middle-Income Countries (IFPRI, 2014). According to FAO (2014), around one in four people remain undernourished in sub-Saharan Africa. In Benin, food insecurity, as determined by availability, accessibility, utilization of food and the stability of these three parameters, is high in households with low income (AGVSA, 2014). As reported by Shi et al (2009), inappropriate complementary feeding practices, too early introduction of complementary foods, restriction in food selection and insufficient amounts of complementary foods, have been identified as one of the major causes of malnutrition in young children in the developing world. However, food fortification can be used to correct or prevent widespread nutrient intake shortfalls and associated deficiencies, to balance the total nutrient profile of a diet, to restore nutrients loss in processing, or to appeal to consumers looking to supplement their diet (Dwyer et al., 2015). According to Dary and Hainsworth, (2008), food fortification is the practice of deliberately increasing the content of essential micronutrients in a food to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health. As reported by Mayer et al., (2008), traditional public health interventions, like supplementation and industrial fortification, have notably reduced micronutrient malnutrition induced morbidity and mortality worldwide. Indeed in the interventions using classical food fortification or supplement, children generally have speedy recovery probably because of bioavailability of nutrients. Note that the classical fortification in this case is the fortification in which micronutrients or vitamins are added to the staple food during the processing or just before the consumption of the food to improve it nutritional quality. According to Macharia-Mutie et al., (2012), the consumption of maize porridge fortified with low-dose highly bioavailable iron multi-micronutrient powder reduce the prevalence of iron deficiency anemia in preschool children but the fortification of this same maize porridge with amaranth grain did not improve the iron status despite a large increase in iron intake, likely due to high ratio of phytic acid/ iron in the meal.

Nevertheless, attainment of the Millennium Development Goals is not on track, mainly because classical interventions require infrastructure, purchasing power, or access to markets and healthcare systems for their success, often not available to people living in remote rural

areas (Mayer et al., 2008). This may be explained by the fact that the determinants of consumption of the intervention food such as availability, accessibility of the food, perception about this food are not taken into account in the study area and therefore the durability of the intervention is a challenge. Moreover, in the interventions using classical food fortification or supplement, the rate of acceptability of the supplement by the target group is low in some studies. Indeed, Beinner et al., (2010) shows that when rice fortified with micronized ferric pyrophosphate was consumed by one group of children and rice with iron drops by another group for five months, hemoglobin and serum ferritin concentrations increased in both groups, but more so in the group who consumes rice fortified with micronized ferric pyrophosphate. As limits mentioned by the authors of this study, parents forgot to give the iron drops thrice weekly or child refused to consume the drops because of taste, child had diarrhea or constipation or child vomited when consuming the iron drops. In addition, after the consumption of foods fortified with some micronutrient supplements named sprinkles powder, crushable nutritabs tablets, or energy-dense, fat-based nutributter, the first three supplements had positive effects on motor milestone acquisition by twelve months compared with no intervention, but only fat-based nutributter affected growth (Adu-Afarwuah et al., 2007). The limit of this study was that mothers forgot the supplement and some children refused the supplement. This may be explained by the fact that children perceived these supplements as medications. How best can be assessed the key determinants of the consumption of intervention food in order to favor the durability of the intervention? Which type of fortification can better solve the issue of acceptability of the intervention food?

Food to food fortification formula using local resources, taking into account not only nutritional quality, organoleptic quality and bioavailability of nutrients but also some key determinants of consumption of the food, may be a potential solution to alleviate malnutrition as it may be easily reproduced by people and particularly those living in remote rural areas. Indeed, there are several local food resources that are neglected and underutilized. Among these foods, baobab have been selected among the ten top species that would merit more attention for food security in Africa (FAO, 2014). The World Health Organization has promoted the moringa tree as an alternative to imported food supplies to treat malnutrition (Salem et al., 2013). In this perspective, a project, ‘’BARINGA”, entitled ‘’*Food to food fortification with moringa leaf powder and baobab fruit pulp as a pathway to improve food and nutrition security among women and children in Benin, West Africa*’’ was funded by Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) through

Graduate Research Grant ID: Grant No. RU 2015 GRG-125. Indeed, analyses of minerals and vitamins showed that *Moringa oleifera* leaf powder is rich in calcium 1443.90 ± 11.03 mg/100 g, magnesium 176.72 ± 0.73 mg/100 g, iron 53.75 ± 5.07 mg/100 g, zinc 17.58 ± 0.89 mg/100 g and β-carotene 624.40 ± 0.41 µg/100 g (Kayalto et al., 2013). In addition, Abioye and Aka, (2015) highlighted that moringa leaves contain more vitamin A than carrots, more calcium than milk, more iron than spinach, more vitamin C than oranges, more potassium than bananas, and the protein quality of moringa leaves is comparable to that of milk and eggs. Chemical analysis of baobab parts revealed abundant amounts of proteins, amino acids, iron, vitamins C, A, E and F in leaves, seeds and fruit pulp (Codjia et al., 2001; Sidibe and Williams, 2002). Moreover, Chadare et al., (2009) reported that baobab fruit pulp contains up to 360 mg/100g dw Vitamin C, up to 3272 mg/100g dw Potassium, up to 702 mg/100 g dw Calcium, up to 10.4 mg/100g dw iron and exhibit 30 times more antioxidant activity than kiwi. In this study, moringa leaf powder and baobab fruit pulp have been used as a fortificant in the sorghum porridge. Indeed, sorghum is an important basic food cereal, especially in parts of Africa and Asia, where it is widely grown due to its drought resistance (Eggum et al., 1983). In the north of Benin, sorghum occupies 40% of the area planted with cereals just behind maize, which accounts for about 44% and most of this production is locally consumed (Missihoun, 2012). However, the protein quality of sorghum grain is poor because of the low content of essential amino acids such as lysine, tryptophan and threonine (Anglani, 1998). Thus this cereal deserves more attention, from a fortification point of view, than has been accorded to it to date. The present study focus on the effect of the consumption of a scientifically designed porridge fortified with moringa leaf powder and baobab fruit pulp on the nutritional status of children in the biogeographic zone of Benin where the moringa leaf powder and baobab fruit pulp are more available, accessible and more consumed.

1.2. Objectives

The overall objective was to improve the nutritional status of children through adequate use of moringa leaf powder and baobab fruit pulp fortified foods. Specifically, the study aimed at:

- assessing the determinants of the consumption of foods containing moringa leaf powder and baobab fruit pulp by children in Benin
- testing the effect of the consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the weight change and prevalence of wasting of children aged 6 to 59 months in northern Benin.

LITERATURE REVIEW

2. LITTERATURE REVIEW

2.1. Determinants of foods consumption

According to Scaglioni et al., (2011), food preferences are the product of an interplay between genetic and environmental factors that result in substantial individual differences in the extent to which children are suspicious and fussy about food in general and in their likes and dislikes for specific foods. Indeed, the review shows that food choice is influenced by a large range of potential factors. It is not determined entirely by physiological or nutritional need, but is also influenced by social and cultural factors; and this factors influencing food choice are categorized as those related to the food, to the individual making the choice and to the external economic and social environment within which the choice is made (Shepherd, 1999). As for Geurts et al., (2016) and Deliens et al., (2014), determinants of food choice and food consumption can be categorized at the level of the: individual, social environment, physical environment, macro-level environment. As reported by Fitzgerald et al., (2010), in a study conducted among American adolescents, factors perceived as important in influencing food choices included hunger, appeal of food, lifestyle factors, food availability, parental influences, benefits of food, situation-specific factors, mood, body image, media, habit and vegetarian beliefs. Figure 1 summarizes the different types of determinants according to the level.

2.1.1. Level of the individual

Individual-level determinants relate to food choices and eating behaviors include cognitions, behaviors, and biological and demographic factors (Geurts et al., 2016). Indeed according to Leng et al., (2016), the food choices are influenced by physiological mechanisms, including signals to the brain from the gastrointestinal tract and adipose tissue, which affect not only our hunger and satiety but also our motivation to eat particular nutrients, and the reward we experienced from eating. For Mela, (2001), biological signals related to satiety and regulation of energy balance are clearly important but exist among a wide set of factors influencing what are ultimately voluntary decisions of what, when, and how much is eaten. Chemical components in the foods, such as the amount of protein or carbohydrate, will have effects on the individual, e.g. reducing hunger, and the learning of the association between the sensory attributes of a food and its postingestional consequences appears to be a major mechanism by which preferences develop (Shepherd, 1999). Psychological differences between individuals, such as personality, may also influence food choice (Shepherd and Farleigh, 1986).

Shepherd, (1999) reported that a psychosocial factor that affects most of the people during a study was the "taste and sensory perception of food. Another noticeable factor is the health and nutritious value of food (Soyer et al., 2008). For Deliens et al., (2014), time and convenience also influenced the food choice. As the authors explained, people interviewed in the study indicated that they would rather spend time on other activities than cooking especially when they have to cook especially for themselves. Gracia and Albisu, (2011) found that lifestyles, and how people live and spend their time and money, also determine food consumption patterns.

2.1.2. Social environment

The social environment refers to interactions with family, friends, peers, and others in the community (Geurts et al., 2016). Eating behavior is strongly influenced by social context (Higgs and Thomas, 2016). According to Bandura, (1977), modeling is a cognitive process whereby individuals form beliefs and attitudes about the behaviors they observe in others, which in turn shapes their own behavior. Modelling occurs when the norms is set by another present person but also when the model is not present such as when the norm is communicated by environmental cues or by textual information (Higgs and Thomas, 2016). As for Contento, (2011), social modelling is a phenomenon whereby eating behaviors are learned by observing the behaviors of peers, and familiar and unfamiliar people that one sees as role models to certain behaviors. It was evident that how much people eat is determined by social modelling, i.e. to conform to the amount eaten by others (Geurts et al., 2016). The family has a major influence on adolescents' eating behavior because it influences food attitudes, preferences and values that affect lifetime eating habits (Soyer et al., 2008). By exposing the family members to certain foods and actively or passively allow them to eat certain foods, parents set social norms regarding food and eating, and these norms are likely to influence initiation and maintenance of children's regular eating habits (Geurts et al., 2016). As confirmed by Larsen et al., (2015), parental dietary behavior and food parenting practices are important interactive sources of influence on children's dietary behavior. Parents and families environment are very important for young children to learn and develop food preferences and eating habits in a dual way (Story et al., 2002). However Sleddens et al (2015), reported that parental influence decreases with advancing age of child as the child is increasingly exposed to others environments (school environment, peers influence). As reported by Aranceta et al., (2003), the peer group is key for adolescents and has a major influence in developing food habits and lifestyle. A study on Spanish children and

adolescents allow understanding that children and young people from a lower socioeconomic background and those whose mothers had a lower level of education showed a higher consumption of sweets and high-fat bakery products as well as sugary and salted snacks, but lower vegetables intake (Aranceta et al., 2003). Social support was also found to be positively associated with improvements in fruit and vegetable consumption and with the preparative stage of improving eating habits (Engbers et al., 2006). Migration may be another important sociodemographic component affecting food behavior (Soyer et al., 2008). The authors explained that when people migrate, dietary changes occur by substitution, addition and modification of food habits.

2.1.3. Physical environment

The physical environment relates to the settings where people eat or procure food (Geurts et al., 2016). According to Deliens et al., (2014), availability, accessibility of foods, appeal of food items and cooking supplies were found to be positively associated with food consumption. For Fitzgerald et al., (2010), home environment influences diminished during adolescence and competed with influences such as nutritional autonomy and lifestyle factors. Note also that some people felt influenced by media and advertising (Deliens et al., 2014).

2.1.4. Macro-level environment

Macro-level factors operate within the larger society including population demographics, economic, social-cultural, technological, ecological and political factors (Geurts et al., 2016). Knowledge, attitude or beliefs has been demonstrated to explain a large part of variations in consumer decision-making towards functional foods (Deliens et al., 2014). Knowledge and beliefs are major motivations for either purchasing or consuming (Verbeke, 2005). According to Macías and Glasauer, (2014), knowledge as the individual's understanding of nutrition, including the intellectual ability to remember and recall food and nutritional terminology, specific information and facts while attitudes are emotional, motivating, perceptive, and cognitive beliefs that positively or negatively influence an individual's behavior or practice. Cultural background and level of education are predictors for functional food consumption patterns (Mullie et al., 2009). This is confirmed by Verbeke, (2005) who found that level of education can influence dietary behavior during adulthood. The cost of the food was also found to have an effect on food choices (Soyer et al., 2008). For Deliens et al., (2014), some people interviewed during a study recognize that they are restricted by policy and legislation which influenced their drinking choices.

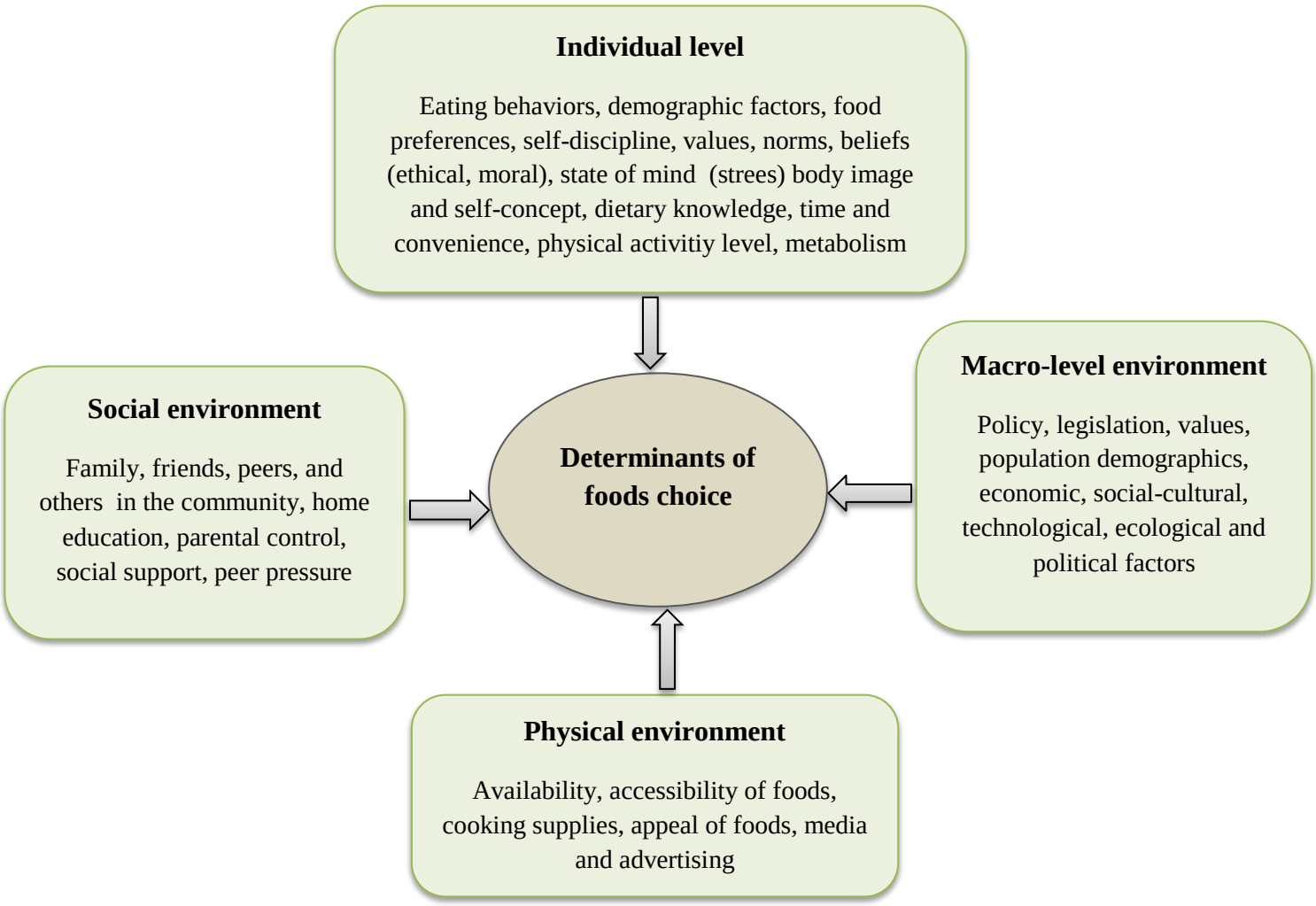

Figure 1: Factors influencing food choices

Source: Geurts et al., (2016) ; Deliens et al., (2014), Shepherd, (1999)

2.2. Nutritional interventions

The literature review shows that subjects commonly targeted for the intervention are vulnerable groups such as children, puberty girls, adolescents and women. The intervention duration varies considerably depending of the nutrients targeted, the nutrient content in the fortified food and the frequency of consumption. There are two ways to fortify foods both in interventions using classical fortification or supplement and interventions using food to food fortification: fortificant (nutrient or food) are added to the staple foods during the processing or just before the consumption of the foods. In some interventions using the supplement, micronutrients such as vitamins, iron, zinc are consumed directly by the target groups.

2.2.1. Interventions using classical food fortification or supplement

According to Christian et al., (2003), the supplementation of folic acid, folic acid-iron, folic acid-iron-zinc, or multiple micronutrients all given with vitamin A, or vitamin A alone (control) among pregnant women showed that folic acid-iron and multiple micronutrient increased mean birth weight and reduced the percentage of low birthweight babies. The daily consumption of lipid-based nutrient supplement by healthy singleton infants aged 6–11 months for 6 months improved the linear growth of young children (Iannotti et al., 2014). However, this lipid-based nutrient supplement did not reduce diarrhea morbidities, which are the leading cause of child mortality in Haiti and a rampant problem. According to Seal et al., (2007), maize meal fortified with Fe and vitamin A is an effective means of reducing childhood anemia and improving adolescent Fe and vitamin A status but it impact on anemia in women remains unclear. Beinner et al., (2010) reported that when rice fortified with micronized ferric pyrophosphate was consumed by one group of children and rice with iron drops by another group for five months, hemoglobin and serum ferritin concentrations increased in both groups, but more so in the group who consumes rice fortified with micronized ferric pyrophosphate. As limits mentioned by the authors of this study, parents forgot to give the iron drops thrice weekly or child refused to consume the drops because of taste, child had diarrhea or constipation or child vomited when consuming. In addition, after the consumption of foods fortified with some micronutrient supplements named sprinkles powder, crushable nutritabs tablets, or energy-dense, fat-based nutributter, the first 3 supplements had positive effects on motor milestone acquisition by twelve months compared with no intervention, but only fat-based nutributter affected growth (Adu-Afarwuah et al., 2007). The limit of this study was that mothers forgot the supplement and some children refused the supplement. This may be explained by the fact that children perceived these supplements as medications. The administration of sorghum meal fortified with micronutrients to HIV-infected men and women revealed that the fortified sorghum meal did not influence serum retinol, CD4 cell count and HIV viral load (Motswagole et al., 2013). This may be explained by the inadequate levels of micronutrients in the supplement. Therefore the authors suggest that future intervention studies should carefully consider the composition and dosing of food supplements needed to improve immune status and delay disease progression.

