RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (2): 969- 977.
Available from *http://repository.ruforum.org*

Research Application Summary

Formulation of infant foods fortified with baobab fruit pulp and moringa leaf powder for children under five

Affonfere, M.,[1] Chadare, F.J.,[1] Madode, Y.E.,[1] Nago, E.S.H.,[2] Houndji, S.[2] & Azokpota, P.[1]
[1]Laboratory of Food Science, Faculty of Agronomic Science, University of Abomey-Calavi BP 526, Abomey-Calavi, 229 Atlantique, Benin
[2]Ecole de Nutrition, Sciences et Technologies Alimentaires, Faculty of Agronomic Science, University of Abomey-Calavi BP 526, Abomey-Calavi, 229 Atlantique, Benin
Corresponding author: fchadare@gmail.com

Abstract

Malnutrition is one of the most serious health problems throughout the world and the children under five are especially vulnerable. The aim of this research is to formulate food fortified with baobab fruit pulp and moringa leaf powder for children under five. Specifically, the research will focus on: (i) mapping local food matrices for food formulation, (ii) developing two food to food fortification formulas per biogeographical zone using baobab fruit pulp and moringa leaf powder, and (iii) assessing actual nutritional value and bio-availability of micronutrients in selected foods. The mapping was performed using a literature review and field survey. The two most important food matrices per biogeographical zone will be selected based on the bioavailability of Ca, Fe and Zn in the food matrices; their accessibility (physical and financial accessibility); their consumption level, their nutritional value and the different taboos relative to each food matrix. The development of the food to food formula will then focus on the nutritional needs of under-five-year old children (codex standard) to cover an important part in their daily nutritional needs. Proximal composition (dry matter, water content, protein, lipid, carbohydrate, total ash) of the selected formula will be determined according to AOAC (1995) and digestibility study of the key micronutrients (Ca, Fe and Zn) will be performed using (Kiers *et al.*, 2000) method. Results indicate that moringa leaf powder and baobab fruit pulp are traditionally used in the infant diet in the three biogeographical zones of Benin. Chi square test showed that their consumption frequency vary significantly from one zone to another ($P<0.05$). The food vehicles identified and the frequencies of their consumption and their nutritional value are key elements for the development of adequately improved food to food fortification formula for under-five-year old children.

Key words:Baobab fruit pulp, food to food fortification, In-vitro digestibility, micronutrients, moringa leaf powder

Résumé

La malnutrition est l'un des problèmes de santé les plus sérieux dans le monde et les enfants sont particulièrement vulnérables. Le but de cette étude est de formuler des aliments fortifiés avec de la pulpe de fruit de baobab et de la poudre de feuille de

moringa pour les enfants de moins de cinq (05) ans. Plus spécifiquement, cette étude vise à (i) recenser les véhicules alimentaires candidats pour la formulation, (ii) développer deux formules de fortification avec de la pulpe de fruit de baobab et de la poudre de feuille de moringa par zone biogéographique et, (iii) déterminer la valeur nutritionnelle et la biodisponibilité des micronutriments dans les formules sélectionnées. Pour le recensement des véhicules, une revue de littérature et une enquête ont été effectuées. Les deux véhicules les plus importants dans chaque zone biogéographique seront sélectionnés suivant la biodisponibilité du Ca, Fe, Zn, leur accessibilité (physique et financière), le niveau de leur consommation, leurs valeurs nutritionnelles et les différents tabous relatifs à chaque véhicule. La formulation utilisera comme contrainte les besoins nutritionnels des enfants de moins de cinq ans (Normes Codex) afin de couvrir une part importante de ces besoins. La composition proximale (matière sèche, teneur en eau, teneur en protéine, en lipide, en glucide, et en cendres totales) dans les formules développées par zone biogéographique sera déterminée selon la méthode AOAC (1995) et l'étude de digestibilité des micronutriments clés (Ca, Fe et Zn) se fera en utilisant la méthode de (Kiers *et al*., 2000). Les résultats indiquent que la poudre de feuille de moringa et la pulpe de fruit de baobab sont utilisées dans l'alimentation des enfants de moins de cinq ans dans les trois zones biogéographiques du Bénin ; le test de Chi deux montre que leur fréquence de consommation varie significativement d'une zone à une autre ($p<0,05$). Les véhicules alimentaires identifiés, leurs valeurs nutritionnelles et leurs fréquences de consommation sont des éléments clés pour le développement des formules adéquates de fortification pour les enfants de moins de cinq ans.

