

Research Application Summary

Effect of consumption of foods fortified with baobab fruit pulp and moringa leaf powder on the nutritional status of children

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Abstract

Malnutrition exists in various forms and affects all countries in the World. Despite several initiatives, the situation remains critical in sub saharan Africa. Non timber forest products (NTFP) are known to be very rich in nutrients but are usually not used the right way. Baobab (*Adansonia digitata*) and moringa (*Moringa oleifera*) are two of these products that are commonly used by the Beninese population partly for their nutritional quality. The purpose of this study is to evaluate the effect of food to food fortification formulas containing baobab fruit pulp and/or moringa leaf powder on the nutritional status of children aged 6 to 59 months. A literature review was performed on food interventions to make the link with interventions using food to food fortified formula. A randomized controlled trial was conducted with two case groups and one control group, among children with moderate acute malnutrition in the three biogeographic zones (North, South, and Center) of Benin. Anthropometric parameters (weight and height) as well as age and serum ferritin levels are being measured. Both cases and control groups will be measured at three points at baseline, mid-term and at the end of the intervention. MiniTab 14 Software will be used for statistical analysis including analysis of variance (ANOVA). The ANOVA test was used to evaluate the difference among the three groups at baseline, midterm and post-intervention and for each group, between baseline and post-intervention period. Variables of interest are weight change, wasting prevalence and iron deficiency prevalence. The present paper presents results of the literature review performed on food interventions. It showed that both classical interventions and interventions using food to food fortification formula improve the nutritional status of children. In classical nutritional interventions, children generally have speedy recovery because of bioavailability of the nutrients. In contrast to the classical interventions, the organoleptic quality of the staple food is most of the time accepted by the subjects during the interventions using food to food fortification formula.

Key words: Baobab, Benin, food fortification, iron deficiency, moringa, malnutrition, nutritional status, wasting

Résumé

La malnutrition existe sous diverses formes et touche tous les pays du monde. Malgré les nombreuses initiatives, la situation demeure critique en Afrique subsaharienne. Les produits forestiers non ligneux (PFNL) sont reconnus pour leur haute qualité nutritive mais ne sont toujours pas utilisés de la bonne façon. Le Baobab (*Adansonia digitata*) et le moringa (*Moringa oleifera*) sont deux de ces produits qui sont couramment utilisés par la population béninoise en partie pour leur qualité nutritionnelle. Le but de cette étude est d'évaluer l'effet des formules de biofortification alimentaire contenant de la pulpe de fruits de baobab et / ou de la poudre de feuilles de moringa sur l'état nutritionnel des enfants âgés de 6 à 59 mois. Une revue de littérature a été réalisée sur les interventions alimentaires pour faire le lien avec les interventions utilisant la formule alimentaire fortifiée. Un essai contrôlé randomisé a été mené auprès de deux groupes cibles et d'un groupe témoin d'enfants atteints de malnutrition aiguë modérée dans les trois zones biogéographiques (Nord, Sud et Centre) du Bénin. Les paramètres anthropométriques (poids et hauteur) ainsi que l'âge et les concentrations sériques de ferritine seront mesurés. Les paramètres seront enregistrés auprès des deux groupes cibles et du groupe témoin en trois temps ; au départ, à mi-parcours et à la fin de l'intervention. Le logiciel MiniTab 14 sera utilisé pour l'analyse statistique incluant l'analyse de variance (ANOVA). Le test ANOVA a été utilisé pour évaluer la différence entre les trois groupes au départ, à mi-parcours et après l'intervention et pour chaque groupe, entre la période de référence et la période post-intervention. Les variables d'intérêts sont le changement de poids, la prévalence de l'amaigrissement et la prévalence de la carence en fer. Le présent article présente les résultats de l'examen de la littérature sur les interventions alimentaires. Il a montré que les interventions classiques et les interventions utilisant la formule de biofortification alimentaire améliorent tous l'état nutritionnel des enfants. Pour les interventions nutritionnelles classiques, les enfants ont généralement une récupération rapide en raison de la biodisponibilité des nutriments. Contrairement aux interventions classiques, la qualité organoleptique de l'aliment de base est pour la plupart du temps acceptée par les sujets pendant les interventions utilisant la formule de biofortification alimentaire.

