

Development of sweet potato-soybean blend, an alternative to maize-legume mix as complementary food for infants in Ghana

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ABSTRACT

Background: The composition of the foods given to infants and young children in Ghana significantly contributes to the prevalence of malnutrition. Currently, a better option may be Weanimix (maize-soybean-groundnut blend) designed to be processed as industrial- or household-level complementary food. Weanimix has adequate protein and energy densities, but is high in phytate an antinutrient which inhibits nutrient bioavailability.

Objective: To formulate a low-phytate complementary food from cream-fleshed sweet potato to contain comparable levels of macronutrients as Weanimix.

Design: A composite blend of sweet potato, defatted soybean and soybean oil was cooked on a stove-top, oven-dried, milled and enriched with fishmeal (referred to as stove-top cooked ComFa).

Outcomes: Stove-top cooked ComFa had a protein level which was higher than that of Weanimix (25.49 ± 0.10 vs. 14.26 ± 0.29 g/100 g; $p=0.001$). However, the energy content was low compared to Weanimix (370 ± 1.70 vs. 431 ± 0.71 kcal/100 g; $p=0.001$). Stove-top cooked ComFa had a 7.5% energy deficit compared to the recommended level of at least 400 kcal/100 g in Codex standard, but met the calcium (105 mg/100 kcal) and zinc (1.6 mg/100 kcal) densities as recommended by WHO for complementary foods.

Conclusion: The sweet potato-soybean blend has the potential to serve as an alternative complementary food if the energy content could be improved.

INTRODUCTION

In 1987, Weanimix, an optimal complementary food which can be processed at either the household-level or at the industrial-level, was introduced in Ghana through collaboration between the Nutrition Unit of the Ministry of Health, Ghana and the United Nations Children's Fund (UNICEF, Ghana) to improve the nutritional status of older infants (Lartey *et al.*, 1999). Weanimix is a blend of maize, soybean and groundnut; it is higher in protein and energy densities compared to *koko* - a household-level complementary food prepared from fermented dough of maize, millet or sorghum only. Weanimix improved growth (height and weight indices) but not micronutrient status unless it was fortified with a vitamin and mineral premix (Lartey *et al.*, 1998, Lartey *et al.*, 1999). Weanimix is also high in phytate (480 mg/100 g) which will limit bioavailability of iron (Hurrell *et al.*, 2003, Hurrell and Egli, 2010), zinc (Gibson and Ferguson, 1998), probably calcium (Perlas and Gibson, 2005) and to some extent protein (Greiner *et al.*, 2006). Therefore, formulation of another complementary food with low phytate and made from available local resources warrants attention.

The objective of this study was to formulate a low-phytate complementary food from cream-fleshed sweetpotato and compare the levels of macro and micronutrients of the sweetpotato-based product with Weanimix. Both formulations were also compared with recommended standards (Codex Alimentarius Commission, 1991, Dewey and Brown, 2003).

METHODS

Ingredients used for processing complementary foods

All ingredients were sourced from New Zealand, unless otherwise stated. *Toka Toka Gold* (cream flesh with orange streaks) sweetpotato (*Ipomoea batatas*) was supplied by Delta Produce Co-op Ltd in Dargaville and processed into flour by peeling, drying and grinding.

Defatted toasted soybean (*Glycine max*) flour was purchased from Oppenheimer, Wellington. Refined white maize meal (Springbok™, South Africa), soybean seed, groundnut (*Arachis hypogea*) paste and soybean oil (SIMPLY™) were obtained from local supermarkets in Palmerston North. Fishmeal prepared by milling smoke-dried anchovies (*Engraulis hepsetus*) with the heads removed was imported from Ghana.

Formulation and processing of sweetpotato-soybean complementary food

The formulation was estimated using published nutrient composition of sweetpotato (FoodWorks, 2009) and the nutritional information on labels of the other ingredients to obtain a product with an energy level of 400 kcal/100 g, fat content between 10 – 25 g/100 g and protein content of at least 15 g/100 g on dry matter basis to meet the specified guidelines for complementary foods for infants and young children (Codex Alimentarius Commission, 1991).

ComFa, a composite blend containing 66% sweetpotato flour, 23% defatted soybean, 10.3% soybean oil, 0.20% lecithin and 0.50% iodised salt, was cooked on a stove to replicate the usual household-level food preparation and then oven-dried (9.31 ± 0.27 g/100 g moisture content). The dried sweetpotato-soybean formulation was broken into smaller chunks, milled and then enriched with fishmeal (20% wt/wt) prepared from anchovies. This is a recommended practice in Ghana to improve the nutrient quality of household-level complementary food (Akor *et al.*, 2001). The complementary food obtained was referred to as stove-top cooked ComFa. Sweetpotato was chosen to replace the maize and groundnut of Weanimix because it is low in phytate (Lukmanji *et al.*, 2008, Gibson *et al.*, 2010), high in vitamin A precursor and available in Ghana (Ofori *et al.*, 2009). It has been confirmed in another study that the calcium content of household-level prepared complementary food increased when this fishmeal was added (Perlas and Gibson, 2005).