Mots clés : fortification aliment-aliment, micronutriments, pulpe de fruit de baobab, poudre de feuille de moringa, digestibilité In-vitro

Introduction

Vitamins and minerals are essential for human growth and metabolism though many people do not consume adquate amounts of these nutrients. The World Health Organization (WHO) estimates that more than two billion people are deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc (Das *et al.,* 2013). Young children are especially vulnerable because of rapid growth and corresponding needs for nutrients to support growth and development . However due to inadquate dietary practices children, particularly in rural areas lack adquate nutition (De-Regil *et al*., 2011). Reduction of these nutritional deficiencies can be achieved efficiently through various strategies such as food fortification, one of the most cost-effective and sustainable strategies to deliver micronutrients to large populations (Bhagwat *et al*., 2014). Conventional food fortification has been pursued for years but reveals problems of sustainability. Therefore, food-to-food fortification is more and more used as an option to addressing nutrient deficiencies. Previous studies confirm the health benefits of food to food fortification (Chadare *et al.,* 2008; Adejuyitan *et al*., 2012; Houndji *et al.*, 2013; Sankhon *et al*., 2013).

The objective of this study is to assess food to food fortification with baobab fruit pulp and moringa leaf powder to enhance food and nutrition security aamong women and children in Benin.

Materials and methods

To reach the goal of the study, a literature review and field survey were performed to document food vehicles using foods and in particular baobab fruit pulp and moringa leaf powder as a fortificant. This will be followed by laboratory work that will lead to development of adequate food to food formulas based on improvement of traditional ones.

Mapping of food matrices: In order to map local food matrices, a literature review was performed to collect information on foods matrices that are used in the different biogeographical zones of Benin. These food matrices were considered to explore options for candidate foods for fortification with baobab and moringa for infant food. As a follow up of the literature review, a survey was conducted in the three biogeographical zones of Benin. Focus group discussions and structured questionnaires were used to collect information on infant food habits especially the food vehicles that use baobab fruit pulp and/or moringa leaf powder as fortificant, their ingredients, their consumption frequency and the traditional forms of food fortification.

Formulation: After screening and mapping, the most important food matrices per biogeographical zone will be selected based on the bioavailability of Ca, Fe, and Zn in the food matrices, their accessibility (physical and financial accessibility), their consumption level, their nutritional value and the different taboos relative to each food matrix. The food to food formulation will then focus on the nutritional needs of under-five-years old children (codex standard). The selected food matrices and their ingredients will be combined according to their nutritional value. The food matrices will be used as an essential source of macronutrients (carbohydrate, protein, lipids). Baobab fruit pulp and/or moringa leaf powder will be used as compulsory ingredients in the formulas. These ingredients will be important sources of micronutrients with a focus on Ca, Fe and Zn.

Preference test: After formulation, a preference test will be performed with ten experienced women who are used to infant foods. The preferred formula will be analyzed for parameters that are relevant to the nutritional needs of the target group.

Laboratory analyses: Proximal composition (dry matter, water content, protein, lipid, carbohydrate, total ash) of the selected formula will be determined according to (AOAC, 1995) method. Before and after digestibility, Ca, Fe and Zn contents of the formulas will be determined using an inductively coupled plasma–optical emission spectrometer (ICP–OES, Elan 6000, Perkin Elmer, Wellesley, MA, USA) according to Temminghoff, (1997) method. Digestibility study on food to food formula will be performed using

in-vitro digestion (with similar enzymes to those found in the human digestive system) at laboratory scale. The in vitro digestion (Kiers *et al.,* 2000) will be performed with minor modifications as presented by (Chadare *et al.*, 2015). After this step, formulas will be adjusted if necessary.