The weekly and daily micronutrients supplementation improved hemoglobin, zinc, and retinol concentrations similarly among Vietnamese children aged 6–24-months (Thu et al.,

1999). However, the authors reported that neither intervention affected growth of the overall population, but growth of children stunted at baseline was improved through both types of supplementation. Note that the acceptability of the supplements throughout this study remained good, and the children took all of the supplements as intended. The daily consumption of the freshly prepared fruit juice, contained 10 mg Zn (as ZnSO4)/d, for 6 months, by preschool children selected according to their socioeconomic status, showed that zinc supplementation increased mid-upper arm circumference by the end of the study and led to greater weight gain in children from the school of medium socioeconomic status at 3 and 8 months (Kikafunda et al., 1998). There was no effect on weight gain of the children from the other schools. This zinc supplementation had no influence on height but infection rates were lower in the zinc-supplemented group than in control subjects. The authors support that although the zinc-supplemented children had slightly better attendance records than the control children, the difference was not significant. Note that the study records some limits that can influence the results. Indeed, as the trial was being carried out at schools, children who missed schools could not consume the fortified food. Some children dropped out the trial before the end. As the authors mentioned, the most common causes of absenteeism were sickness, insufficient funds for school fees, and rain in the mornings.

The consumption of a micronutrient-fortified beverage (containing 12 micronutrients) for 8 weeks led to improvements in weight, mid-upper arm circumference and several measures of micronutrient status in peri-urban school children aged 6- 11 years in Botswana (Abrams et al., 2003). The authors revealed that the use of multiple fortification strategies, which includes fortified beverages, has several advantages such as: ease of distribution, high levels of acceptance, the ability to provide the beverage isolated from meals containing substances such as phytates, which can inhibit nutrient absorption, and the potential for purchase by private consumers rather than reliance on government programs. For Sazawal et al., (2006), the consumption of milk fortified with specific micronutrients providing additional 7.8 mg zinc, 9.6 mg iron, 4.2 g selenium, 0.27 mg copper, 156 g vitamin A, 40.2 mg vitamin C, 7.5 mg vitamin E per day significantly reduce the burden of common morbidities among preschool India children aged 1-3 years, especially in the first two years of life. According to Hambidge et al., (1979), the administration of the zinc-fortified cereals by preschooler children increased the daily zinc intake to a level that was very close to the recommended dietary allowances (10 mg) of the National Academy of Sciences for children less than 10 years of age. However, the authors mentioned that precise zinc requirement for preschool

children have not been established, and it is apparent that these will vary considerably depending on the bioavailability of zinc in different diets. Brown et al., (2007) reported that provision of additional zinc, either in the form of an aqueous zinc containing multi-nutrient supplement or a zinc-fortified cereal porridge did not affect the physical growth or morbidity from common childhood infections among the children in this study population, possibly because they were not sufficiently growth restricted or zinc deficient initially or because the level of zinc intake or absorption was inadequate. Whereas the mean plasma zinc concentration increased significantly among those who received zinc in the form of an aqueous supplement, the authors found that there was no plasma zinc response to the zinc fortified product.

The consumption of calcium-enriched foods by prepubertal girls for 48 weeks increased significantly bone mass accrual in prepubertal girls, with a preferential effect in the appendicular skeleton, and greater benefit at lower spontaneous calcium intake (Bonjour et al., 1997). The supplementation of calcium (calcium citrate malate) among white prepubertal identical twins children (in each pair, one twin served as a control for the other) from India, in whose average of dietary intake of calcium approximated the recommend dietary allowance, calcium supplementation enhanced the rate of increase in bone mineral density (Johnston et al., 1992). The authors support the view that if the gain persists, peak bone density should be increased and the risk of fracture reduced. According to Yamani et al., (2009), the daily supplementation of 10 grams of spirulina on a regular basis for 6 months showed a significant improvement in the main follow-up criteria: weight, arm girth, number of infectious episodes, CD4 count, and protidemia, in both groups i.e. HIV-infected patients and control groups, but no difference was found between the two groups except with regard to protidemia and creatinemia that were higher in the group receiving spirulina supplement. From a clinical standpoint, the authors explained that results were less clear-cut since the Karnofsky score was better in the group receiving spirulina than in the group receiving the placebo at 3 months but not at 6 months and fewer patients presented pneumonia at six months.

2.2.2. Nutritional interventions using food to food fortification

2.2.2.1. Interventions using various resources as fortificant

After the consumption of the red palm oils for 8 weeks by women, starting at 26 to 28 weeks of gestation and extending to 34 to 36 weeks of gestation, results showed that the red palm oil supplementation significantly improved maternal and neonatal vitamin A status and reduced the prevalence of maternal anemia (Radhika et al., 2003). This is confirmed by Zagre et al., (2003) who found that the introduction of red palm oil for 24 months as a source of vitamin A for mothers and children in a non-consuming area, as a dietary diversification strategy, contributed to reducing vitamin A deficiency in children and women of childbearing age. After the consumption of the soy-beverage diet by children aged 6 to 12 years for 4 weeks, results showed that there was no change observed in either plasma cholesterol, low-density lipoprotein cholesterol and apolipoprotein concentrations (Laurin et al., 1991). However, this soy beverage significantly reduced the concentration of triglyceride and very low-density lipoprotein cholesterol and significantly increased the concentration of high-density lipoprotein cholesterol. Note that the rate of acceptability of the fortified foods within the subjects is not mentioned in all of the studies. This may influence a little bit the results obtained. After the consumption of fortified meals and snacks with b-carotene–rich food and dietary fat by preschool children aged 3 to 6 years for 3 weeks, results showed that the incorporation of b-carotene sources (mainly in the form of red sweet potatoes) into the meal significantly increased serum retinol concentrations (Jalal et al., 1998). The greatest rise in serum retinol occurred when meals contained added b-carotene sources and added fat and the children were dewormed.

2.2.2.2. Nutritional interventions using Non Timber Forest Product (NTFP) as fortificant including moringa leaf powder and baobab fruit pulp

After the consumption of the untreated mushrooms, UV-treated mushrooms, purified ergocalciferol plus untreated mushrooms contained ergocalciferol by different groups of adults for 6 weeks, results indicated that ergocalciferol was absorbed from UV-treated mushrooms and converted into 25(OH) D2 with an efficiency similar to that seen for ergocalciferol or D3 from supplements. However, serum 25(OH) D3 decreased in proportion to the increase in 25(OH) D2, with the net effect that there was no improvement in overall vitamin D status in participants receiving the UV-treated mushrooms or supplements (Stephensen et al., 2012). The daily supplementation of 10g of moringa leaf powder for six months improved significantly the nutritional status of children: wasting, growth retardation

and underweight (Houndji et al. 2013). This is confirmed by Zongo et al. (2013) who reported that this supplementation appears to be effective in improving the nutritional recovery of severely malnourished children. However, this study support the view that there was no significant improvement in hemoglobin rate in either group (experimental and control groups). This may be explained by the fact that a small number of children showed resistance to their first bowls of porridge mixed with moringa powder during the first week because the use of moringa imparted green coloration to the products making them appear greenish, as mentioned by the authors; or the dose 10 g was not high enough to make a significant improvement in hemoglobin rate. According to Ndong et al., (2007), the iron in moringa is not totally available and therefore the food fortified with this powder affects a bit the iron bioavailability. However, for (Tété-Bénissan et al., 2012), the daily supplementation of 25g/ day for nursling, 30 g / day for children of moringa leaf powder for 14 weeks showed that after hemogram analysis, the increase of red blood cell, hemoglobin, hematocrit mean cell volume, mean cell hemoglobin concentration and for mean cellular hemoglobin concentration values and the increase in hemoglobin is more important among seronegative subject. As for stunting, Houndji et al. (2013) found that the z-score of male children in the intervention group were statistically higher than those of the female because of their propensity to eat more. Note that there is lack of data regarding to the nutritional interventions using food fortified with baobab fruit pulp. It is important to mention that although the non-timber forest products are known and used traditionally by populations for their proven nutritional properties, interventions using them as fortificant to fortify foods are still not common.

2.2.3. Average weight gain during the nutritional rehabilitation hearth

The rehabilitation of severely undernourished Indian children aged 6 to 60 months in a hospital by using a mixed diet and mean energy intake, allows getting an average weight gain of 6.1 g/kg/day (Mamidi et al., 2010). Bhimani et al., (2015), showed that an evaluation of the effect of a nutritional intervention on children aged 0-60 months admitted in the nutritional rehabilitation center revealed that an average weight gain among boys and girls were respectively 6.63 g/kg/day and 7.60 g/kg/day whereas the mean weight gain for the entire study group was 7.13 ± 3.91 g/kg/day. Zongo et al (2016) reported that when one group aged 6 - 59 months received the CREN's standard nutritional care diet and another one received the CREN's standard nutritional care diet plus 10g of moringa leaf powder, the group consuming the moringa supplement recorded a higher average weight gain 8.9 ± 4.3 g/kg/day, against 5.7 ± 2.72 g/kg/day in the one who don't consume the moringa. According

to DSME, (2011), an average weight gain < 8 g/kg/day shows that the treatment is not appropriate. Based on this reference, it can be concluded that the treatment used in Mamidi et al., (2010) and Bhimani et al., (2015) studies was not appropriate. However, this document highlight that the average weight gain in the ambulatory nutritional center for children with severe acute malnutrition, is most of the time between 6 et 8g/kg/jour with duration of stay of more than six weeks but this average weight is not alarming as children are treated at home. Moreover, it is important to mention that the formula used to calculate the weight gain is not the same in all of the studies. Indeed, Mamidi et al., (2010) used the formula:

"Weight gain (g / kg / day) = [Final weight (g) – Initial weight (g)] / [Duration between minimum date and day of exit] * Initial weight" whereas in the protocol, the formula used is: "Weight gain (g / kg / day) = [Final weight (g) - minimum weight (g)] / [Duration between minimum date and day of exit] * Minimum weight".

In the other studies the formula used was not pointed out. Therefore, this cannot facilitate the comparison of studies results.

METHODOLOGY

III. METHODOLOGY

3.1. Assessing the determinants of the consumption of foods fortified with moringa leaf powder and baobab fruit pulp by children in Benin

Assessing determinants allows finding out in which of the three biogeographic zones (Sudanian, Sudano-guinean and Guinean zone), a nutritional intervention using the sorghum porridge fortified with moringa leaf powder and baobab fruit pulp may be performed. The determinants addressed in this study are essentially physical determinants, economic determinants and knowledge, attitudes, perceptions as they are the most important determinants of food consumption according to the literature review. To assess these determinants, some surveys were conducted in the three biogeographic zones of Benin. Only the municipalities in which moringa leaf powder and/or baobab fruit pulp are used in children diet were selected. In each municipality the choice of villages was guided by two criteria: geographical criteria (easily accessible villages, less accessible villages, halfway villages) and economic criteria: disadvantaged villages. Thus, two municipalities per biogeographic zone and two villages per municipality were selected. In total, 6 municipalities and 12 villages (were selected. To carry out the surveys, a questionnaire Knowledge Attitude perception (KAP) as well as checklist of Focus Group Discussion were designed and pretested. The sample size for this survey was calculated taking into account the proportion of children consuming moringa leaf powder and/or baobab fruit pulp.

- **Focus group discussions**

the checklist used focuses on the economic and physical determinants such as availability and accessibility of moringa leaf powder, baobab fruit pulp and moringa leaf powder or baobab fruit pulp vehicles. In each village, two focus group discussions were performed. Group discussion gathered 8 to 10 women randomly selected among women who have at least one under-five-years old child.

- **KAP**

The KAP is a representative study conducted with a particular population to identify knowledge (C), attitudes (A) and practices (P) of a population on a specific topic (goutille, 2009). Thus, the questionnaire KAP included mainly the consumption frequency questionnaire as well as resources person interviews and allow to get information related to: frequency of consumption of vehicles fortified with moringa leaf powder or baobab fruit pulp (mothers' practices), importance of moringa leaf powder and baobab fruit pulp (mothers

knowledge), and the perceptions against these two resources. In total 196 children mothers and 30 resources persons were interviewed. Thus for each zone, the percentage of people who recognize the availability and accessibility of the two resources throughout the year in the study area, the nutritional and medicinal importance of the two resources and the percentage of children who consume the foods fortified were calculated. Then, was selected as the intervention area, the zone in which:

- ✓ The moringa leaf powder and baobab fruit pulp are more available and accessible,
- ✓ The importance of the two resources is well known,
- ✓ No tabous related to the consumption of sorghum, moringa leaf powder and baobab fruit pulp were observed, and
- ✓ The foods traditionally prepared with the two resources were most consumed,

3.2. Testing the effect of the consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the weight change and prevalence of wasting in children aged 6 to 59 months from Benin

3.2.1. Study area

The study was performed in two villages of the district of Taïakou, Tanguieta (Benin). The municipality of Tanguiéta is one of the nine (09) municipalities of the Department of Atacora. It is located to the northwest of the department of Atacora, which corresponds to the northwest part of the Republic of Benin. Between 10 ° 37 'and 11 ° 46' north latitude and between 01 ° 07 'and 02 ° east longitude, this municipalities is limited to the North by the park of Pendjari, to the South by the municipalities of Toucountouna and Boukombe, to the West by the municipalities of Matéri and Cobly and to the East by the municipalities of Toucountouna, Kouandé and Kérou. Tanguiéta covers an area of 5,456 km² and includes 39 villages and five (5) districts such as: Tanguiéta (301 km² with 9 districts), Taïakou: (74 km² with 12 villages), Tanongou (4816 km² with 5 Villages), Cotiacou (131 km² with 6 villages) and N'dahounta (134 km² with 7 villages). The district of Taïakou where the study was taken place is composed of 12 villages. Thus, Nontingou and Ouankou were choosen as case village and control village respectively. The distance between the two villages is 5 km. As for the demography, the fourth general census of population and housing, INSAE, (2013) revealed a population of 74 675 inhabitants in the municipality of Tanguiéta with 53 638 of the agricultural population ie 71.83% of total population. Meanwhile, the two villages

(Nontingou and Ouankou) in which the study was carried out, counted respectively 516 and 1196 inhabitants but 81 and 262 children aged 0 to 5 years.

3.2.2. Experimental design

The study was designed as a two arm randomized controlled trial among children with moderate and fruste acute malnutrition in two villages of Tanguiéta (Benin). Villages have been assigned randomly to one case village (Nontingou) and one control village (Ouankou). The case group in Nontingou village consumed daily the food formula in the nutritional rehabilitation hearth during two weeks whereas the control group in Ouankou village consumed common foods from the study area.

3.2.3. Sample size

The sample size was calculated using the formula of (Dagnelie, 2011) :

$$\mathbf{n = [p(1-p)/d^2] \ X \ [U^2_{(1-\alpha/2)}]}$$

n = sample size;

p: prevalence of basic variable (proportion of children consuming moringa leaf powder and/or baobab fruit pulp);

d: margin of error (6% of prevalence of basic variable);

$\mathbf{U_{(1-\alpha/2)}}$: statistic of the reduced normal distribution determined on the basis of the level of confidence. Thus the minimum sample size obtained for both groups (case group and control group) was 43. To account for eventual dropouts, 10% of the minimum sample size calculated, was added to obtain approximately 47. However for statistic reasons, the minimum sample size is raised to 60 children for both groups ie a minimum of 30 children per group.

3.2.4. Children selection

Exhaustive census of children in the defined age range was performed in the two different villages (case and control) of the study area. Indeed, among children resident in the study area, 105 children in case village and 95 children in the control one were initially enrolled. Their anthropometric measurements such as weight and height were taken using stadiometer and scale. The age was recorded from the children birth certificates. The anthropometric index Z-score weight for height (WHZ) <-2ET that reflects the acute malnutrition were calculated using the software who Anthro. Children with severe acute malnutrition (Z-score <-3) as well as children without acute malnutrition were excluded. Children severely malnourished excluded were referred to the Therapeutic Nutrition Center of Tanguiéta. Only

children with moderate (-3 ≤Z-score <-2) and fruste acute malnutrition (-2 ≤Z-score<-1) were included. After that, the eligible children parents were gathered and an information note was explained to them. Sick children as well as children under special diet or under a treatment that could influence their nutritional status were excluded. With informed parental consent, 67 children were included in the study at the beginning. During the trial, 3 cases of dropout in the case group and 1 in the control group were recorded. In total, 63 children have completed the study: 31 in the case group and 32 in the control one. In the case group, 8 children aged 6-12 months, 14 aged 13-24 months, 4 aged 25-36 months and 5 aged 37- 59 months were selected whereas in the control group 7 children aged 6- 12 months, 13 aged 13- 24 months, 7 aged 25-36 months and 5 aged 37-59 months were selected. Figure 2 summarizes the methodology of the participants selection.

3.2.5. Determination of nutritional composition of the food formula

The intervention food was formulated in a laboratory during another study taking into account daily nutritional needs of children. Thus the micronutrients contained in the food formula were measured in laboratory (AOAC, 1995) whereas the macronutrients contents were theoretical estimated (Chadare et al., 2009; Amabye, 2016).