Processing of maize-soybean-groundnut blend (Weanimix)

The method described by Lartey *et al.* (1999) was used with a slight modification. Refined (dehulled) maize flour was used instead of flour prepared from roasted white maize grain. This modification was necessary due to the unavailability of white maize grain for human consumption in New Zealand.

Nutrient analysis

The moisture, protein, fat and ash contents of the ComFa formulation and Weanimix were determined using the standard methods described by the AOAC International (AOAC, 2005). Carbohydrate and the energy contents were estimated (FAO, 2003). Calcium, iron and zinc in the samples were determined by atomic absorption spectrophotometry. All the analyses were performed on three independent replicates.

Data analysis

The data were analysed using two-sample t-test procedure in Minitab v15.1™ (Minitab Inc., US). Means were considered to be significantly different at $p < 0.05$. Results are reported as means of triplicate determinations \pm standard error of the mean (SEM).

RESULTS

Nutrient composition

The stove-top cooked ComFa met protein and fat specifications of the Codex Standard (Codex Alimentarius Commission, 1991) for complementary foods for infants and young children (Table 1). However, the ComFa formulation met approximately 70% of the estimated carbohydrate (60 – 75%) and 92% of the specified energy (400 kcal/100 g) in the Codex standard. It is evident that the fat in the ComFa formulation and Weanimix was not significantly different. Although protein content of the stove-top cooked ComFa was higher than Weanimix by about 56% ($p = 0.001$), the estimated energy value of the ComFa formulation was lower than Weanimix by 15% ($p < 0.001$). The estimated carbohydrate content of ComFa was lower than that of Weanimix by 34% ($p < 0.001$). The protein level of Weanimix was slightly lower (by 4.7%) than the protein level stipulated in the Codex standard but met the stipulated fat level. Weanimix met the minimum energy specification of complementary foods stated in the Codex standard.

Table 1: Macronutrient composition of complementary food processed from cream-fleshed sweetpotato, defatted soybean flour, soybean oil enriched with anchovies-fishmeal at 20% wt/wt (stove-top cooked ComFa) and maize-soybean-groundnut (Weanimix)^a

Nutrient(/100 g)	Codex Standard ^b	Stove-top cooked		p-value ^c
		ComFa	Weanimix	
Protein, g	15	25.49 ± 0.10	14.29 ± 0.29	0.001
Fat, g	10 - 25	11.76 ± 0.11	12.02 ± 0.23	0.22
Ash, g		6.07 ± 0.01	1.84 ± 0.01	<0.001
Carbohydrate, g (by difference)	60 – 75 ^d	47.36 ± 0.27	66.52 ± 0.37	<0.001
Energy, kcal	400	370.06 ± 1.70	431.27 ± 0.71	0.001

^a Values (mean ± SEM, n=3) reported on dry matter basis;

^b Source: Codex Alimentarius Commission (1991);

^c ComFa formulation and Weanimix are significantly different at $p < 0.05$;

^d Estimated from data given for protein and fat in the Codex Standard.

The stove-top cooked ComFa containing anchovies met the requirement for calcium and zinc, and about 49% of the recommended level of iron from complementary food for breastfeeding infants (6 – 8 months old) (Dewey and Brown, 2003) (Table 2). Weanimix met only approximately 3.0% of the calcium, 30% of the iron and 94% of the zinc recommended levels. The nutrient densities for calcium and iron but not zinc of the ComFa formulation were significantly higher than that of Weanimix.

Table 2: Calcium, iron and zinc densities of cream-fleshed sweetpotato, defatted soybean flour, soybean oil enriched with anchovies-fishmeal at 20% wt/wt (stove-top cooked ComFa) and maize-soybean-groundnut (Weanimix) complementary foods compared to average desired densities^a

Nutrient density (mg/100 kcal)	Recommended level (WHO 2002) ^b	Stove-top		p-value ^c
		cooked ComFa	Weanimix	
Calcium	105	131.50 ± 8.10	3.59 ± 1.10	0.004
Iron	4.5	2.19 ± 0.02	1.34 ± 0.14	0.03
Zinc	1.6	2.13 ± 0.52	1.50 ± 0.17	0.37

^a Values (mean ± SEM, n=3) reported on dry matter basis;

^b Source: WHO recommended levels as cited by Dewey and Brown (2003);

^c ComFa formulation and Weanimix are significantly different at $p < 0.05$.