Acceptability test: Finally, an acceptability test of the formulas among under-five-years old children will be performed, taking into account ethical issues. Indeed, fifty (50) mother-child couples will be randomly selected in each biogeographical area and the facial expression will used for children to appreciate the acceptability level of the fortified foods.

Mothers will appreciate according to the sensorial attributes under evaluation. Outputs of these tests will be used to operate final formula choices per biogeographical zone for food intervention trials. The experimental plan of this research is summarized in Figure 1.

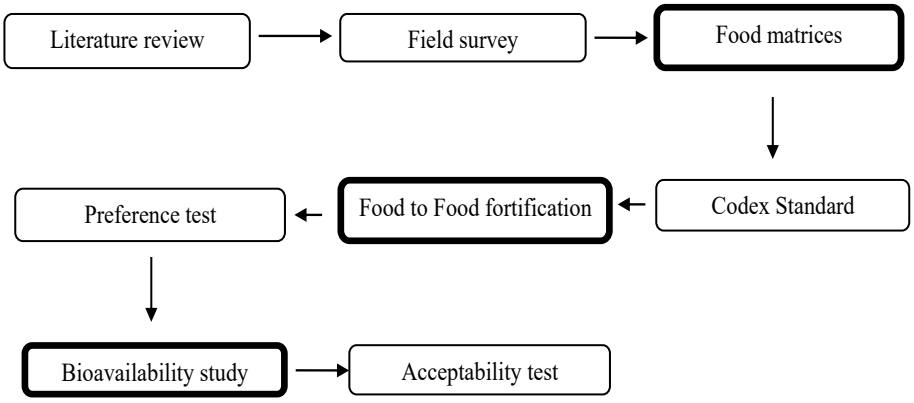


Figure 1: Conceptual framework process and flow for the study

Data processing and statistical analysis

An access database is being used to compile the information collected from the survey data. Statistical analysis is being performed with Minitab 14. A Chi square test was used to check for difference per biogeographical zones of the consumption frequency of traditional foods fortified with moringa and baobab pulp. After food to food formulation, the statistical t test of student (conformity test) will be performed to check whether the nutritional values of the developed formulas are in conformity with the Codex standards for the target group. Analysis of variance ANOVA will be used to compare the theoretical nutritional value and the nutritional value after laboratory analyses of the developed formula.

Preliminary results

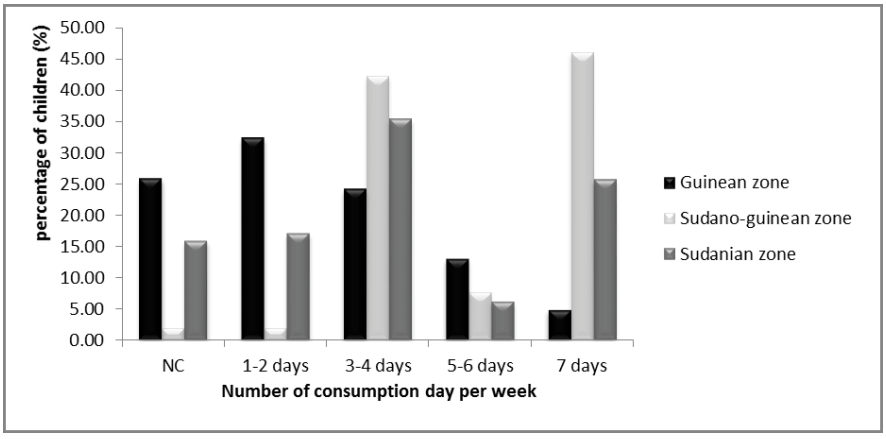
Staple foods used as vehicles for baobab pulp and moringa leaf powder