3.2.6. Preparation of food vehicle and fortificant

The food vehicle used for the intervention is sorghum porridge. To obtain this porridge, the sorghum is sorted, washed and soaked in water having an ambient temperature for about 24 hours. Then, it is removed from the water and ground. Ground sorghum is then mixed with water and filtered. Thus the filtered sorghum obtained is left for few hours in order to be fermented. After that, a quantity of water is boiled and removed from the fire. Then the fermented filtered sorghum is poured into the boiled water and stirred until the mixture is completely homogenized. Figure 3 shows the technological diagram of the production of fermented sorghum porridge. Beside the vehicle, moringa leaf powder and baobab fruit pulp are the two fortificants used in the trial. Moringa leaf powder was produced as described by Houndji et al (2013) in the figure 4. Indeed, after harvesting the plant of moringa, the leaflets are separated, sorted, washed with water, drained and dried under the shade for about 3 to 4 days. The dry leaflets are then milled and sieved to obtain moringa fine textured leaf powder. The baobab fruit pulp was extracted as described by Chadare et al., (2008). Thus the capsules received are crushed for the release of the seeds coated with pulp. The extract (seeds + pulp)

is pounded in a mortar with a pestle. The crushed product is sieved to separate the pulp from the seeds.

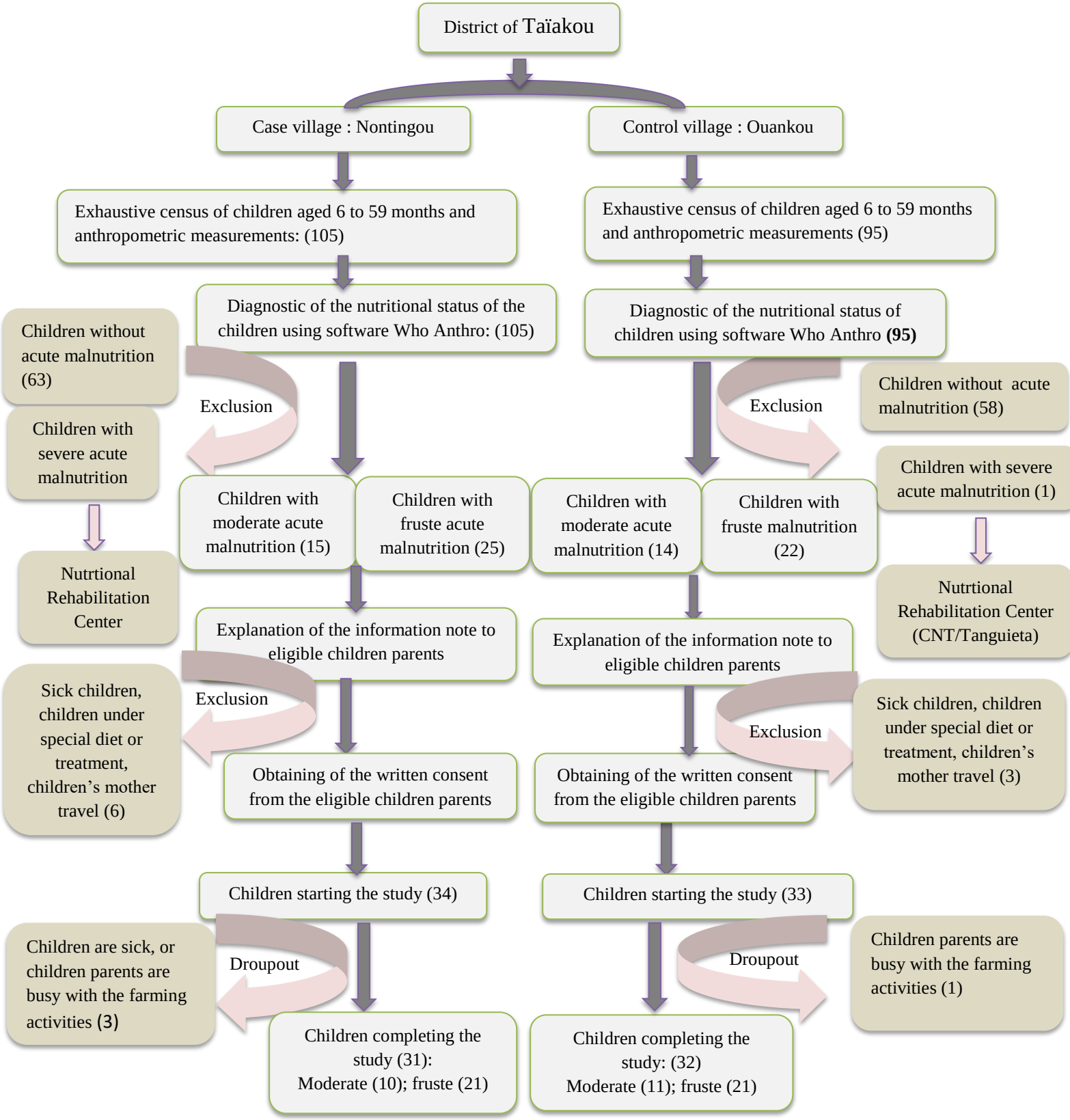

Figure 2: Methodology of children selection

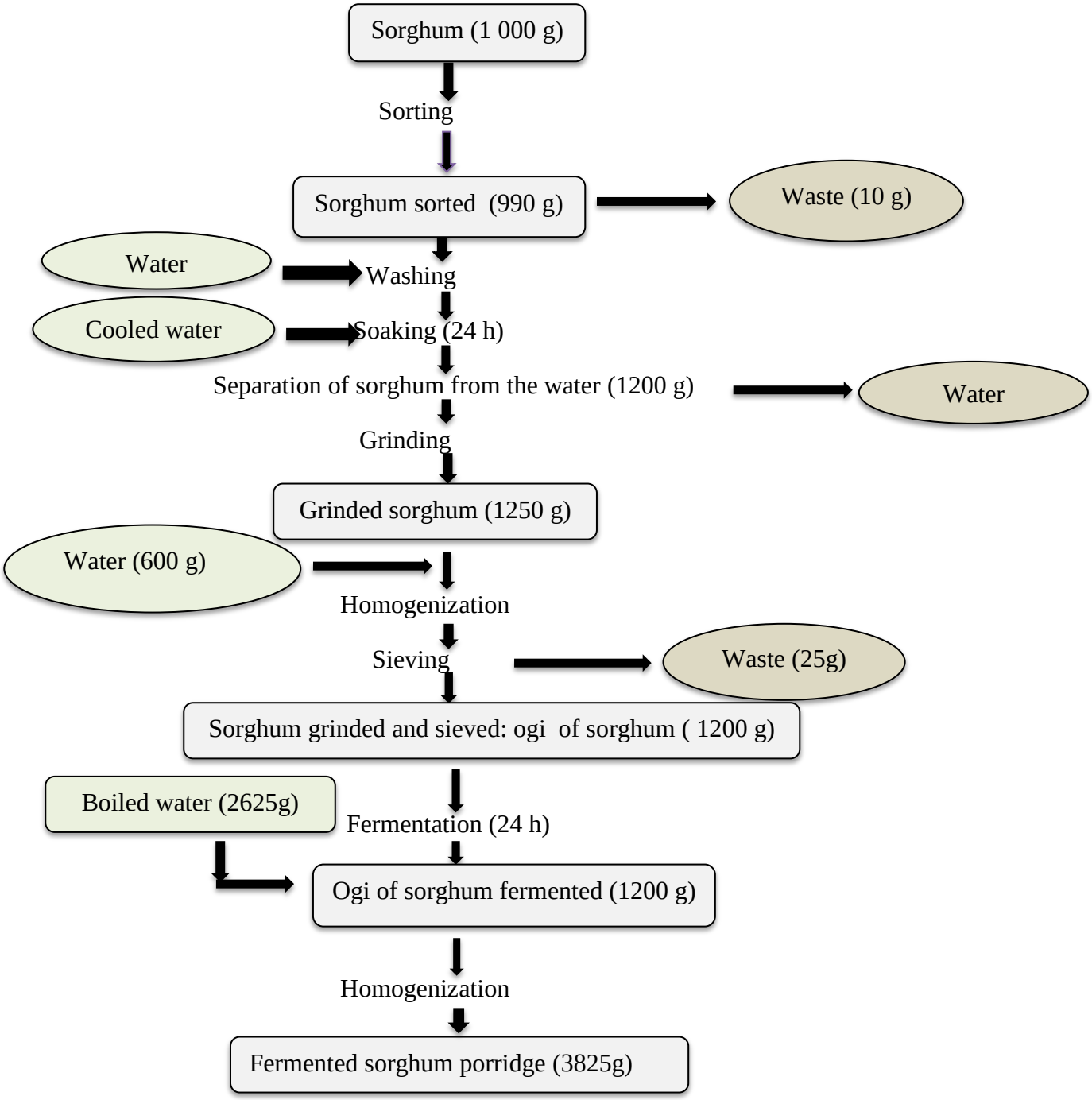

Figure 3: Technological diagram of production of fermented sorghum porridge

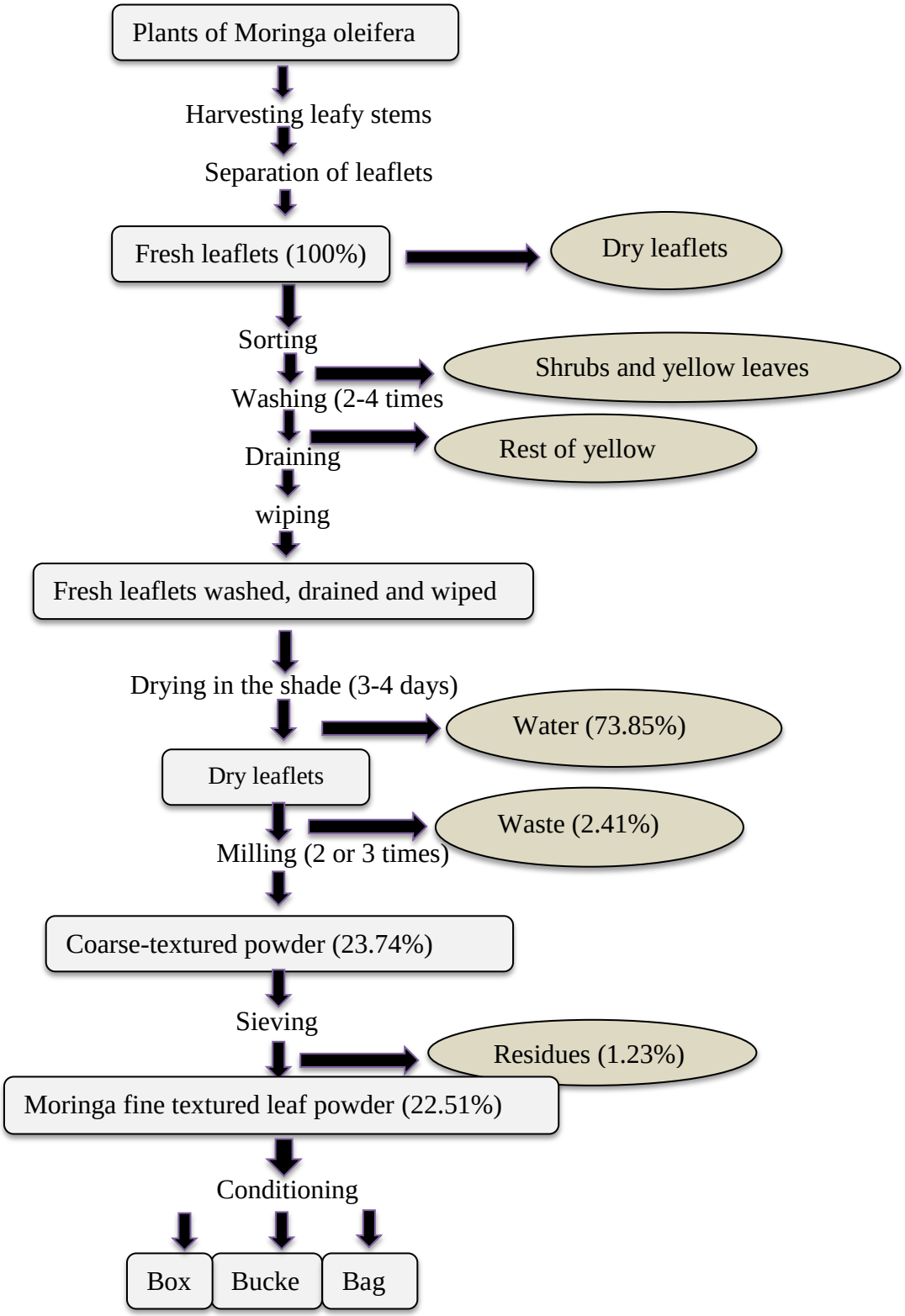

Figure 4 : Technological diagram of production of moringa leaf powder

Source: Houndji et al, 2013

3.2.7. Intervention

3.2.7.1. Nutrition rehabilitation hearth

The case village chief's house was transformed into a nutritional rehabilitation hearth where eligible children mothers brought their children every day to consume the food formula. Children were brought every morning for two weeks to consume the food in the nutritional rehabilitation hearth. Children's mothers are those who process the vehicle in the house in the way they use to do it in this area. Cooked porridge is left few minutes to cool down and the moringa leaf powder and baobab fruit pulp were added. The food formula consumed by each child is composed of 400 g of sorghum porridge, 10 g of moringa leaf powder and 5 g of baobab fruit pulp. Each child had his own bowl on which his name was written. In case child is a bit sick or refuse the porridge or can't finish the porridge before returning home, mothers were authorized to cover and bring the porridge to home so that children can finish it during the day. Questions related to the reaction of the children towards the food formula were recorded every day.

3.2.7.2. Nutrition education

Nutrition education sessions were carried out among the mothers of children in case and control groups. The major focus of these sessions was the promotion of the consumption of a variety of locally available and nutritious foods including animal-source protein such as meats, fish and eggs in order to improve children dietary diversity and diet quality. As the intervention was carried out during the rainy season when people are busy with farming activities, each nutrition education session was followed by singing and dancing as a distraction to incite children's mothers to be more interested by the study.

3.2.7.3. Anthropometric measurements

The anthropometric measurements were performed every day in the case group to follow the change in children weight whereas these measurements in the control group were taken three times namely at baseline, mid-term and at endline of the trial. Depending on the child age and ability to stand, the height was measured in a lengthened position or standing using a sliding and graduated stadiometer. Thus, for children under 2 years old, or those who are too weak to stand, the "length" of the child was measured in supination. As for the children aged two years old and more, the height was measured in a standing position. Each child was measured two times. The value used was the mean of the two measures. For the weight, an electronic

scale “Seca” was used. Each child was weighed two times. The value chosen is the mean of the two weightings.

3.2.8. Ethical Consideration

The proposal was approved by the “National Ethical Committee for Research on Health” of Benin. To avoid discrimination, the unfortified sorghum porridge was also available for mothers of children in the case group during the trial. In addition, children in the control group received an amount of the moringa leaf powder and baobab fruit pulp at the end of the intervention.

3.2.9. Assessment of the intervention effect

The effect of intervention was assessed through:

-Some nutritional variables: Z-score weight for height and prevalence of malnutrition as well as dietary diversity

-Some indicators used in the nutrition rehabilitation hearth: average weight gain and recovery rate;

-Statistical analysis.

3.2.9.1. Nutritional variables

- **Z-score**

The anthropometric index Z-score weight for height (WHZ) < - 2ET that reflects the acute malnutrition was calculated using the software Who Anthro V3.0.1 to characterize the state of emaciation (acute malnutrition) among children. Indeed Z-score < -3 expresses severe acute malnutrition, -3 ≤ Z-score < -2 expresses moderate acute malnutrition and -2 ≤ Z-score < -1 expresses fruste acute malnutrition and ≥ -1 expresses good nutritional status.

- **Prevalence of acute malnutrition**

The prevalence of acute malnutrition is the percentage of children under the age of five who suffer from wasting. This prevalence is calculated within the two groups (case and control) at baseline and endline.

- **Participants diet quality**

The 24h dietary recalls questionnaire was designed taking into account thirteen food groups, such as cereals, white roots and tubers, vitamin a rich vegetables and tubers, dark green leafy

vegetables, other vegetables, vitamin a rich fruits, other fruits, eggs, fish and seafood, legumes, nuts and seeds, milk and milk products, organ meat, flesh meats, to get information about the different foods consumed by children in the study area. Respondents were mothers of children in the case and control groups. Data were collected at baseline and endline of the trial. The dietary diversity was obtained using the software Epi data and excel.

3.2.9.2. Indicators used for nutritional rehabilitation hearth

These indicators such as average weight gain and recovery rate allows assessing the performance of the nutritional rehabilitation hearth (DSME, (2011).

- **Average Weight Gain**

Weight Gain (g/kg/day) = (discharge weight (g) – minimum weight (g))/(number of days between date of minimum weight and discharge day x minimum weight (kg))

Average Weight Gain (g/kg/day) = Sum of weight gains of the discharged children /total number of the discharged children.

- **Recovery Rate**

Recovery Rate = number of beneficiaries that have reached discharge criteria within the reporting period / the total exits.