DISCUSSION

This research shows it is possible to process a dried complementary food from sweetpotato as reported in another study (Nandutu and Howell, 2009). The low energy and carbohydrate content of the stove-top cooked ComFa could be increased by modifying the formulation. For instance, the use of full-fat soybean flour instead of the defatted flour would increase the energy content. The fishmeal added to the ComFa formulation accounted for the high protein content compared with the level in Weanimix. A similar protein content of 28 g/100 g was obtained when Weanimix was enriched with anchovies-fishmeal at 20% (wt/wt) (Lartey *et al.*, 1999). The pronounced effect of the addition of the fishmeal on the calcium content in ComFa suggests that it could be used as a rich source of calcium in complementary feeding and should be encouraged in other localities where anchovy is available. Our findings support the observation that adding fishmeal prepared from anchovies improved calcium content of plant-based complementary food as reported in another study (Perlas and Gibson, 2005). A further advantage of the sweetpotato-based complementary food containing anchovies is that the overall micronutrient content is increased, and so

combined with its low level of phytate (Gibson *et al.*, 2010), the bioavailability of micronutrients would be enhanced. This would make the sweetpotato-based product more useful for improving micronutrient status of infants than the maize-based complementary food.

CONCLUSIONS

The preliminary results from this study suggest that cream-fleshed sweet potato has the potential for providing the basis of an alternative complementary food for infants in Ghana. However, the energy value of the formulation needs to be increased to make it suitable as complementary food. The addition of anchovies-fishmeal to sweet potato-soybean blend provided the requirement for calcium and zinc densities and about half the recommended level for iron density.

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REFERENCES

- Akor S, Arthur P, Antwi KY (2001) Findings of the Ghana country study. In: Draper AandNestel P, eds. A Study of Factors Influencing Operational Issues for Iron Supplements for Infants and Young Children. Washington DC, USA: ILSI Press.
- AOAC (2005). Official methods of analysis of AOAC International. Gaithersburg, MD, Washington, DC, USA: AOAC International.
- Codex Alimentarius Commission (1991) Guidelines for formulated supplementary foods for older infants and young children (No. CAC/GL 8). Rome, Italy: Codex Alimentarius Commission. Available at: http://www.codexalimentarius.net/download/standards/298/CXG_008e.pdf.
- Dewey KG, Brown KH (2003) Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food and Nutrition Bulletin* 24, 5-28.
- FAO (2003) Food energy-methods of analysis and conversion factors. (No. Food and Nutrition Paper, 77). Rome, Italy: Food and Agriculture Organization of the United Nations. Available at: <ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf>.
- FoodWorks (2009) Foodworks 2009 Version6. Highgate Hill QLD, Australia: Xyris software (Australia) Pty Ltd.
- Gibson RS, Bailey KB, Gibbs M, Ferguson EL (2010) A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. *Food and Nutrition Bulletin* 31, S134-S146.
- Gibson RS, Ferguson EL (1998) Food processing methods for improving the zinc content and bioavailability of home-based and commercially available complementary foods. Micronutrient interactions: Impact on child health and nutrition. Washington DC, USA: ILSI Press, Washington DC, USA.
- Greiner R, Konietzny U, Jany K-D (2006) Phytate - an undesirable constituent of plant-based foods? *Journal für Ernährungsmedizin* 8, 18-28.
- Hurrell RF and Egli I (2010) Iron bioavailability and dietary reference values. *American Journal of Clinical Nutrition* 91, 1461S-1467S.
- Hurrell RF, Reddy MB, Juillerat MA, Cook JD (2003) Degradation of phytic acid in cereal porridges improves iron absorption by human subjects. *American Journal of Clinical Nutrition* 77, 1213-1219.
- Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG (1999) A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12 mo of age. *American Journal of Clinical Nutrition* 70, 391-404.

- Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG (1998) Vitamin A status of Ghanaian breast-fed infants 6-12 months fed improved complementary foods. *FASEB Journal* 12, A648.
- Lukmanji Z, Hertzmark E, Mlingi N, Assey V, Ndossi G, Fawzi W (2008) Tanzania Food Composition Tables. First ed. Dar es Salaam, Tanzania: Muhimbili University of Health and Allied Sciences (MUHAS), Tanzania Food and Nutrition Centre (TFNC) and Harvard School of Public Health (HSPH).
- Nandutu AM, Howell NK (2009) Nutritional and rheological properties of sweet potato based infant food and its preservation using antioxidants. *African Journal of Food, Agriculture, Nutrition & Development* 9, 1076-1090.
- Ofori G, Oduro I, Ellis W, Dapaah KH (2009) Assessment of vitamin A content and sensory attributes of new sweet potato (*Ipomoea batatas*) genotypes in Ghana. *African Journal of Food Science* 3, 184-192.
- Perlas LA, Gibson RS (2005) Household dietary strategies to enhance the content and bioavailability of iron, zinc and calcium of selected rice- and maize-based Philippine complementary foods. *Maternal and Child Nutrition* 1, 263-273.