The literature review revealed the main foods derived from staple food in the three biogeographical zones of Benin. However, it was not clear which ones are traditionally fortified with baobab fruit pulp and/or moringa leaf powder for infant food. The survey

allowed identification of infant local food matrices that use baobab fruit pulp and/or moringa leaf powder as fortificants in the three biogeographical zones of Benin. Table 1 presents the synthesis of the traditional staple foods identified in the literature and those identified after field survey as vehicles that are traditionally fortified with baobab fruit pulp and moringa leaf powder or moringa leaves. Thus, considering the sudanian (northern Benin) and the sudano-guinean (central Benin), about 15 % of the vehicles identified in the literature as derived from staple foods are used for the fortification with baobab fruit pulp. For the guinean zone (southern Benin), no vehicle was identified using baobab fruit pulp as fortificant. Concerning the fortification with moringa leaf powder, about 30 % of the vehicles identified in the literature as derived from staple foods are used both in northern and central zones of Benin against approximately 15 % in the southern zone. In addition, some new vehicles are identified through field survey in each biogeographical zone (two new vehicles in guinean zone, five in sudanian zone and five in sudano-guinean zone).

Consumption frequency of foods traditionally fortified with moringa leaf powder

The survey showed that the weekly consumption frequency of traditional foods fortified with moringa leaf powder by children vary from one to two days per week to seven days per week. Indeed, a Chi square test performed to check whether the consumption frequency depends on the biogeographical zone showed that this frequency significantly vary from one biogeographical zone to another ($P<0.05$) (Fig. 2).



NC: Not consumed

Figure 2. Frequency of consumption (number of day per week) of the vehicles fortified with moringa leaf powder for under five-years-old children in Benin.

In the guinean zone, 32.26 % of children consume traditional foods fortified with moringa leaf powder 1-2 days per week while about 24% of them consume those foods 3-4 days per week. In sudano-guinean zone, 46.15% of the children consume almost every day traditional foods fortified with moringa leaf powder followed by 42% who consume it 3-4 days in the week. In the sudanian zone the frequency of 3-4 days per week is practiced for 35.37% of the children.

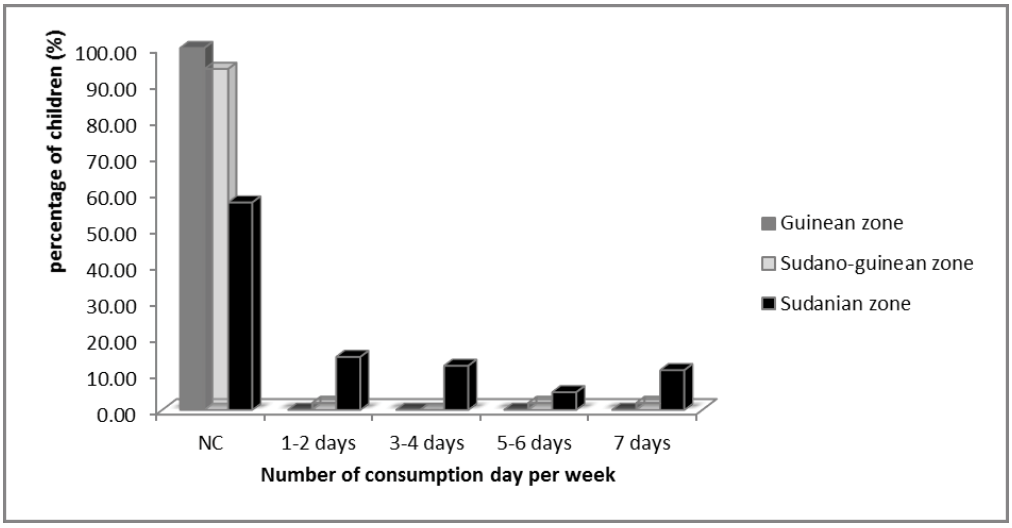
Table1: Staple foods and "vehicle" using baobab and moringa leaves powder as fortificants