Table 1: Reference values for the indicators

Indicators	Acceptable	Alarming
Recovery Rate (%)	> 75	< 50
Average Weight Gain (g/kg/day)	≥ 8	< 8

Source: DSME, (2011)

3.2.9.3. Statistical analysis

The effect of the consumption of food formula was assessed by taking into account some variables namely prevalence of malnutrition, weight, height, Z-score and dietary diversity. Then univariate chi-square tests were first used to examine whether prevalence of malnutrition and the dietary diversity differed between the control group (coded 0) and the case group (coded 1) at baseline (coded 0) and endline (coded 1) survey. The t-student test

was also used to find out the baseline characteristics (weight, height and age) of children in both groups. The intervention effect from the baseline to endline was assessed using the difference in-differences (D.I.D) estimator under generalized estimating equations (GEE) framework (Zuur et al., 2009). For each variable (weight, height and Z-score), the D.I.D estimator was calculated. The DID technics calculates the effect of a treatment (i.e., an explanatory variable) on an outcome (i.e., a response variable) by comparing the average change over time (here from the baseline to the endline) in the outcome variable for the treatment group, compared to the average change over time for the control group (Abadie, 2005). The D.I.D. technics is intended to mitigate the effects of extraneous factors and selection bias (Abadie, 2005). The explanatory factors in the models were mainly time (baseline = 0 *vs.* endline = 1), treatment (control group = 0 *vs.* case group = 1) and sex (male=0 vs. female = 1). Covariate in the model was children age (continuous). In this model, the D.I.D estimator was simply the coefficient of the interaction term "*Time×treatment*". If this coefficient estimate is statistically significant, it is likely the slopes in the two groups (case *vs.* control) are not parallel, and so the intervention has affected the outcome (weight, height and z-score) in the case group differently than the underlying background trend, as captured by the control group. In particular if the D.I.D estimator is negative then the consumption of the food formula has negative effect on the nutritional status of children. In contrary, if the coefficient is positive, then the consumption of the food formula improves the nutritional status of children. All statistical analyses were implemented in R software version 3.2.4 (R Core Team 2016) except the GEE models that were run in SPSS version 19.

RESULTS

IV. RESULTS

4.1. Assessing determinants of the consumption of foods traditionally prepared with the moringa leaf powder and baobab fruit pulp by children

4.1.1. Economic and physical determinants

4.1.1.1. Availability of moringa leaf powder and baobab fruit pulp in the study area

In both Sudanian and Guinean zones, respectively 66.67% and 53.33% of people investigated recognized the availability of moringa leaf powder throughout the year and more during the rainy season (Fig 5). However in the Sudano-guinean zone, 100% of people recognized the availability of this powder only during the rainy season. Baobab fruit pulp is more available in the Sudanian and Sudano-guinean zones than in the Guinean zone where this pulp is only available during the dry season (Fig 5).

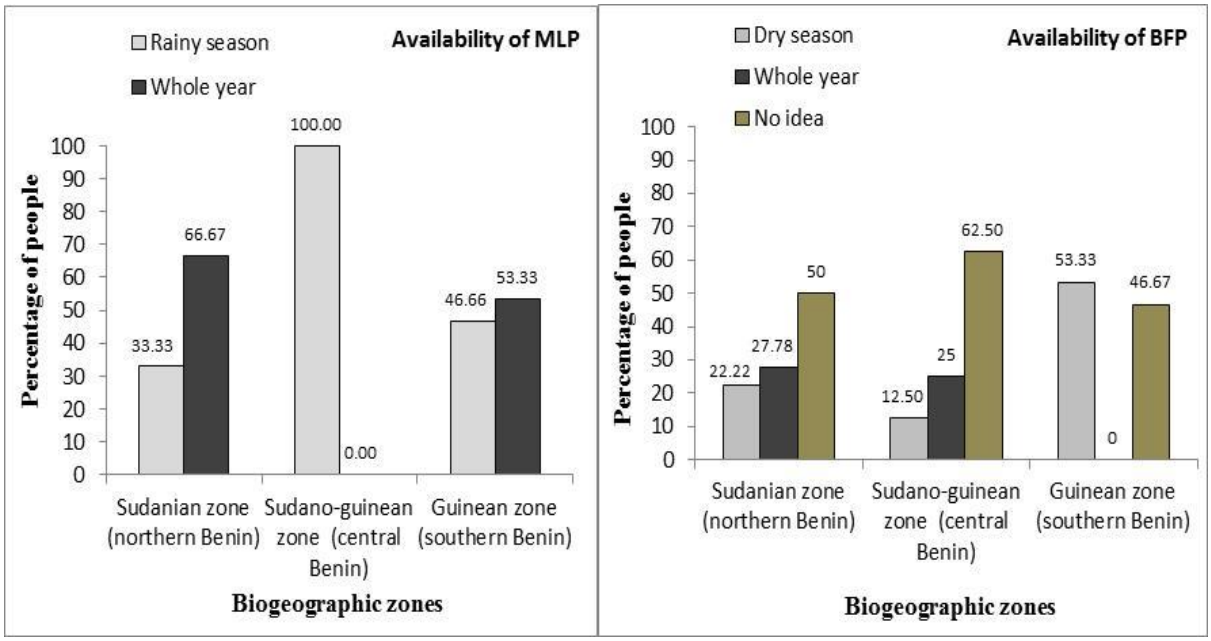

Figure 5: Availability of moringa leaf powder (MLP) and baobab fruit pulp (BFP) according to the biogeographic zones

4.1.1.2. Availability of food vehicles of moringa leaf powder and baobab fruit pulp

Both moringa leaf powder and baobab fruit pulp foods vehicles, such as maize, sorghum and koata (Cochlospermum tinctorium) are almost available all year round in the three biogeographic zones (Fig 6).

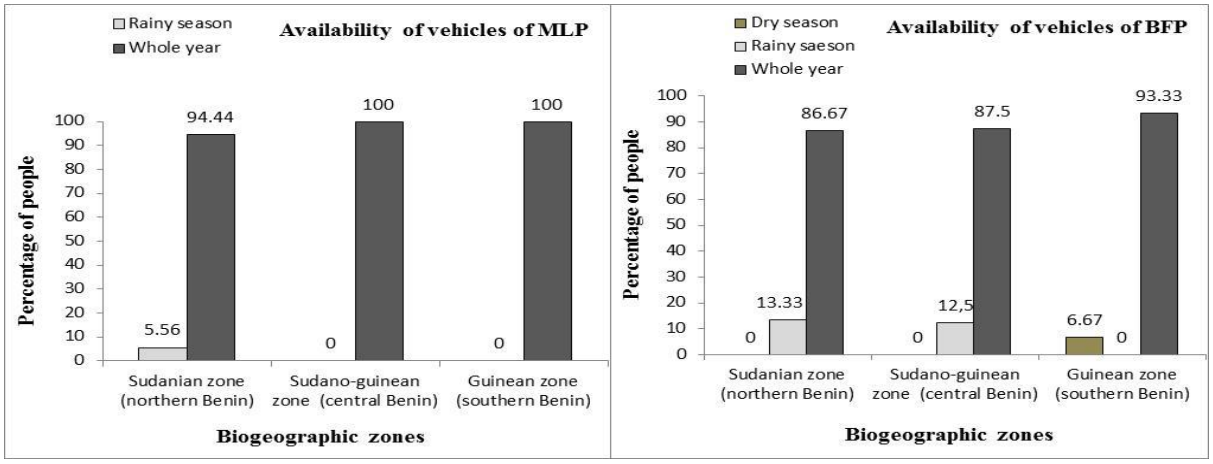

Figure 6 : Availability of vehicle of moringa leaf powder (MLP) and baobab fruit pulp (BFP) according to the biogeographic zones

4.1.1.3. Accessibility of moringa leaf powder and baobab fruit pulp

Accessibility of moringa leaf powder and baobab fruit pulp varies considerably according to biogeographic zones. Indeed, moringa leaf powder is more accessible in the Sudanian zone than in the Guinean zone and more accessible in the Guinean zone than in the Sudano-guinean zone (Fig 7). In addition this powder is more accessible physically than financially in the Sudanian and Guinean zones. However, the opposite occurs in the Sudano-guinean zone. The baobab fruit pulp is physically and financially accessible only in the Sudanian zone while the physical accessibility is also slightly observed in the Guinean zone (Fig 7). Note that these two resources are most of the time picked and processed for a personal use by mothers especially in the Sudanian zone.

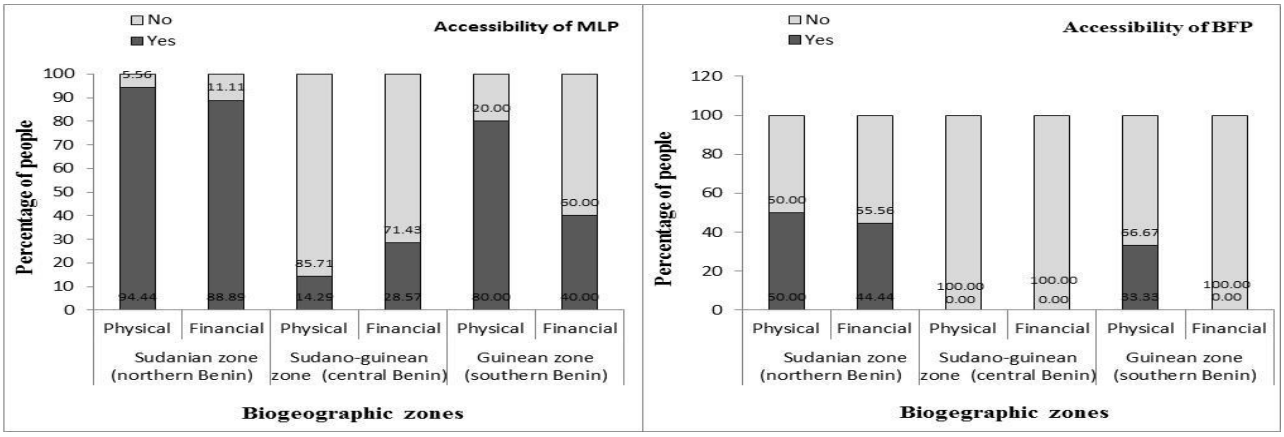

Figure 7 : Physical and financial accessibility of moringa leaf powder (MLP) and baobab fruit pulp (BFP) according to the biogeographic zones

4.1.2. Knowledge, attitudes, practices and perception about moringa leaf powder and baobab fruit pulp in the study area

4.1.2.1. Consumption frequency of foods traditionally prepared with moringa leaf powder and baobab fruit pulp in children

Consumption frequency of foods traditionally prepared with moringa leaf powder and baobab fruit pulp as ingredients in children diet varies considerably among biogeographical zones. Foods prepared with moringa leaf powder as ingredient are more consumed by children in the Sudano-guinean and Sudanian zones than in the Guinean zone (Fig 8). However, the majority of the children did not consume foods traditionally prepared with baobab fruit pulp in the three biogeographic zones. In addition, consumption frequency of foods prepared with baobab fruit pulp by children decreases from the Sudanian to the Guinean zone (Fig 8). As mentioned by mothers, the best way to make more people consume moringa leaf powder and baobab fruit pulp should be the production of supplements based on these powders. For others, sensitization followed by cooking demonstration would encourage their consumptions.

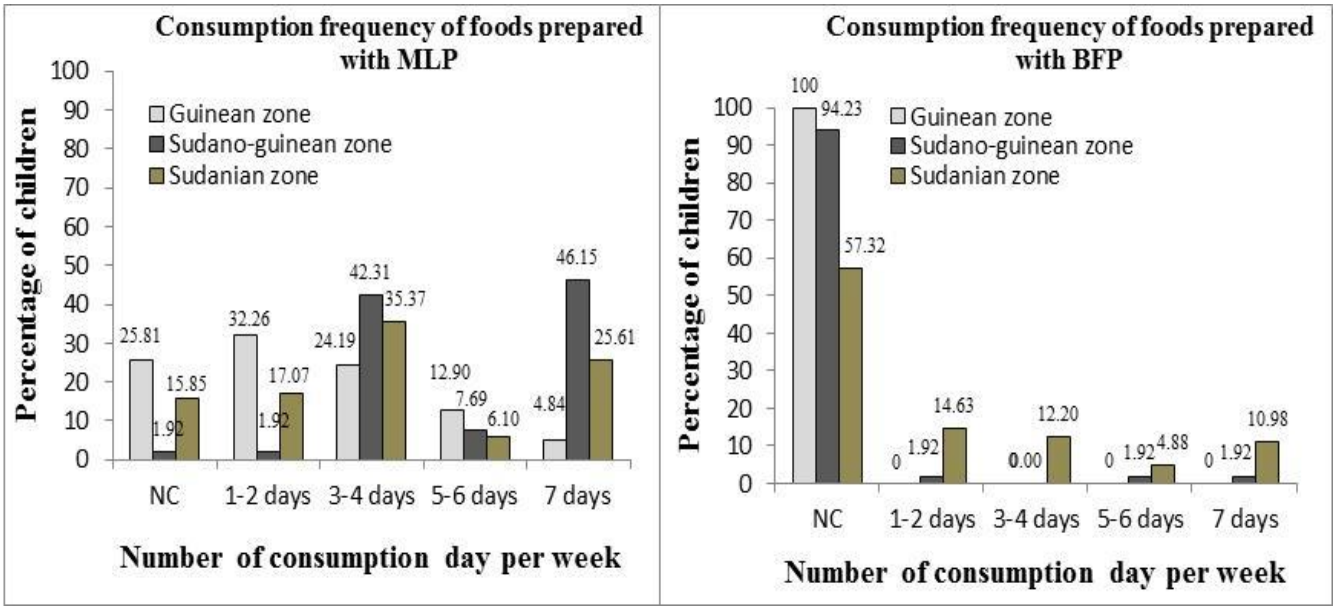

Figure 8 : Consumption frequency of foods traditionally prepared with moringa (MLP) and baobab (BFP) by children according to the biogeographical zones

4.1.2.2. Importance of moringa leaf powder and baobab fruit pulp

Moringa leaf powder and baobab fruit pulp are known for their nutritional and medicinal benefits in the three biogeographic zones. About moringa leaf powder, this knowledge is

more emphasized in the Sudanian zone and Sudano-guinean zones than in the Guinean zone whereas people almost have the same knowledge levels about the benefits of baobab fruit pulp in the three biogeographic zones (Fig 9). Nutritional advantages of moringa leaf powder and baobab fruit pulp are more understood than the medicinal one by mothers.

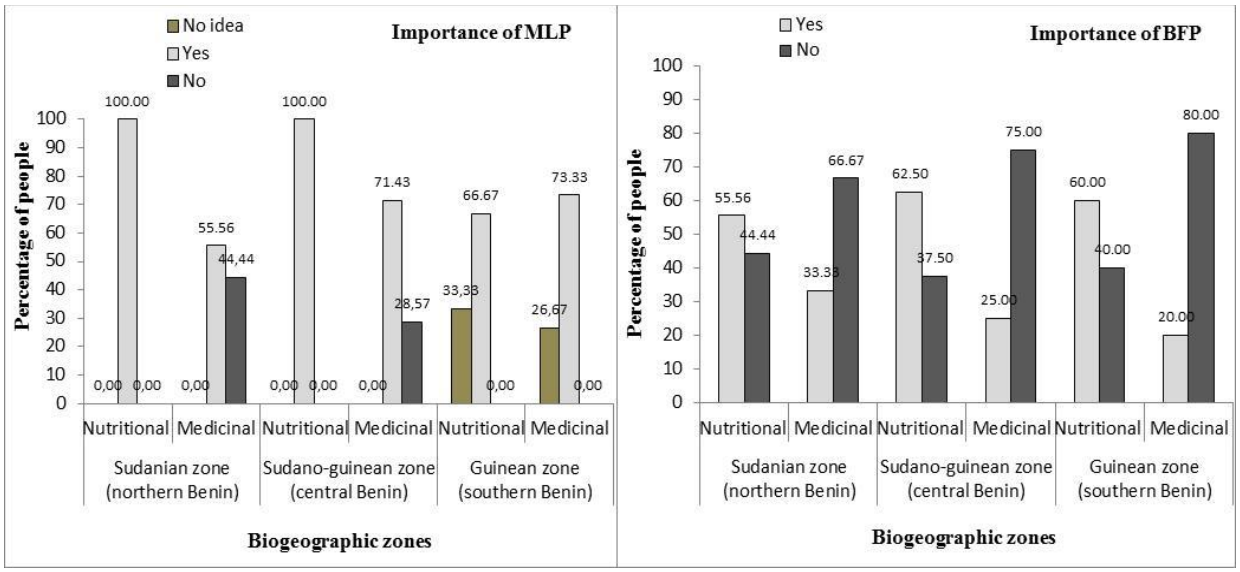

Figure 9: Importance of moringa leaf powder (MLP) and baobab fruit pulp (BFP) according to the biogeographic zones

4.1.2.3. Children negative perceptions about moringa leaf powder and baobab fruit pulp

In the Guinean zone, no negatives perceptions were found about moringa leaf powder whereas in the Sudanian zone 33.34% of mothers explained that their children do not appreciate the green color, bitter taste and bad smell of the moringa leaf powder. In the Soudano-guinean zone, no negative perception was observed (Fig 10). Only 5.56% of mothers in the Sudanian zone reported that their children found baobab fruit pulp to have acid taste. No negative perception about baobab fruit pulp was found either in the Guinean or in the Sudano-guinean zones (Fig 11).