Mots clés: Baobab, Bénin, fortification alimentaire, carence en fer, moringa, malnutrition, état nutritionnel, gaspillage

Background

Malnutrition in all its forms remains one of the most serious and neglected health problems. Indeed, in Sub-Saharan Africa (SSA), around one in four people remain undernourished (FAO *et al.* 2014). The World Health Organization (WHO) estimates that more than two billion people worldwide are deficient in key vitamins and

minerals, particularly vitamin A, iodine, iron and zinc (Das *et al.*, 2013). In addition, in Benin, chronic malnutrition is high in households with low income, due to inadequate food consumption and hence food insecurity, as determined by availability, access, utilization of food and the stability of these three parameters (AGVSA, 2014). Many efforts have been initiated in Africa but the situation remains critical in SSA. Therefore, nutritional food interventions using food formulas containing local foods such as baobab pulp and moringa leaf powders, may contribute to improving the nutritional status of children under five. In Africa, the baobab tree plays an important role in human nutrition (Wickens, 2008). It has high micronutrient contents (vitamins C, A, E and F) and provides a major portion of human daily needs for human (Assogbadjo *et al.*, 2012). Baobab fruit pulp contains up to 500 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 (Chadare *et al.*, 2009). The World Health Organization has promoted moringa tree as an alternative to imported food supplies to treat malnutrition (Salem *et al.*, 2013). According to Abioye and Aka (2015), 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. This study aims at testing the effect of consumption of food fortified with baobab fruit pulp and/or moringa leaves powder on the nutritional status of children in Benin aged 6 to 59 months. Specifically, the study aims at (i) studying the effect of the fortified formulas on weight change and the prevalence of wasting and iron deficiency in children aged 6 to 59 months and (ii) studying the effect of food formula consumption of the children on mothers' feeding practices.

Study description

The study is being conducted in the three biogeographical zones of Benin (South, Center and North) and involves children aged 6 to 59 months. The preliminary studies focused on (i) mapping local food matrices and (ii) formulating adequate food to food formula with baobab and/or moringa as fortificant in each biogeographical zone for children aged 6 to 59 months, according to their nutritional needs and bioavailability of key micronutrients.

Methodology

Literature review. The aim of the literature review was to identify existing body of knowledge of all relevant trials on the nutritional food intervention regardless of language or publication status, the sex and age of the target group. Computerized bibliographic databases and documents in libraries were searched by using appropriate key words.

Assessment of the effect of the fortified formulas on weight change, wasting and iron status of children . The sample size was calculated, based on the prevalence of moderate acute malnutrition among children between 6 and 59 months in the study areas, using the formula adopted from Magnani (1997):

$$n = D [(Z_a + Z_b)^2 * (P1 (1 - P1) + P2 (1 - P2))] / (P2 - P1)^2$$

with n= required minimum sample size per intervention group; D = design effect; P1 = estimated prevalence of child moderate acute malnutrition in the study areas; P2 = the target prevalence of child moderate acute malnutrition in the study areas; Z_a = the Z-score corresponding to the desired confidence level; and Z_b = the z-score corresponding to the desired power level.

Experimental design. The subsequent study will be designed as a three-arm randomized controlled trial among children with moderate acute malnutrition in the three biogeographical zones (North, South, and Center) of Benin. Participants will be assigned randomly to two case groups or the control group. The case groups will consume daily the two food fortified formulas (with baobab and /or with moringa) during 6 months whereas the control group of the same size will eat traditional foods containing baobab fruit pulp and moringa leaf powder. The sampling frame will consist of households with at least one child under five. Only one child per household within the defined age range will be randomly selected to get a representative sample according to the calculated sample size. Households will be selected using the random walk method until the desired sample size is achieved. Informed verbal and written consent will be obtained from the head of household. Anthropometric measurements, height and weight (using infantometer and electronic scales, respectively) as well as measurements of serum ferritin level (laboratory analysis) will be performed. Age will be recorded from birth certificates or health books. Participants in the three intervention groups (case and control groups) will be measured three times: at baseline, after three months and at the end of the trial.

Statistical analysis. The MiniTab 14 Software will be used for statistical tests. The ANOVA test will be used to evaluate the difference among the three groups at baseline, mid-term and post-intervention and for each group, between baseline and post-intervention period. Variables of interest are weight change, wasting prevalence and iron deficiency prevalence.

Assessment of the effect of food formula consumption of the children on mothers' feeding practices. A food frequency questionnaire and knowledge, attitudes and practices (KAP) questionnaire was designed and pre-tested to assess changes in household diet quality, estimated with the food consumption score (MAEP *et al.*, 2014), and in child feeding practices (in particular with regard to micronutrient-rich foods including baobab and moringa). Mothers or guardians of the selected children were the respondents of this survey. ANOVA was used to evaluate differences amongst mothers/guardians of children from the three groups in terms of at baseline, after three months and at the end of trial.