Biogeographical zones	Staple foods	Vehicles using baobab fruit pulp as fortificant	Vehicles using moringa leaves powder as fortificant	Synthesis
Guinean zone (southern Benin)	Maize paste, ''akassa'', cooked cassava, gari, tapioca, bean (cooked), maize farina, rice, maize flour porridge, cooked bean combined with gari and palm oil, peanut, ''atassi'' (rice+ bean) , djongoli (cooked bean+ roasted maize flour + palm oil)	-	Maize porridge, Sorghum porridge; Palm nut sauce; fresh tomato sauce	**15. 38 %** of the vehicles indentified in the literature are used for the fortification with moringa leaf powder. Two new vehicles are identified (sorghum porridge and fresh tomato sauce)
Sudano-guinean zone (central Benin)	Maize paste + sauce (fresh tomato, vegetables), paste of maize and cassava farina + sauce (fresh tomato, vegetables), Akassa, maize porridge, gari, rice, vegetables sauce	Maize porridge	Maize porridge; millet porridge ; soya porridge; sorghum porridge; sauce of ''goussi''; fresh tomato sauce, peanut sauce	**16. 66%** of the vehicles identified in the literature used baobab fruit pulp as fortificant against **33. 33 %** for the fortification with moringa leaf powder. Fortification with moringa leaf powder revealed five new vehicles (millet porridge ; soya porridge sorghum porridge, sauce of ''goussi'', peanut sauce)
Sudanian zone (northern Benin)	Pounded yam, wassa wassa (yam couscous), fried yam (chips of yam), maize porridge, sorghum porridge, rice, dried cassava, ''waché''(rice+ bean), sorghum+ maize porridge, sorghum+ maize paste, sorghum+ maize+ millet porridge , sorghum+ maize+ millet paste , vegetables sauces (baobab leaf , *vernonia amygdalina* and *amaranthus hybridus*), fresh tomato sauce	Maize porridge; soya porridge ; sorghum porridge; maize+sorghum porridge	Maize porridge; Sorghum porridge; millet porridge ; soya porridge; Peanut sauce ; fresh tomato sauce; bean sauce	For the fortification with baobab fruit pulp, **14. 28 %** of the identified vehicles (in the literature) against **28. 57 %** for the fortification with moringa leaf powder are used. Two new vehicles (soya porridge, maize+ sorghum porridge) are identified for the fortification with baobab fruit pulp against three (soya porridge, peanut sauce, bean sauce) for the fortification with moringa leaf powder.

Source: Literature review and survey

Consumption frequency of foods traditionally fortified with baobab fruit pulp

Findings from this survey indicate that consumption frequency of foods traditionaly fortified with baobab fruit pulp by children varied from one to two days per week up to seven days per week (Fig. 3). The Chi square showed that this frequency of traditional foods fortified with baobab pulp significantly vary from one biogeographical zone to another ($P<0.05$).



NC: Not consumed

Figure 3: Frequency of consumption of the vehicles fortified with baobab fruit pulp in the biogeographical zones of Benin for under five-years-old children

Figure 3 reveals that in the guinean zone no food fortified with baobab fruit pulp is consumed. In the sudano-guinean zone there is a low but equal proportion children (1.96%) who consume foods fortified with baobab pulp 1-2 days per week, 5-6 days per week and seven days per week. In the sudanian zone the proportion (14.63%) of children who consume traditional foods fortified with baobab pulp 1-2 days per week.

Finally, the vehicles fortified with moringa leaf powder are more consumed by a large proportion of children in sudano-guinean zone with seven days per week as frequency and the vehicles fortified with baobab fruit pulp are more consumed by the children in sudanian zone with 1-2 days per week. The proportion of children who do not consume food fortified with moringa leaf powder or baobab fruit pulp is highest in the guinean zone. The research is on-going and the next step will be to generate: (i) two food to food fortification formulas per biogeographical zone using baobab pulp fruit and/or moringa leaf powder, (ii) actual nutritional value, and (iii) bioavailability of Ca, Fe and Zn in the selected food to food formula for each of the three biogeographical zones.