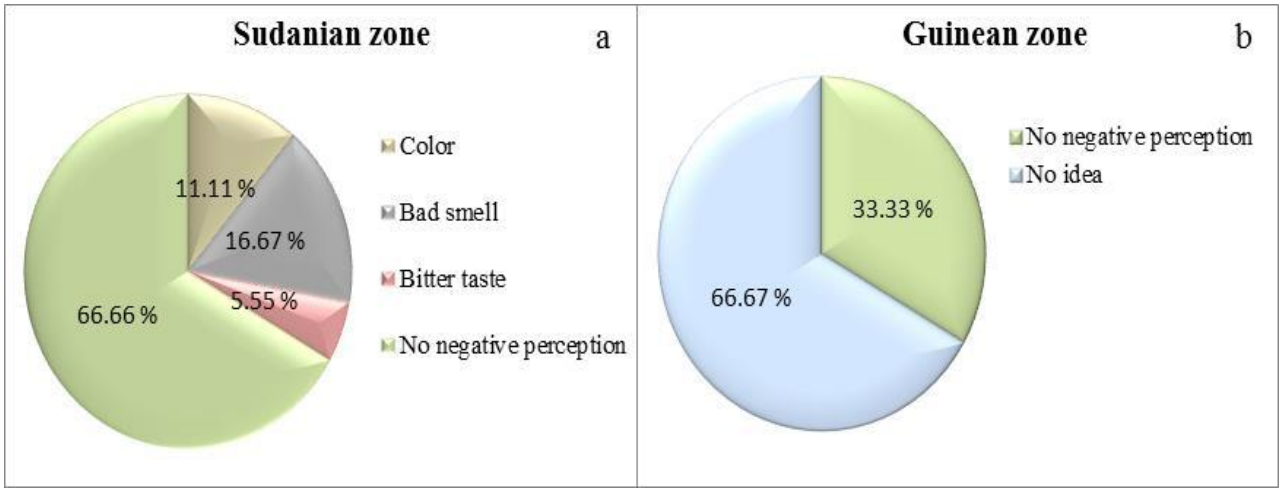

Figure 10: Children negative perceptions about moringa leaf powder in Sudanian (a) and Guinean (b) zone

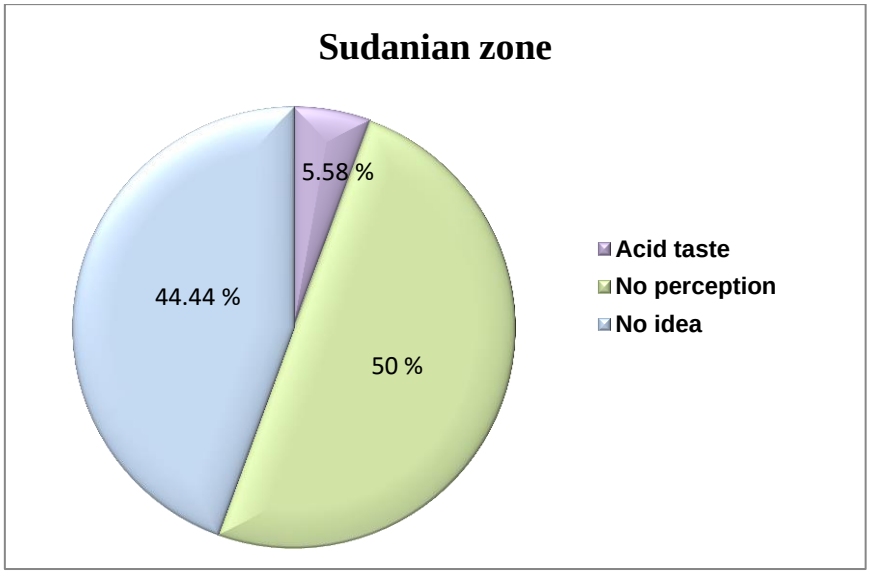

Figure 11: Children negative perceptions about baobab fruit pulp in Sudanian zone

4.2. Assessment of the effect of the consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on weight change and the prevalence of wasting

4.2.1. Nutritional quality of the children daily diet

The nutritional quality of children's diet was evaluated based on the nutritional quality of food formula and children agro-nutritional profile. Indeed, table 2 shows the nutritional value of the food formula and the Estimated Average Requirements. According to this table, the Estimated Average Requirements may be achieved if children consume the food formula daily.

Table 2: Nutritional value of food formula (dry weight) and infants under five years Estimated Average Requirements

	Protein	Iron	Zinc	Calcium
Estimated Average Requirements				
Children (6-12m)	NA	6.9 (mg/d)	2.5 (mg/d)	NA
Children (12-36 m)	0.87 (g/Kg/d)	3 (mg/d)	2.5 (mg/d)	0.5 (g/d)
Children (36-59m)	0.76 (g/Kg/d)	4.1 (mg/d)	4 (mg/d)	0.8 (g/d)
Nutritional value				
400g of fermented sorghum porridge + 10g of moringa leaf powder + 5g of baobab fruit pulp	31.19±2.96 (g/100g dw)	29.82±10.08 (mg/100gdw)	261.18±238.20 (mg/100gdw)	327.77±312.67 (mg/100gdw)

Source: Ross et al., (2011) ; Chadare et al., (2009); Amabye, (2016)

m : month, NA : Not available

The children diet in both groups at baseline and endline was essentially based on cereals (maize, sorghum, millet), legumes nuts and seeds (beans, soya), dark green leafy vegetables (moringa leaf, baobab leaf), others vegetables (tomato, onion), and other fruits (tamarin fruit, mango, baobab fruit, African Locust fruit) (Fig 12.a, 12.b). Note that other groups of foods such as fish and seafoods (small fish), milk and milk products (cheese), white roots and tubers (cassava, yam) were also consumed but by a small proportion of children. There was no significant difference between the case group and control group at baseline (Chi-Sq =

4,033; DF = 5; P-Value = 0,545) (Fig 12.a) and endline (Chi-Sq = 4,539; DF = 5; P-Value = 0,475) (Fig 12.b).

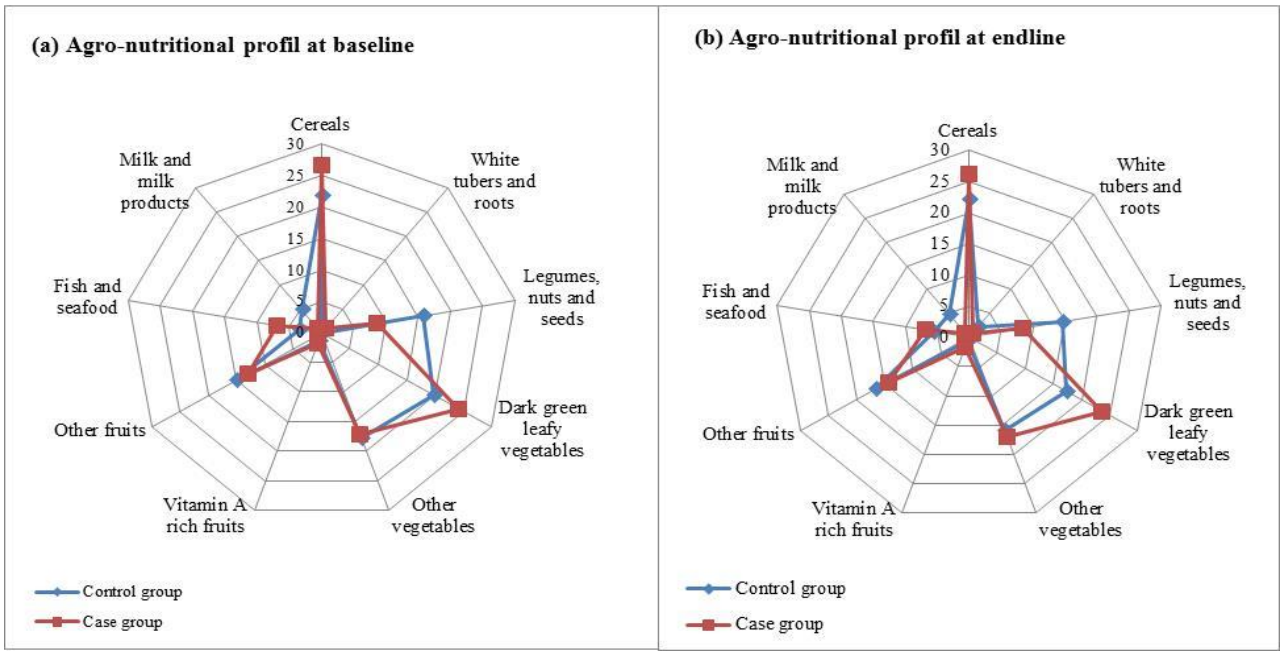

Figure 12 : Agro-nutritional profile of children in the case and control group at baseline (a) and endline (b)

4.2.2. Effect of the intervention on the nutritional variables and indicators

The results obtained help find out the effect of the nutritional intervention ie the effect of consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the children nutritional variables and indicators such as: weight, height, Z-score weight for height, prevalence of malnutrition, recovery rate and average weight gain.

The table (3) pointed out that there were no significant difference between the case group and control group in terms of children age, weight and height as all the p-values > 0.05.

Table 3: Baseline characteristic of children in both groups

Group Variables	Case group	Control group	T-Value	P-Value	DF
Number	31	32	-	-	-
Age	25.4 ± 2.8	23.7 ± 2.5	-0.06	0.959	1
Weight	9.1 ± 0.4	8.6 ± 0.4	-0.04	0.971	1
Height	80.2 ± 1.9	78 ± 1.7	-0.02	0.986	1

Children' Z-score weight for height was the same in both groups at baseline (T-Value = -0.02; P-Value = 0.988; DF = 1). An improvement was observed at the end of the trial but the difference between the case group and control group was not significant (T-Value = -0.13; P-Value = 0.918; DF = 1) (Fig.13).

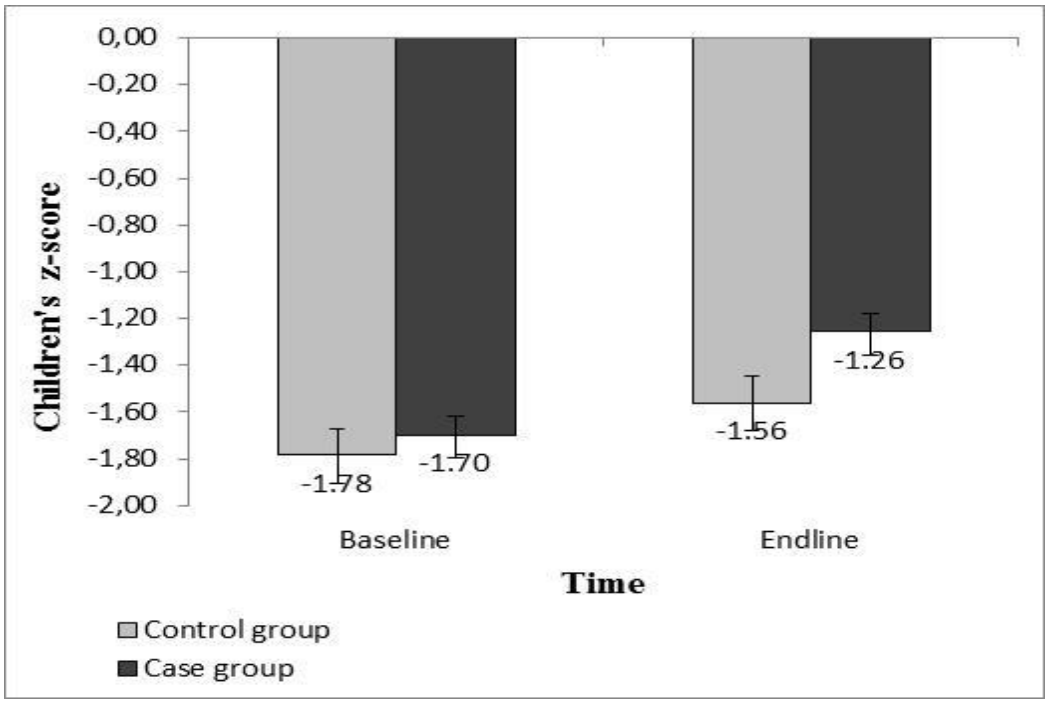

Figure 13: Children's z-score weight for height in case group and control group

The prevalence of fruste malnutrition as well as moderate malnutrition (Fig.14) was the same in both groups at baseline (Chi-Sq = 0.032; DF = 1; P-Value = 0.859). An improvement of the prevalence but not significant was noted in the case group at endline, (Chi-Sq = 3,641; DF = 1; P-Value = 0.056). Indeed, at the end of the trial, 45.16 % of children had recovery whereas the proportion of the moderate malnutrition as well as the fruste malnutrition decreased (Fig.14).

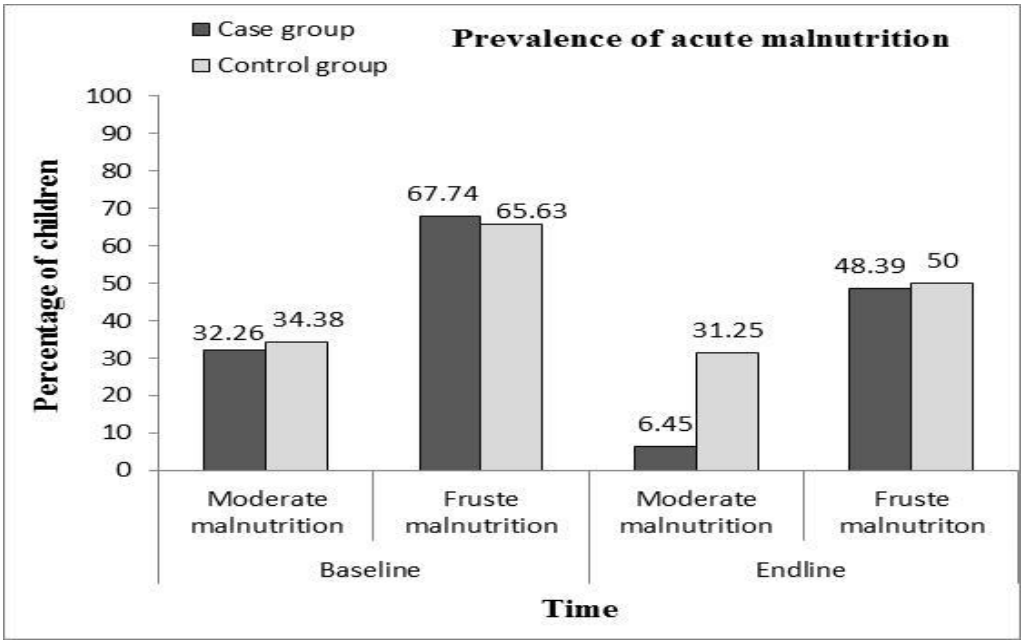

Figure 14 : Prevalence of acute malnutrition in the case and control group at baseline and endline

Figure 15 shows that children weight increased from day 1 to day 4 before decreasing. From day 5 to day 6 children's weight increased and no important change was observed in the second week. In the control group, the weight increased in the first week but remained stationary until the end of the trial. An improvement of the children weight in the case group compared to the one in the control group was observed even if this difference may not be significant. The average weight gain of children in the case group was 9.85 g/kg/day. This average weight gain is higher to the reference (8 g/kg/day). It can be concluded that the treatment was appropriate.

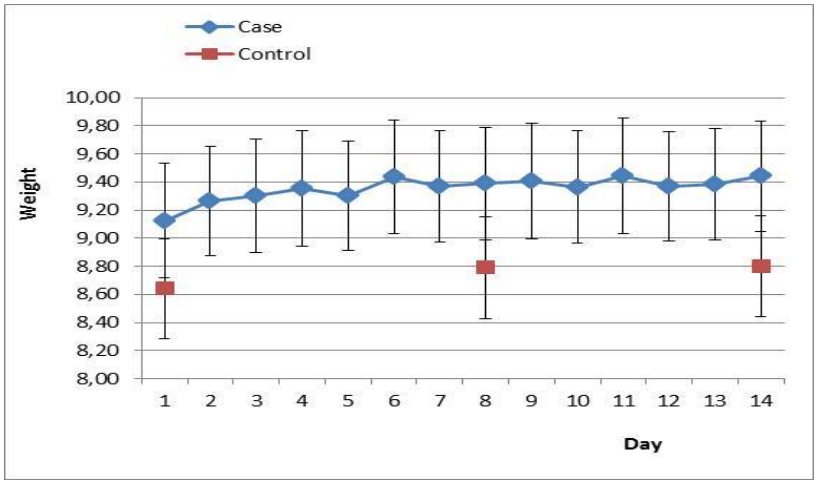

Figure 15 : Evolution of the children weight as function of time

Generalized estimating equations models allow understanding more the effect of the food formula. Indeed, results from this model showed that time has significant or almost significant effect on the children weight (p=0.054; est=0.10(0.05)) and Z-sore (p= 0.001; est=0.22(0.07) (Table 4; 5). The positive value of the estimates indicates that weight and Z-score were higher at endline than at baseline. In contrast, treatment has no significant effect on those anthropometric variables. The D.i.D estimator was positive but not significant (p-value>0.05) for any of the anthropometric variables, indicating that the nutritional intervention has no significant effect on the variables (weight, height and Z-score) after two weeks (Table 4; 5).

Table 4 : Effect of the nutritional intervention on weight, height and z-sore: results of the generalized estimating equations models

Terms in the models	**Df**	**Weight**		**Height**		**Z-score**	
		Wald-stat	p-value	Wald-stat	p-value	Wald-stat	p-value
Sex	1	0.07	0.785	0.35	0.552	0.28	0.598
Time	1	3.70	0.054	51.05	0.325	11.52	0.001
Treatment	1	0.90	0.343	0.81	0.369	0.41	0.523
DiD	1	2.17	0.141	0.51	0.476	3.38	0.066
Age	1	68.35	0.000	74.47	0.325	0.15	0.702
Sex * DiD	1	0.03	0.857	2.74	0.098	0.01	0.918

Table 5 : Summary of the models: coefficient, standard error and significance levels

Terms in the model		**Df**	**Weight**		**Height**		**Z-score**	
			est (se)	p-value	est (se)	p-value	est (se)	p-value
Threshold	[status=2]	1	-	-	-	-	-	-
	[status=1]	1	-	-	-	-	-	-
Intercept		1	5.90 (0.32)	0.000	63.99 (1.49)	0.000	-1.89 (0.18)	0.000
Sex(1)		1	-0.08 (0.36)	0.816	1.26 (1.69)	0.458	0.09 (0.14)	0.520
Time(1)		1	0.10 (0.05)	0.054	-0.26 (0.04)	0.325	0.22 (0.07)	0.001
Treatment(1)		1	0.28 (0.30)	0.343	1.23 (1.37)	0.369	0.09 (0.13)	0.523
DiD		1	0.14 (0.13)	0.272	0.13 (0.07)	0.061	0.23 (0.19)	0.225
Age		1	0.03 (0.00)	0.000	0.14 (0.02)	0.325	0.00 (0.00)	0.702
Sex × DiD		1	-0.03 (0.14)	0.857	-0.47 (0.28)	0.098	-0.02 (0.20)	0.918

Df=degree of freedom, est=estimates, se=standard error of estimates, p-value=significance level

Reference: for sex was 0 (male), for time was 0 (baseline), for treatment 0 (control)

DiD is the estimator of the difference in difference and Sex × DiD is the estimator of the sex-specific DiD

4.2.3. Acceptability of the food formula

Only 45.16 % of children had consumed the food until the end without any negative reaction (Fig 16). During the intervention some children became sick because of teething and had fever so that they could not consumed the formula every day. The high amount of moringa leaf powder than the baobab fruit pulp was not appreciated by children. Thus, 32.26 % of children showed resistance to the bowl, vomited and had diarrhea during the trial.