Preliminary results

Classical food and nutritional intervention. The literature review shows that the subjects commonly targeted for the intervention are children, 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 several ways to fortify the food in classical interventions. Micronutrients are added to the staple foods during the processing or just before the consumption of the foods. In both cases, the fortified foods improve the nutritional status of the children. 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 its impact on anemia in women remains unclear. Beininger *et al.* (2010) showed 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 consumed rice fortified with micronized ferric pyrophosphate. One limitation is that parents often forgot to give the iron drops thrice weekly or the child refused to consume the drops because of taste which led to diarrhea or constipation or vomiting. 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 to give 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 daily consumption of freshly prepared fruit juice, containing 10 mg Zn (as ZnSO₄)/d, for six months by preschool children selected according to their socioeconomic status, revealed that Zinc supplementation increased midupper arm circumference by the end of the study and led to greater weight gain in children from the school of medium socioeconomic status at three and eight months (Kikafunda *et al.*, 1998). There was no effect on weight gain of the children from the other schools. Zinc supplementation had no influence on height but infection rates were lower in the zinc-supplemented group than in control subjects. The study found that although the zinc-supplemented children had slightly better attendance records than the control children the difference was not significant. Note that the study recorded some limits which can influence the results. Indeed, as the trial was carried out at schools, children (subject) who missed schools could not consume the fortified food. Some children also dropped out of the trial before the end. As mentioned by the author, the most common

causes of absenteeism were sickness, insufficient funds for school fees, and rain in the mornings.

Nutritional intervention using food to food fortification formula. The literature review revealed two ways to fortify staple foods with other foods as fortificants. The fortificant food can be added to the staple food just before the consumption or mixed with the staple food during the processing. Each of these ways is used according to the type of food, the targeted subject and the objective of the intervention. Indeed, after the consumption of the red palm oils for eight week by women, starting at 26 to 28 weeks of gestation and extending to 34 to 36 weeks of gestation, the results show 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 contributes to reducing vitamin A deficiency in children and women of childbearing age.

According to Yamani *et al.* (2009), the daily supplementation of 10 grams of spirulina on a regular basis for six months caused 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. After the consumption of the untreated mushrooms, UV-treated mushrooms, purified ergocalciferol plus untreated mushrooms contained ergocalciferol by different groups of adults for six weeks, the results indicates that ergocalciferol was absorbed and metabolized to 25(OH) D2 but did not affect vitamin D status, because 25(OH)D3 decreased proportionally (Stephensen *et al.*, 2012).

The administration of soy protein as a beverage to children aged 6 to 12 year for four weeks showed no change in either plasma cholesterol, low-density lipoprotein cholesterol and apolipoprotein concentrations. However, the soy beverage significantly reduced the concentration of triglyceride and very low-density lipoprotein cholesterol and significantly increased the concentration of high-density lipoprotein cholesterol (Laurin *et al.*, 1991). Note that the rate of acceptability of the fortified foods within the subjects is not mentioned in certain studies. This may influence the results obtained.

The daily supplementation of 10g of moringa leaf powder for six months improves significantly the nutritional status of children: wasting, growth retardation and underweight (Houndji *et al.*, 2013). This is supported by Zongo *et al.* (2013) who reported that this supplementation appeared to be effective in improving the nutritional recovery of severely malnourished children. However, this study supports the view that there is 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, 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 fortification with this powder affects to some extent iron bioavailability. However, in the case of Tété-Bénissan *et al.* (2012), the daily supplementation of 25g/ day for nursing, 30g/day for children, of moringa leaf powder for 14 weeks showed after hemogram analysis increase in red blood cell, hemoglobin, hematocrit mean cell volume, mean cell hemoglobin concentration and mean cellular hemoglobin concentration values. 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.

Discussion and conclusion

From the review, it is noticed that both classical interventions and interventions using food to food fortification formula improve the nutritional status of children. In classical nutritional interventions, children generally have speedy recovery because of bioavailability of the nutrients. Indeed, according to Lartey *et al.* (1999), the consumption of a food, called weanimix and three other locally formulated foods (weanimix plus vitamins and minerals, weanimix plus fish powder, and koko plus fish powder) by breast-fed infants especially children from 6 to 12 months, revealed that all four foods improved growth in six months within the intervention group but infants fed weanimix plus vitamins and minerals had better iron stores and vitamin A status than those fed three other foods. In addition, the consumption of maize porridge fortified with low-dose highly bioavailable iron multi-micronutrient powder reduced 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 (Macharia-Mutie *et al.* 2012). Contrast to the classical interventions, the organoleptic quality of the staple food is most of the time accepted by the subjects during the interventions using food to food fortification formula. However, Zongo *et al.* (2013) found that during the supplementation of moringa leaf powder, a small number of children showed resistance to their first bowls of porridge mixed with Moringa powder during the first week because of the uncommon green coloration of the food. Therefore, the mixing of the moringa leaf powder during the processing of the staple food should somehow improve the organoleptic quality of the fortified food. Note that there is lack of data regarding the nutritional interventions using baobab fruit pulp as fortificant. Research is needed to assess effect of the food fortified with moringa leaf powder on the change of hemoglobin rate and also to find out whether this fortified food has a significant difference between male and female z-scores in terms of stunting.

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