Discussion

Moringa leaf powder and baobab fruit pulp are used for food fortification in Benin . In the three biogeographical zones, the proportion of children consuming these resources as fortificant is variable. This variation can possibly be due to the availability, the accessibility of these resources and mainly to the food habits of the target. 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). This is in accordance with the results of the present study which showed that baobab pulp is not used as fortificant in children foods in Southern Benin. The vehicles used in these three biogeographical zones show a high similarity as a result of low variability in traditional food combination. Moringa leaf powder, used as fortificant for any type of vehicle can be considered as a local food supplement to fight against malnutrition (Houndji *et al.,* 2013). The difference between vehicles identified in the literature as staple foods and those revealed by the survey as vehicles used for food fortification indicate that there is a preferential vehicle for food fortification with baobab fruit pulp and moringa leaf powder especially for infant foods.

Conclusion

The study has confirmed the use of moringa leaf powder and of baobab fruit pulp as fortificants in the infant diet in three biogeographical zones of Benin. The food vehicles identified and the frequency of their consumption are the key elements for development of adequate food to food fortification formula.

Acknowledgment

This research is funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) through GRG Grant ID No. RU 2015 GRG-125. This paper is a contribution of the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

References

Adejuyitan, J. A., Abioye, A. O., Otunola, E. T. and Oyewole, Y. N. 2012. An evaluation of some properties of baobab fruit powder and ogi mixte. *Transnational Journal of Science and Technology* 2: 90-102.

Association of Official Analytical Chemists (AOAC). 1995. Analyses bromatologiques. *16ème édition.*

Bhagwat, S., Deepti Gulati, D., Sachdeva, R. and Sankar, R. 2014. Food fortification as a complementary strategy for the elimination of micronutrient deficiencies: case studies of large scale food fortification in two Indian States. *Asia Pac J Clin Nutr* 23: 4-11.

Chadare , F. J., Hooiveld, G. J. E. J., Linnemann, A. R., Nout, M. J. R. and Hounhouigan, D. J. 2015. Effect of cooking on in vitro solubility of minerals and carotenoids in *Adansonia digitata*. *Annales des sciences agronomique*s 18: 1-19.

Chadare, F. J., Hounhouigan, J. D., Linnemann, A. R., Nout, M. J. R. and Van B, M. A. J. S. 2008. Indigenous knowledge and processing of *Adansonia digitata* L. food products in Benin. *Ecology of Food and Nutrition* 47: 338 - 362.

Das, J. K., Salam, R. A., Kumar, R. and Bhutta, Z. A. 2013. Micronutrient fortification of food and its impact on woman and child health: a systematic review. *Systematic Review* 2: 2-24.

De-regil, L. M., Suchdev, P. S., Vist, G. E., Walleser, S. and Peña-Rosas, J. P. 2011. Home fortification of foods with multiple micronutrient powders for health and nutrition in children under two years of age (Review). *Cochrane Review Journal* 8: 112–201.

Houndji, B. V. S., Bodjrenou, S. F., Londji, S. B. M., Oouetchehou, R., Acakpo, A., Amouzou, K. S. E. and Hounmenou, 2013. Amélioration de l'état nutritionnel des enfants âgés de 6 à 30 mois à Lissèzoun (Centre-Bénin) par la poudre de feuilles de *Moringa oleifera* (Lam.). *Int. J. Biol. Chem. Sci*. 7: 225-235.

Kiers, J. L., Nout, R. M. J. and Rombouts, F. M. 2000. In vitro digestibility of processed and fermented soya bean, cowpea and maize. *Journal of the Science of Food and Agriculture* 80: 1325-1331.

Sankhon, A., Amadou, I. and Yao, W. 2013. Application of resistant starch in bread: processing, proximate composition and sensory quality of functional bread products from wheat flour and African locust bean *(Parkia biglobosa*) flour. *Agricultural Sciences* 4: 122-129.