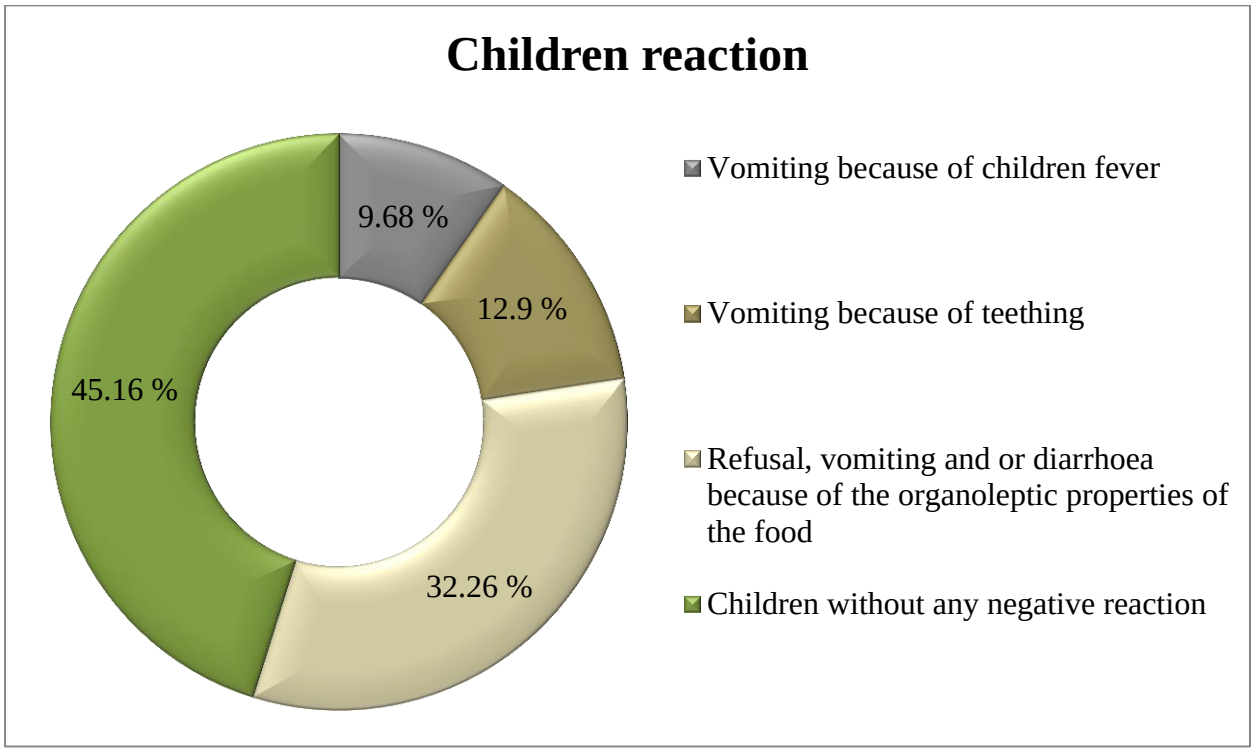

Figure 16 : Children reaction towards the food formula

4.2.4. Effect of the intervention on nutritional variables and indicators according to the acceptability of the food formula

Based on the above evidence, two categories of children were distinguished in the case group. The first category (category I) concerns children who consumed the food formula every day until the end of the trial and the second one (category II) made of children who were not able to consume the food because of disease or organoleptic properties of the formula. The effect of the intervention was then examined for each of this group, with the hypothesis that the children in category I will be positively affected by the intervention. Indeed, for category I, time has significant effect ($p<0.05$) on the weight and the Z-score (Table 6). Treatment significantly influenced ($p<0.05$) the weight. The DiD estimator was positive and significant

for the weight (Fig 7) but not significant for the Z-score. However, as for the children in the category II, time, treatment as well as DiD estimator had no significant effect on the nutritional variables such as weight, height and Z-score (table 8 & 9).

Moreover, results revealed that in the both categories, some children had recovery but more in the category I (62.50%) compared to those in the category II (29.41%) (Fig.17). Thus, no children with moderate malnutrition were found at the end of the trial in the category I whereas in the other one, 11.76% case of moderate malnutrition were still registered. The fruste malnutrition decreased in both categories but more in the category I (Fig. 17).

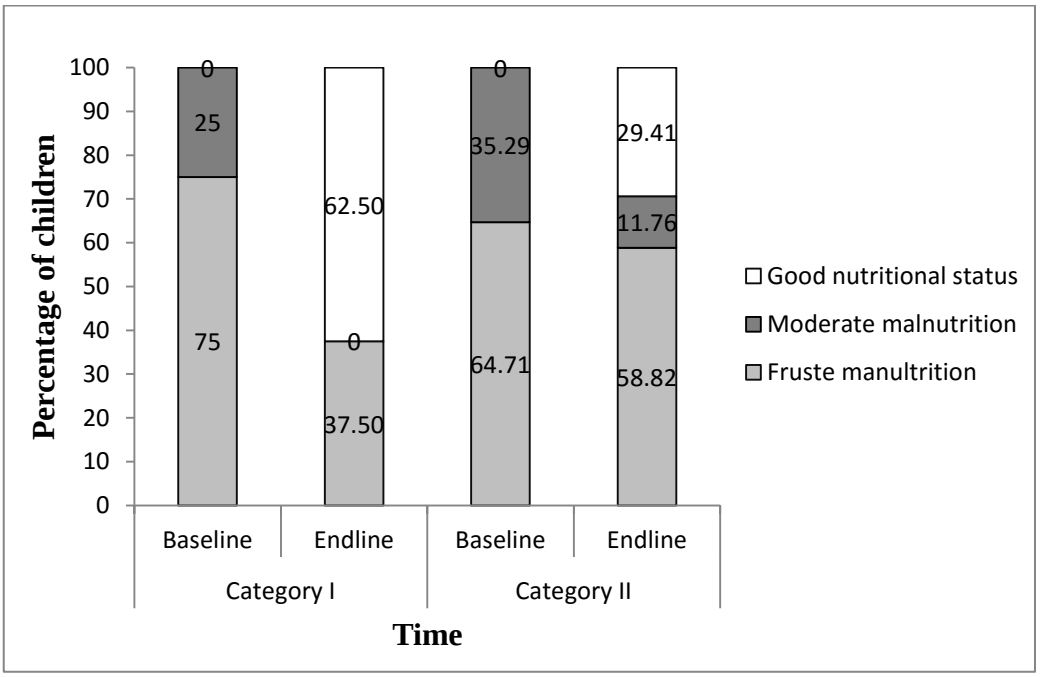

Figure 17 : Nutritional status of children in the case group at baseline and endline

Category 1: children who consumed the food formula every day until the end of the trial
Category 2: children who were not able to consume the food formula every day until the end of the trial because of its organoleptic properties or diseases.

Table 6 : Effect of the nutritional intervention on weight, height and z-sore of children in category I: results of the generalized estimating equations models

Terms in the models	Df	Weight		Height		Z-score	
		Wald-stat	p-value	Wald-stat	p-value	Wald-stat	p-value
Sex	1	0.186	0.666	1.870	0.172	0.101	0.751
Time	1	4.049	0.044	34.120	0.325	8.891	0.003
Treatment	1	0.000	0.988	0.064	0.800	0.353	0.552
DiD	1	8.583	0.003	0.305	0.580	2.248	0.134
Age	1	40.051	0.325	47.610	0.325	0.815	0.367
Sex * DiD	1	1.105	0.293	0.119	0.730	0.245	0.621

Table 7 : Summary of the models: coefficient, standard error and significance levels of children in category I

Terms in the model			Weight		Height		Z-score	
		Df	est(se)	p-value	est(se)	p-value	est(se)	p-value
Threshold	**[status=2] [status=1]**	1						
Intercept		1	5.877 (0.3624)	0.000	(1.5877)	0.000	-1.953 (0.2355)	0.000
Sex(1)		1	0.289 (0.4395)	0.511	2.861(2.0867)	0.170	0.008 (0.2212)	0.972
Time(1)		1	0.105 (0.0523)	0.044	-0.230 (0.0394)	0.325	0.310 (0.1038)	0.003
Treatment(1)		1	-0.005 (0.3396)	0.988	-0.381(1.5081)	0.800	0.119 (0.2004)	0.552
DiD		1	0.401 (0.1496)	0.007	0.018 (0.0287)	0.523	0.405 (0.3431)	0.238
Age		1	0.027 (0.0043)	0.325	0.126 (0.0182)	0.325	0.001 (0.0016)	0.367
Sex × DiD		1	-0.190 (0.1808)	0.293	-0.010 (0.0299)	0.730	-0.18 (0.36)	0.621

Df = degree of freedom, est = estimates, se = standard error of estimates, p-value = significance level

Reference: for sex was 0 (male), for time was 0 (baseline), for treatment 0 (control)

DiD is the estimator of the difference in difference and Sex × DiD is the estimator of the sex-specific DiD

Table 8 : Effect of the nutritional intervention on weight, height and z-sore of children in category II: results of the generalized estimating equations models

Terms in the models	Df	Weight		Height		Z-score	
		Wald-stat	p-value	Wald-stat	p-value	Wald-stat	p-value
Sex	1	0.078	0.780	1.404	0.236	0.065	0.799
Time	1	3.684	0.055	35.637	0.325	9.049	0.003
Treatment	1	3.532	0.060	3.827	0.050	0.303	0.582
DiD	1	0.050	0.824	0.935	0.334	0.617	0.432
Age	1	36.486	0.000	46.719	0.325	0.001	0.971
Sex * DiD	1	0.329	0.566	0.063	0.802	0.100	0.752

Table 9 : Summary of the models: coefficient, standard error and significance levels of children in category II

Terms in the model		Df	Weight		Height		Z-score	
			est(se)	p-value	est(se)	p-value	est(se)	p-value
Threshold	[status=2]	1						
	[status=1]	1						
Intercept		1	5.797 (0.4030)	0.000	62.878 (1.7713)	0.000	-1.740 (0.2163)	0.000
Sex(1)		1	0.069 (0.3992)	0.862	2.230 (1.8748)	0.234	-0.098 (0.1916)	0.609
Time(1)		1	0.100 (0.0523)	0.055	-0.267 (0.0447)	0.325	0.096 (0.1753)	0.003
Treatment(1)		1	0.599 (0.3188)	0.060	2.950 (1.5078)	0.050	-0.191 (0.2516)	0.582
DiD		1	-0.059 (0.1189)	0.618	-0.022 (0.0275)	0.430	-5.566E-05 (0.0015)	0.432
Age		1	0.030 (0.0049)	0.000	0.144 (0.0211)	0.325	0.313 (0.1039)	0.971
Sex × DiD		1	0.080 (0.1392)	0.566	-0.010 (0.0412)	0.802	0.093 (0.2942)	0.752

Df = degree of freedom, est = estimates, se = standard error of estimates, p-value = significance level

Reference: for sex was 0 (male), for time was 0 (baseline), for treatment 0 (control)

DiD is the estimator of the difference in difference and Sex × DiD is the estimator of the sex-specific DiD

DISCUSSION

V. DISCUSSION

This study tested the effect of the consumption of sorghum porridge fortified with moringa leaf powder and baobab fruit pulp on the nutritional status of children. Prior to this, determinants of the consumption of foods containing the moringa leaf powder and baobab fruit pulp were evaluated in the three biogeographic zones. Indeed there are several types of determinants of food consumption. Those addressed in this document were physical determinants, economic determinants, knowledges, attitudes, practices and perceptions.

5.1. Availability, accessibility, cultural beliefs and organoleptic attributes: consequence for acceptability of the food formula

The moringa leaf powder was found to be more available and accessible throughout the year in the Sudanian and the Guinean zones than in the Sudano-Guinean zone. This availability is most effective during the rainy season. Due to the fact that moringa leaf is difficult to be processed into powder, people in this area are more accustomed to the consumption of moringa leaves as a vegetable sauce than as powder to fortify foods. According to Madukwe et al., (2013), moringa plant is drought resistant and grows all the year round. However, baobab is more available in the Sudanian and Sudano-guinean zones than in the Guinean zone throughout the year and especially during the dry season but it quality can be deficient in scarcity period. As mentioned by Assogbadjo et al., (2005), in Benin, baobab fruit maturation period extends from December to March, approximately 6 to 7 months after the beginning of flowering which corresponds to the season of food shortage. While the accessibility of baobab was found to be more emphasized in the Sudanian and Guinean zone, Assogbadjo et al (2006) reported that the baobabs in the Sudanian and Sudano-guinean zones produce higher yields of pulp, seeds and kernels in comparison with the ones in the Guinean zone. As explained by the population, the non-accessibility of the baobab in the Sudano-guinean zone is due to the fact that the baobabs are generally found on the hills in this area and thus difficult to physically access, harvest and process. The food consumption frequency survey showed that foods traditionally prepared with baobab fruit pulp were more consumed in the Sudanian zone and not consumed in the Guinean zone. Previous studies showed that food habits are passed on from generation to generation and that baobab utilization and knowledge about baobab decreases from northern to southern Benin (Chadare et al., 2008). According to Assogbadjo et al., (2006) in the South of Benin (Guinean zone), the species was considered as diabolic and the seedlings and saplings are systematically removed from the traditional agroforestry systems by the farmers whereas in the center and north of Benin

(Sudano-Guinean and Sudanian zones), the species has an economical and cultural value and is over-exploited for food and medicinal purposes by local people. Note that currently, though baobab is not consumed in Southern Benin rural area, its economic importance is more and more valued in towns. This could be explained by the fact that the taboos observed by Assogbadjo et al (2006), are perhaps given up in this area over time due to research advertisement and claims about nutritional value of the fruit pulp performed by some non-governmental organizations. Furthermore, the populations showed a high level of knowledge about the nutritional and medicinal benefits of moringa leaf powder and baobab fruit pulp. This knowledge was more emphasized on the moringa leaf powder in the Sudanian and Sudano-guinean zone than in the Guinean zone although this powder is less consumed in the Sudanian zone. The nutritional advantages of both moringa leaf powder and baobab fruit pulp were more known compared to the medicinal ones. Indeed, according to Madukwe et al., (2013), dry Moringa leaf extract is rich in essential nutrients and is suitable in food supplementation. For Kasolo et al., (2010), the rural community in Uganda use *Moringa oleifera* leaves to treat common diseases but a few use it for preventing and treating malnutrition. Nevertheless moringa leaf powder and baobab fruit pulp showed some limits related to their taste, smell, color that do not facilitate their consumption. In addition the baobab fruit pulp was more appreciated in the study area than the moringa leaf powder in terms of organoleptic properties. Indeed Adejuyitan et al., (2012), found that fortification of Ogi using baobab fruit pulp showed that 50% level of substitution had slightly highest sensory scores for taste and general acceptability while 0 and 20% level had higher sensory scores for color and appearance but all the fortified samples were acceptable. At the same time, the fortification of yam flour with moringa leaf powder showed that the addition of this powder greatly affected the aroma and overall acceptability of the sample (Karim et al., 2013). However, for Oyeyinka and Oyeyinka, (2016), in many parts of the world including Africa, the use of moringa as a food fortificant is on the increase: for instance, both fresh and dried moringa leaves are included in meals in African countries such as Ghana, Nigeria, Ethiopia, East Africa and Malawi. Of all the above, the moringa leaf powder and baobab fruit pulp are more available, accessible and more consumed in the Sudanian zone but are not used the right way. It becomes therefore important to perform a nutrition intervention, in the Sudanian zone among vulnerable group, using food fortified with moringa leaf powder and baobab fruit pulp, taking into account the sensory properties, bioavailability of nutrients contained in the food formula as well as the nutritional needs of the target group in order to

facilitate the perpetuation of the consumption of the fortified food. As highlighted by Oyeyinka and Oyeyinka, (2016), foods to be fortified must be consumed adequately by a large proportion of the target individuals in a population. The fortificant should also be readily available, accessible and well absorbed into a food without causing a significant change in the sensory attributes of the fortified foods (Allen, 2006).

5.2. Children's dietary diversity and cultural beliefs

The children diet in both groups at baseline and endline was essentially based on cereals; legumes, nuts and seeds; dark green leafy vegetables; others vegetables; and others fruits. As explained by mothers, the children diets are almost limited to these groups of food not only because these foods are commonly cultivated or locally available in the study area but also the previous season was not good due to the rain delay. This favors the consumption of the same meal by children almost all day long. However, children diets were most of the time composed of many groups of food. For example to cook a sauce called ''beans sauce'', mothers used up to 3 groups of food such as: legume beans, moringa leaf and baobab leaf, tomato and onion. In addition, this sauce is accompanied with cereal based food (maize, sorghum, millet) and fruits (tamarin fruit, mango, baobab fruit, African Locust fruit) are then consumed as dessert. Thus, children may achieve the minimum dietary diversity score even by eating only one type of meal all day long. Nevertheless, it is important to mention that children diets were poor in animal protein such as fish, milk products and meat. As explained by mothers, family resources are needed to access them. This study was in accordance with Kabahenda et al., (2011) who found that changes in food-selection practices were determined by food access. In addition, Egyir et al., (2016), reported that animal protein based foods such as meat and milk were often reserved for special occasions or provided to adult male household members because most mothers could not afford to buy them. The notion that complementary foods fed to children aged 6–24 months, particularly in developing countries, are plant-based and are not sufficient to meet nutrient needs at this age is supported by Waswa et al., (2015). In the present study, no taboo related to the consumption of animal protein source foods among children was found but the importance of the consumption of these foods was not well known by caregivers. However, from the study performed in China, Nepal, Ethiopia, Kenya, mothers believed that animal protein source foods such as egg, fish and meat should be avoided in children diet because: they are "difficult to digest" for children under the age of one year; it would encourage unrealistic taste preferences but it would not always be possible to meet; feeding young children eggs could result in delayed speech

development (Waswa et al., 2015; Alive and Thrive, 2010; Shi et al., 2009). It is somewhat surprising that the several nutrition education performed in rural areas were not able to improve the consumption of animal protein source foods by children. Nevertheless, Kuchenbecker et al., (2017) reported that participatory community-based nutrition education for caregivers improved child dietary diversity even in a food insecure area. Moreover Kabahenda et al, (2009) found that a nutrition education among Ugandan caregivers significantly improved feeding practices and children's nutritional status. Of all the above, the need for interventions especially strategies focusing on food diversification that aim to increase the production, availability and accessibility of animal-source foods and to address barriers affecting the consumption of a variety of animal protein source foods among young children should be a good asset.

5.3. Acceptability and potential of moringa leaf powder and baobab fruit pulp fortified food to improve nutritional status of children

The results from the intervention (consumption of 400g of sorghum porridge fortified with 10g of moringa leaf powder and 5g of baobab fruit pulp) revealed that the treatment had no significant effect on the weight and z-score when all children (category I: children who consumed the food formula every day until the end of the trial and category II: children who were not able to consume the food formula every day until the end of the trial because of the organoleptic properties or diseases) are considered in the statistical analysis. Note that some cases of vomiting, diarrhea and malaria were observed throughout the study. This may be due to the fact that the study registered some limits that may influence the results. Indeed children were not dewormed before the trial. Moreover no analysis was performed, as regards to parasitic infection and malaria, to eliminate all risk of intestinal nutrient malabsorption during the intervention. For mothers, some cases of illness are due to the fact that children are teething. Supporting this, in one prospective study, mothers of 224 infants reported 74% and 100% to suffer at least one local disturbance during the eruption of the front and backteeth, respectively (Swann et al 1979). Moreover, Tasanen (1968) ascribed daytime restlessness, increased finger sucking, gum rubbing, drooling and loss of appetite to teething. Failure to observe the hygiene rules (consumption of unwashed fruit by children for example) in this area could lead to infections and consequently make dentition more difficult for children. Furthermore, although the sensory test, performed among some children in the study area, indicated that the food formula was acceptable, it consumption every day for two weeks was a challenge for some children. Thus, 32.26% of children showed resistance to the formula,

vomiting, had diarrhea during the trial. Indeed, moringa leaves are more consumed as a vegetable sauce in the study area than as fortificant in porridge. Zongo et al (2016) also pointed out the problem of acceptability among of children (3.84%) who vomited, had diarrhea, showed resistance to their first bowls of porridge mixed with moringa leaf powder during the first week because the use of moringa imparted green coloration to the products making them appear greenish. However, the problem of acceptability was not indicated by Houndji et al (2013) as moringa is mixed with any food ready to be consumed by children. In addition, in this same study, children may not consume the 10g of this powder with a single food during a day. The composition of the staple food, the number of fortified food intake during the day and the amount of fortified food are not mentioned in Zongo et al, (2016). Thus, the staple food used in this study could be more compatible with moringa in terms of color and taste than the one use in the present study. Although in addition to moringa leaf powder, the baobab fruit pulp which was much appreciated by children in the study area, was also used as a fortificant, the rate of acceptability of food formula is low. However, the amount of moringa used in this food formula is greater than that of baobab. Note that children's mothers generally mention in the present study that their children have lack of appetite. As explained above, the previous season was not good and thus children eat the same meal almost every day. This may slightly affect their appetite and therefore affect the acceptability of the food formula. According to Rusell and Worsley, (2016), the appetitive traits fussiness, food responsiveness and enjoyment of food were associated with children's food preferences in meaningful way. However, an acceptable average weight gain (9.85 g/kg/day) was obtained.

This average weight gain is higher to the one found by Zongo et al (2016) (8.9 ± 4.3) when the standard nutritional care diet with 10g of moringa leaf powder was administrated to children for 6 weeks though the present intervention last only two weeks. The recovery rate obtained was 45.16% when all children (category I and II) are considered. According to the DSME, (2011), the recovery rate should be > 75% with an average length of stay of 4 weeks to conclude an adequate treatment. It is important to mention that the rate of children who consumed the formula without any negative reaction was also 45.16% when all children are concerned. Thus, a deeper analysis of the data by categorizing children revealed that children who consumed the food formula every day for two weeks (category I) had their weight improved significantly at the end of the trial compared to those who didn't consumed the food formula every day (category II). In addition, the recovery rate was 62.50 % among

children who consumed regularly the food against 29.41 % among those who didn't eat every day. Note that all the children had recovery from severe malnutrition after 6 weeks in the study performed by Zongo et al (2013). With the shorter duration stays, and so the efficient recovery and average weight gain in the present study, an extension of the duration up to 4 weeks could allow achieving at least 75% of recovery rate. The results from this study are in accordance with those obtained by Houndji et al. (2013) and Zongo et al. (2013), in which the daily supplementation of 10g of moringa leaf powder for six months improved significantly children weight and Z-score. However the z-score was not significantly improved in the present study, possibly because of the short term of the intervention. In addition, the sample was composed of moderate and fruste malnutrition and thus, a bit improvement of Z-score even not significant may result in children recovery from fruste malnutrition. However, according to Zongo et al. (2013) the supplementation of 10g of moringa leaf powder for six months didn't improve significantly the hemoglobin rate in either group (experimental and control groups). This may be explained by the fact that a small number of children showed resistance to their first bowls of porridge mixed with moringa leaf powder during the first week or the dose 10g was not high enough to make a significant improvement in hemoglobin rate or the staple food used did not favor the bioavailability of the iron. Indeed Hemalatha et al., (2007) reported that the bioavailability of micronutrients, particularly zinc and iron is low from plant foods. As confirmed by Macharia-Mutie et al., (2012), the consumption of maize porridge fortified with low-dose highly bioavailable iron multi-micronutrient powder reduce the prevalence of iron deficiency anemia in preschool children but the fortification of this same maize porridge with amaranth grain did not improve the iron status despite a large increase in iron intake, likely due to high ratio of phytic acid/ iron in the meal. Ndong et al., (2007) highlighted that the iron in moringa leaf is not totally available and therefore the food fortified with this powder affects a bit the iron bioavailability. As for Kayodé et al., (2012), polyphenols, especially those condensed such as tannins, are also contained in the sorghum grains and have the faculty to complex the cations (Fe 2+, Zn 2+), decreasing their bioavailability. The authors reported that the washing of sorghum grain, soaking, sieving and the fermentation are the process that decreases significantly the total phenols and anthocyanin in the sorghum porridge. Thus, Abrams et al., (2003) found that the use of multiple fortification strategies, which includes fortified beverages, has several advantages such as: ease of distribution, high levels of acceptance, the ability to provide the beverage isolated from meals containing substances such as phytates, which can inhibit nutrient absorption, and

the potential for purchase by private consumers rather than reliance on government programs. Although the present study was not researching the effect of the intervention food on the iron deficiency, it is important to mention that the sorghum porridge used in this study is fermented and the baobab fruit pulp is an acidulant that can facilitate the bioavailability of iron contained in both moringa leaf powder and sorghum grain. Nevertheless, for Tété-Bénissan et al., (2012), the daily supplementation of 25g/ day for nursling, 30 g / day for children of moringa leaf powder for 14 weeks increase of red blood cell, hemoglobin, hematocrit mean cell volume, mean cell hemoglobin concentration and for mean cellular hemoglobin concentration values and the increase in hemoglobin is more important among seronegative subject. It would be interesting to perform an intervention to find out the effect of the food formula tested in the present study on hemoglobin rate in children.

CONCLUSION

CONCLUSION

The study was designed to assess the determinants of the consumption of foods containing moringa leaf powder and baobab fruit pulp but also to test the effect of the food formula on the nutritional status of children. It was found that the moringa leaf powder and baobab fruit pulp are more available, accessible and more consumed in the Sudanian zone than in the others. In addition, mothers have high level of knowledge in terms of nutritional and medicinal importance about the two resources in the three biogeographic zones. No taboos related to the consumption of moringa leaf powder and baobab fruit pulp were registered during the survey. However, children perceptions were related to the uncommon taste, color and smell of moringa leaf powder. As for the intervention, the daily consumption of the fermented sorghum porridge fortified with moringa leaf powder and baobab fruit pulp for two weeks improved significantly the children weight at the end of the trial but did not improve significantly their z-score. An acceptable recovery rate and average weight gain were obtained but children diet was poor in animal source protein. Therefore, the sorghum porridge fortified with moringa leaf powder and baobab fruit pulp should be a good food to food fortification formula that may contribute to fight against children malnutrition in Benin. For further research, the findings from the present study suggest:

- An improvement of the food formula in order to make it more acceptable by children even those who are sick;
- Nutritional intervention to test the effect of the food formula on the children iron deficiency;
- Interventions focusing on food diversification aimed to increase the production, availability and accessibility of animal-source foods and to address barriers affecting the consumption of a variety of animal-source foods among young children.
- A promotion of the food formula in the two municipalities of Benin such as Karimama and Malanville, where the rate of malnutrition remains so high.

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ANNEXES

ANNEXE 1: Poster

Effet de la consommation de bouillie de sorgho fortifiée avec la poudre de feuille de moringa et la pulpe de fruit de baobab sur l'état nutritionel des enfants agés de 6 à 59 mois au Nord du Bénin

Agossadou J.O.[2], Chadare F.J.[1], Nago E.[3], Houndji S[2], Madode Y.E.[1], Moumouni, M.I.[4], Hounhouigan D.J.[1]
[1] Laboratoire de Science des Aliments, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi
[2] Ecole de Nutrition, Science et Technologie Alimentaire, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi
[3] Ecole des Sciences et Techniques de Conservation et de Transformation des Produits Agricoles, University d'Agriculture de Kétou
[4] Faculté des Sciences Agronomiques, Université de Parakou
Auteur correspondant: fchadare@gmail.com


Poudre de feuille de moringa


Matériels de travail


Pulpe de fruit de baobab

INTRODUCTION

La malnutrition sous toutes ses formes reste l'un des problèmes de santé les plus sérieux en Afrique Sub-saharienne. La fortification alimentaire par les aliments utilisant la poudre de feuille de moringa et la pulpe de fruit de baobab pourrait être une solution potentielle.

OBJECTIFS

- Evaluer les déterminants de la consommation des aliments préparés avec la poudre de feuille de moringa et la pulpe de fruit de baobab au Bénin;
- Tester l'effet de l'aliment formulé sur la malnutrition aiguë chez les enfants agés de 6 à 59 mois au Nord du Bénin.

METHODOLOGIE

Une enquête a été effectuée dans les trois zones biogéographiques du Bénin sur les déterminants de la consommation des aliments contenant la poudre de feuille de moringa et la pulpe de fruit de baobab. Ensuite, une intervention nutritionnelle a été réalisée au nord du Bénin chez les enfants âgés de 6 à 59 mois souffrant de la malnutrition aiguë modérée ou fruste. Le groupe d'intervention a consommé quotidiennement 400g de bouillie de sorgho fortifiée avec 10g de poudre de feuille de moringa et 5g de pulpe de fruit de baobab dans un foyer de récupération nutritionnelle pendant deux semaines. L'étude a été approuvée par le comité d'éthique (CNERS).

RESULTAT

Table 1: Evaluation des déterminants de la consommation des aliments préparés avec la poudre de feuille de moringa et la pulpe de fruit de baobab dans les zones biogéographiques du Bénin

Déterminants	Zone Soudanienne	Zone Soudano-Guinéenne	Zone Guinéenne
Disponibilité et accessibilité de la poudre de feuille de moringa	+++	+	++
Disponibilité et accessibilité de la pulpe de fruit de baobab	+++	+	++
Consommation des aliments contenant la poudre de feuille de moringa	+++	+	++
Consommation des aliments contenant la pulpe de fruit de baobab	+++	++	+

La zone Soudanienne est la zone où ces ressources alimentaires sont plus disponibles, accessibles et plus consommés. L'intervention nutritionnelle a été donc effectuée dans cette zone.
La consommation de l'aliment formulé pendant deux semaines a permis de réduire de façon significative la prévalence de la malnutrition aiguë (Fig.2). Cependant le Z-score poids pour taille ne s'est pas amélioré significativement (Fig.1). Le taux de récupération nutritionnel et le gain de poids moyen étaient respectivement de 62,50% et de 9,85g/kg/jour.

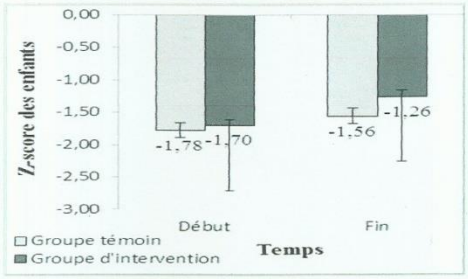


Figure 1: Z-score poids pour taille des enfants dans les deux groupes

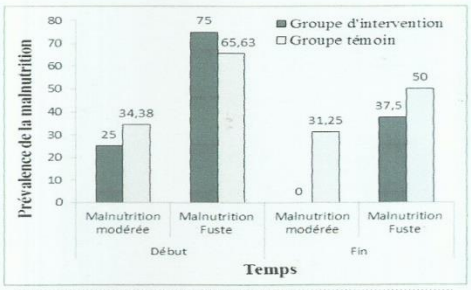


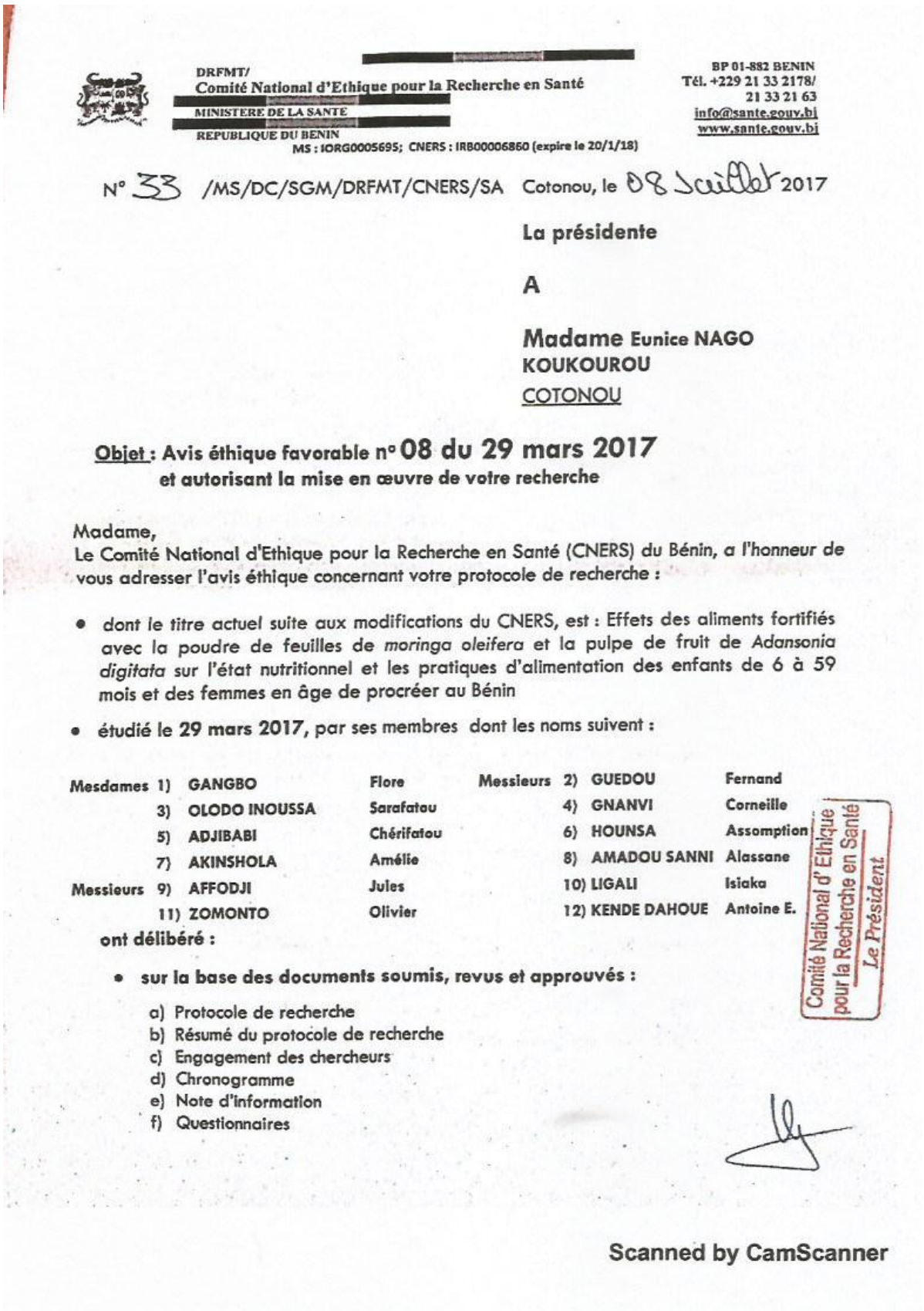
Figure 2: Prévalence de la malnutrition aiguë dans les deux groupes

CONCLUSION

La bouillie de sorgho fortifiée avec la poudre de feuille de moringa et la pulpe de fruit de baobab pourrait être une bonne formule alimentaire qui peut contribuer à lutter efficacement contre la malnutrition infantile au Benin.

REMERCIEMENTS:

ANNEXE 2: Avis éthique favorable



DRFMT/
Comité National d'Ethique pour la Recherche en Santé
MINISTERE DE LA SANTE
REPUBLIQUE DU BENIN
MS : IORG0005695; CNERS : IRB00006860 (expire le 20/1/18)

BP 01-882 BENIN
Tél. +229 21 33 2178/
21 33 21 63
info@sante.gouv.bj
www.sante.gouv.bj

N° 33 /MS/DC/SGM/DRFMT/CNERS/SA Cotonou, le 08 Juillet 2017

La présidente

A

Madame Eunice NAGO KOUKOUROU
COTONOU

Objet : Avis éthique favorable n° 08 du 29 mars 2017 et autorisant la mise en œuvre de votre recherche

Madame,
Le Comité National d'Ethique pour la Recherche en Santé (CNERS) du Bénin, a l'honneur de vous adresser l'avis éthique concernant votre protocole de recherche :

- dont le titre actuel suite aux modifications du CNERS, est : Effets des aliments fortifiés avec la poudre de feuilles de *moringa oleifera* et la pulpe de fruit de *Adansonia digitata* sur l'état nutritionnel et les pratiques d'alimentation des enfants de 6 à 59 mois et des femmes en âge de procréer au Bénin
- étudié le **29 mars 2017**, par ses membres dont les noms suivent :

Mesdames	1)	GANGBO	Flore	Messieurs 2)	GUEDOU	Fernand
	3)	OLODO INOUSSA	Sarafatou	4)	GNANVI	Corneille
	5)	ADJIBABI	Chérifatou	6)	HOUNSA	Assomption
	7)	AKINSHOLA	Amélie	8)	AMADOU SANNI	Alassane
Messieurs	9)	AFFODJI	Jules	10)	LIGALI	Isiaka
	11)	ZOMONTO	Olivier	12)	KENDE DAHOUE	Antoine E.

ont délibéré :

- **sur la base des documents soumis, revus et approuvés :**
  a) Protocole de recherche
  b) Résumé du protocole de recherche
  c) Engagement des chercheurs
  d) Chronogramme
  e) Note d'information
  f) Questionnaires

Comité National d'Ethique pour la Recherche en Santé
Le Président

Scanned by CamScanner

g) Budget
h) Demande adressée à la Présidente du Comité
i) Formulaire de consentement éclairé

- **ainsi que sur la base de** l'avis scientifique fourni par l'expert HOUNDJI B. Victor Saturnin

Aucun conflit d'intérêt n'a été évoqué, ni par les membres du CNERS, ni par les chercheurs.

Après avoir validé globalement les aspects scientifiques et évalué les aspects éthiques centrés sur : les bénéfices attendus pour la santé des participants à la recherche et ainsi que sur la qualité des informations transmises en vue de l'obtention d'un consentement libre et éclairé, le CNERS a émis un **Avis éthique favorable n°08 du 29 mars 2017.**

Le présent avis éthique favorable est exécutoire et vous autorise à mettre en œuvre la recherche ci-dessus intitulée.

Il est valable pour une durée d'un (01) an à compter de sa date de signature. Passé ce délai, vous êtes tenu de soumettre votre protocole à une nouvelle ré-évaluation du CNERS.

Par ailleurs, le CNERS vous demande de :

1) **l'informer de** toute nouvelle information/ modification, qui surviendrait à une date ultérieure à cette approbation-ci et qui impliqueraient des changements dans le choix des participants à la recherche, dans la manière d'obtenir leur consentement, dans les risques encourus ou tout évènement indésirable survenant dans le cadre du déroulement de cette recherche.

   Le CNERS doit, en effet, dans ces cas, ré-évaluer et donner une nouvelle approbation avant l'entrée en vigueur desdites modifications

2) **utiliser les documents qu'il a validé;**
3) **faire signer au participant, le formulaire de consentement, en deux exemplaires,** dont l'un lui sera remis et l'autre, conservé dans vos dossiers ;
4) **lui adresser un rapport, au terme de la validité** de cet avis éthique.

Tout en vous souhaitant plein succès dans la réalisation de votre recherche, le CNERS vous prie de recevoir Madame, ses salutations les meilleures.

Comité National d' Ethique pour la Recherche en Santé
Le Président

La présidente

Professeur Flore GANGBO

Avis éthique favorable n° 08 du 29 mars 2017

ANNEXE 3 : Autorisation de rédaction de Mémoire de Master en Anglais

RÉPUBLIQUE DU BÉNIN
UNIVERSITÉ D'ABOMEY-CALAVI
FACULTÉ DES SCIENCES AGRONOMIQUES
Vice-Doyen

COORDONNATEUR DES ETUDES

N° 879/17 /FSA/UAC/VD-CE Abomey-Calavi, le 31/05/ 2017

Le Vice-Doyen, Coordonnateur des Etudes

A

Madame AGOSSADOU Julienne
(Etudiante en Master NHSA/FSA/UAC)

Objet : a/s votre demande d'autorisation de rédaction de mémoire de Master en anglais

Madame AGOSSADOU,

J'ai pris connaissance du contenu de votre lettre enregistrée sous le numéro 871 du 5 avril 2017 relative à votre demande d'autorisation de rédaction du mémoire de master en anglais.

Après examen de votre demande, la Coordination des Etudes vous autorise à le faire, à condition que la soutenance dudit mémoire se déroule aussi bien en français qu'en anglais, devant un jury mixte composé de francophones et d'anglophones, pour une meilleure analyse du document.

Tout en espérant que cette explication qui vous est fournie vous servira pour que la soutenance se passe dans les meilleures conditions possibles, je vous prie de recevoir, Madame AGOSSADOU, mes salutations cordiales.

Le Vice-Doyen, Coordonnateur des Etudes

Le Vice Doyen

Professeur Bonaventure Cohovi AHOHUENDO

Copies à :
Doyen (ATCR) : 01
Vice-Doyen : 01
SGE : 01
Chrono : 01

Campus universitaire d'Abomey-Calavi. Tél. :(229) 21 36 01 22 / 21 04 83 10 - Fax : (229) 21 36 01 22
03 BP 2819 R.P. COTONOU E-mail : fsa.uac@fsa.uac.bj - Site web : www.fsa-uac.org

ANNEXE 4: Note d'information

Effet de la bouillie de sorgho fortifiée avec la poudre de feuille de *Moringa oleifera* et la pulpe de fruit de baobab sur l'état nutritionnel des enfants âgés de 6 à 59 mois et des femmes en âge de procréer au Bénin

Nous vous sollicitons à participer à cette étude réalisée selon la loi n°87-015 du 21 septembre 1987 relative à la politique de santé publique. Nous vous présentons ici les informations nécessaires pour comprendre l'intérêt et le déroulement de l'étude. Lisez attentivement cette notice, posez toutes les questions qui vous sembleront utiles. Après avoir obtenu les réponses satisfaisantes à vos questions et disposé d'un détail de réflexion suffisant, vous pourrez alors décider si vous voulez participer à l'étude ou non.

Pourquoi cette étude ?

La malnutrition sous toutes ses formes reste un problème de santé sérieux et négligé. Cependant, le moringa et le baobab sont deux ressources alimentaires locales connues des populations du fait de ses propriétés nutritionnelles avérées. Ainsi la fortification des aliments avec la poudre de feuilles de moringa et la pulpe de fruit de baobab constituera un grand atout pour améliorer le statut nutritionnel des enfants et des femmes qui sont des groupes vulnérables de la société.

Quel est l'objectif de cette étude ?

L'objectif principal de cette étude est d'évaluer l'effet des aliments fortifiés avec la poudre de feuilles de moringa et la pulpe de fruit de baobab sur le statut nutritionnel des enfants de 6 à 59 mois et des femmes en âge de procréer.

Comment va se dérouler cette étude ?

L'étude se déroulera dans trois zones biogéographiques du Bénin : le nord, le sud et le centre. Cette étude durera 6 mois et va inclure des couples mère-enfants qui seront subdivisés en deux groupes dont l'un consommera tous les jours les aliments formulés avec la poudre de feuille de moringa et la pulpe de fruit de baobab et l'autre sera témoin donc prendra les

aliments habituellement consommés dans le milieu. Une formation sera organisée au cours de laquelle la façon de préparer les aliments sera expliquée aux participants après les avoir sélectionnés.

Qui peut participer?

Pourront se porter volontaires pour cette étude les couples mères-enfants c'est-à-dire les femmes en âge de procréer (de 15 à 49 ans) ayant des enfants de 6 à 59 mois résidant dans la zone et capable d'y résider durant toute l'étude.

Que vous demandera-t-on?

- Au cours de cette étude, vos informations personnelles telles que votre nom, prénom, votre âge, statut matrimoniale, votre état physiologique (enceinte ou non) seront recueillies.
- Des questionnaires relatifs aux fréquences de consommation alimentaire, attitudes et pratiques vous seront posés avant, pendant et après l'intervention. Les mères ou tuteurs dans les échantillons d'étude seront les répondants de cette enquête
- Vos mesures anthropométriques (poids et taille) et des prélèvements sanguins seront aussi pris.
- Il vous sera aussi demander de consommer pendant six mois des formules d'aliments, disponibles dans votre localité et auxquels vous êtes déjà habitués.

Quels sont vos droits ?

Toutes les informations vous concernant recueillies pendant cette étude seront traitées de façon confidentielle, avec codage des données ne faisant pas apparaître les données nominatives. Les résultats de cette étude ne seront utilisés qu'à des fins scientifiques conformément à l'article 15 de la loi n° 2009-09 du 21 mai 2009 portant protection des données à caractère personnel en République du Bénin. Seuls les responsables de l'étude pourront avoir accès à ces données. A l'exception de ces personnes, qui traiteront les informations dans le plus strict respect du secret scientifique, la confidentialité de vos données sera préservée. Les données enregistrées à l'occasion de cette étude feront l'objet d'un traitement informatisé. Vous pourrez à tout moment décider de vous soustraire à cette étude, sans avoir donné les raisons de motivation de cette

décision, et sans aucune conséquence pour vous. En tant que participant à l'étude, vous serez informé des résultats globaux de l'étude à la fin de son élaboration.

Quels sont les avantages liés à cette étude ?

Cette étude vous permettra de consommer des aliments disponibles dans votre localité qui ont étés formulés au laboratoire en fonction des besoins nutritionnels des femmes en âge de procréer et des enfants de 6 à 59 mois. Les participants sont habitués à la consommation des aliments dont la valeur nutritionnelle est en adéquation avec leur besoin nutritionnelle. Ainsi à la fin de cette étude, le statut nutritionnel des participants se verra améliorer d'une manière ou d'une autre. Les résultats obtenus de cette étude permettront de promouvoir et de vulgariser ces formules d'aliments à toute la population afin de lutter contre la malnutrition. L'étude permettra de valoriser les ressources locales.

Quels sont les risques liés à cette étude ?

Les participants auront à consommer les aliments auxquels ils sont déjà habitués et dont la formulation a été réalisée au laboratoire. Les prélèvements sanguins seront pris par les agents qualifiés. Cette étude n'affectera ni l'état état physiologique, ni l'état état psychologique ou encore la santé des participants.

Cette note d'information vous appartient et vous pouvez la communiquer à vos proches pour avis.

Nous vous remercions de votre coopération.

ANNEXE 5: Formulaire de consentement (personne majeure)

Je soussigné (e),……. déclare avoir lu la note d'information concernant l'étude **« Effet des aliments fortifies avec la poudre de feuilles de *Moringa oleifera* et la pulpe de fruit de baobab *Adansonia digitata* sur l'état nutritionnel et les pratiques d'alimentation des enfants de 6 à 59 mois et des femmes en âge de procréer (15 à 49 ans) au Bénin»** et accepte d'y participer.

J'ai reçu une explication concernant la nature, le but, la durée de l'étude et j'ai été informé de ce qu'on attend de ma part. Je suis libre de participer ou non, d'abandonner ma participation à l'étude à tout moment sans qu'il soit nécessaire de justifier ma décision et sans que cela n'entraîne le moindre désavantage pour moi. J'accepte que les données sur moi fassent l'objet de traitements ultérieurs à des fins scientifiques, en relation directe avec les objectifs de la recherche ci-dessus mentionnés, dans le respect de la loi Béninoise n°2009-09 du 27 avril 2009 relative à la protection de la vie privée à l'égard des traitements de données à caractère personnel. Mon nom, les réponses aux questionnaires et mes informations personnelles seront gardés confidentiels. Les responsables scientifiques de cette étude et les personnes qui traiteront les données s'engagent à respecter cette confidentialité de données. J'accepte que les résultats de cette étude, qui seront toujours anonymes, soient diffusés à des fins scientifiques et en respectant la déontologie de la communauté scientifique. Les responsables du traitement de ces données (*Nom-prénom*) peuvent être contactés à l'adresse suivante :

AGOSSADOU Julienne : 00 229 96 94 40 02

SOMESSI Axèl : 00 229 95642164

Je consens de mon plein gré à participer à cette étude.

Nous vous remercions d'apposer la mention « lu et approuvé ».

…….....

Signature du sujet/participant *Date (jour/mois/année)*

Le sujet confirme son accord de participation par sa signature personnelle datée.

Je confirme que j'ai expliqué la nature, le but et la durée de l'étude à l'enquêté(e) mentionné ci-dessus.

…… ……

Signature de la personne qui procure l'information *Date (jour/mois/année)*

ANNEXE 6: Fiches de collecte de données anthropométriques

Date de l'enquête …….....……..... Nom de l'enquêteur ……

Commune …… Village …….....

Heure début ……Heure de fin ……

Informations sur les participants

Mère

Nom et Prénom (s)…….....……

Age …… Numéro de Téléphone (le cas échéant) ……

(Prendre le contact téléphonique du chef de ménage ou d'un proche si la mère n'en n'a pas)

Maison (nom et prénoms du chef de ménage/concession) …….……..……

Enfant *Enfant le plus jeune (6-59 mois) chez la femme enquêtée (si jumeaux ou triplés les prendre tous en compte, annexer un autre exemplaire de cette fiche au besoin)*

N°	Prénom et Nom	Poids1 (kg)	Poids 2 (kg)	Taille1 (cm)	Taille 2 (cm)
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					

ANNEXE 7 : Questionnaire rappel de 24 h

Quels sont les repas que vous avez consommés dans les 24 dernières heures ? Décrivez les aliments et donnez la quantité de chaque aliment.

Type de repas	Nom de l'aliment consommé	Description de l'aliment	Quantité de repas consommé Code portion [a]
Petit déjeuner			
Déjeuner			
Gouter			
Diner			

[a] bol codé servant d'instrument de mesure

COMMENTAIRES OU OBSERVATIONS EVENTUELLES

……
……
……

Rappel qualitatif des aliments sur les dernières 24 heures

Faire un rappel des aliments mangés au cours des 24 dernières heures avant l'enquête afin d'indiquer les groupes d'aliments consommés par l'enfant et indiquer le nombre de fois (utiliser le tableau correspondant). Ce tableau pourrait être rempli par l'enquêteur sur la base des informations de II.

Liste des groupes d'aliments pour les enfants de 24 à 59 mois		Oui	Non	Si oui, lesquels ?
G1	Céréales			
G2	Racines et tubercules			
G3	Légumineuses, noix et graines			
G4	Légumes vert foncé à feuilles			
G5	Autres légumes			
G6	Fruits riches en fer			
G7	Autres fruits			
G8	Abats			
G9	Viande			
G10	Œufs			
G11	Poisson			
G12	Lait et produits laitiers			
G13	Huiles et graisses			

ANNEXE 8 : Questionnaire KAP et checklist

1. Est-ce que votre enfant consomme-t-il du moringa/ Baobab ?

- Moringa ☐

- Baobab ☐

2. Quelles sont les raisons qui vous poussent à lui donner :

a. Le moringa

- Raisons économique s
- Qualités organoleptiques
- Qualités nutritionnelles
- Qualités médicinales

b. le Baobab

- Raisons économiques
- Qualités organoleptiques
- Qualités nutritionnelles
- Qualités médicinales

3. Quels sont selon vous les effets de la consommation des aliments fortifiés avec la poudre de feuille de moringa sur les enfants 6-59 mois? (sonder sur l'état nutritionnel : traitement de l'anémie, croissance, force ; la réaction des consommateurs)

……
……
……
……

4. Quels sont selon vous les effets de la consommation des aliments fortifiés avec la pulpe de baobab sur les enfants 6-59 mois? (sonder sur l'état nutritionnel : traitement de l'anémie, croissance, force.. ; la réaction des consommateurs)

……
……

……
……

5. Quels sont les facteurs qui pourraient vous encourager à utiliser comme fortifiant dans votre alimentations et celles de vos enfants de 6-59 mois ? (sonder les facteurs socioculturel, nutritionnel, personnes…)

a. La poudre de feuille de moringa

……
……
……
……
……

b. La pulpe du fruit de baobab

……
……
……
……
……

6. Quels sont les facteurs qui pourraient vous décourager à utiliser comme fortifiant dans votre alimentations et celles de vos enfants de 6-59 mois ? (sonder les facteurs socioculturel, nutritionnel, les personnes…)

a. La poudre de feuille de moringa

……
……
……
……

b. La pulpe du fruit de baobab

……
……
……

……

……

7. Comment savez-vous :

a. l'importance de la consommation du moringa?

- Média
- Parents
- De bouche à oreille

b. l'importance de la consommation du baobab?

8. Est-il bon selon vous de consommer régulièrement :

a. la poudre de feuille de moringa ?

Oui ☐

Non ☐

Sinon pourquoi ?

……
……
……
……

b. la pulpe de fruit de baobab ?

Oui ☐

Non ☐

Sinon pourquoi ?

……
……
……
……

9. Est-ce que le moringa est disponible et accessible dans votre localité ?

Oui ☐

Non ☐

Sinon que faites-vous pour qu'il soit disponible et accessible ?

……
……
……

10. Est-ce que le baobab est disponible et accessible dans votre localité ?

Oui ☐

Non ☐

Sinon que faites-vous pour qu'il soit disponible et accessible ?

11. Quels sont les tabous liés à la consommation de la poudre de feuille de moringa dans votre village/communauté ?

……
……
……

12. Quels sont les tabous liés à la consommation de la pulpe de baobab dans votre village/communauté ?

……
……

……

ANNEXE 9: Liste des photos


Sorgho


Sorgho trempé


Préparation de la bouillie


Bouillie non fortifé


Emballage des fortifiants


Poudre de feuille de moringa


Pulpe de fruit de baobab


Materiels utilisés

Prise du poids des enfants

Prise de taille des enfants

Education nutritionnelle

Consommation de la formule d'aliment par les enfants