Sweetpotato-based complementary food for infants in Ghana

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“We are guilty of many errors and many faults, but our worst crime is abandoning the children, neglecting the foundation of life. Many of the things we need can wait. The child cannot. Right now is the time his bones are being formed, his blood is being made and his senses are being developed. To him we cannot answer “Tomorrow”. His name is “Today”.” Gabriela Mistral, 1948.

To my

Prudent wife

Flora

And our angels

Mawutor

Mawuena

Makafui

Abstract

Background: *In an effort to reduce the prevalence of protein-energy malnutrition among Ghanaian infants after the period of exclusive breastfeeding when complementary food (CF) is introduced, Weanimix, which is a blend of non-dehulled maize, groundnut and non-dehulled soyabean/cowpea, was introduced in Ghana, in 1987 through collaboration between the Nutrition Division, Ministry of Health, Ghana and the United Nations Children's Fund. Weanimix is an improvement over traditional maize-, millet-, or sorghum-only porridge in protein and energy densities, but it is high in phytate. Phytate limits the bioavailability of nutrients such as iron and zinc, and probably calcium and some proteins. Also, unless fortified, Weanimix is low in β-carotene (vitamin A precursor) as the white maize is the commonly consumed variety in Ghana. Additionally, cereal-based CF (example, Weanimix) forms a very thick porridge that requires dilution with water to get the desirable viscosity, leading to* "energy and nutrient thinning" *(that is, the reduction of energy and nutrient densities). Thus, the widely used unfortified cereal-based CF could be a major contributing factor to the persistently high occurrence of vitamin A, iron and zinc deficiencies among infants in sub-Sahara Africa.* ***Purpose:*** *The main focus of this study was to develop a CF using locally accessible ingredients in Ghana that will be low in phytate, contain measurable levels of β-carotene and forms a low viscous porridge, which could be produced at home or industrially.* ***Method:*** *A computer-assisted programme (Nutrition Calculator) obtained from Global Alliance for Improved Nutrition- Infant and Young Child Nutrition Programme was used to formulate composite flours containing sweetpotato, soyabean and fish powder from anchovies or skim milk powder to meet the protein, fat and energy specifications in the Codex standards (CAC/GL 8 and STAN 074-1981, Rev.1-2006) for CF. The household-level ComFa formulation with fish powder as an ingredient was toasted in an oven and denoted oven-toasted ComFa, while the industrial-level formulations (roller-dried ComFa and extrusion-cooked ComFa) had skim milk powder (a common ingredient in industrial-processed dry infant cereal) as a component and were produced using a roller drier or an extruder. The nutritional, functional and consumer acceptance analyses of sweetpotato-based CFs were carried out and compared with enriched*

Weanimix. In this research, Weanimix was slightly modified by using dehulled maize and soyabean flours, and further addition of 17% fish powder and 0.50% sugar to the basic formulation, and referred to as enriched Weanimix. Additionally, the stability of β-carotene in the oven-toasted ComFa was evaluated under simulated average temperature of 32°C and 85% relative humidity, mimicking the ambient conditions of Ghana. ***Results:*** *The ComFa formulations and the enriched Weanimix met the stipulated energy and fat values specified in the Codex standards. However, the protein content of the industrial ComFa formulations was lower by 17%, but the oven-toasted ComFa and enriched Weanimix met the protein specification. The sweetpotato-based formulations had total dietary fibre that was about twice the Codex specification of less than 5.0%, but was likely to be partly soluble fibre and, thus beneficial. The phytate content in all the ComFa formulations was approximately a quarter of the level of 0.80 g/100 g in the enriched Weanimix. Only the sweetpotato-based infant foods contained measurable levels of β-carotene, resulting in significantly higher vitamin A content of the oven-toasted ComFa compared with enriched Weanimix (28.80 vs. 1.20 µg retinol equivalents/100 kcal). Most of the β-carotene in the oven-toasted ComFa was retained for up to eight weeks when stored in containers with a good moisture barrier under simulated ambient conditions of Ghana. Oven-toasted ComFa, roller-dried ComFa and enriched Weanimix, using an estimated daily ration of 40 g (dry weight), contained less than half of the World Health Organization recommended levels for calcium (400 mg/day), iron (9.3 mg/day) and zinc (4.1 mg/day) from CFs processed for 6 to 8 month-old breastfeeding infants, with the exception of the oven-toasted ComFa, which contained 60% of the recommended calcium level. The two selected ComFa formulations are likely to be less inhibitory regarding calcium, iron and zinc absorption by infants than the enriched Weanimix based on the phytate: calcium, iron and zinc molar ratios, and the level of β-carotene to predict relative availability of these essential minerals. All the CFs had phytate: calcium molar ratios lower than the maximum recommended ratio of 0.17, but their phytate: iron molar ratios exceeded the maximum recommended ratio of 1.0. However, the phytate: zinc molar ratio of the oven-toasted ComFa and roller-dried ComFa were approximately lower by 24% than the recommended*

ratio of 15. In contrast, the phytate: zinc ratio of enriched Weanimix was higher by 53% compared to the recommended ratio. Also, the ComFa formulations and enriched Weanimix, had levels of total polyphenols (84.70 and 76.96 mg/meal, respectively), which may inhibit iron absorption. On average, sweetpotato-based formulations were higher in maltose (26 times), sucrose (5 times), free glucose (19 times) and fructose (7 times) than levels in enriched Weanimix, but the ComFa formulations contained significantly less starch (10-13 vs. 47 g/100 g). The high simple sugar and low starch levels in the ComFa formulations could explain the lower apparent viscosity (9-, 13- and 20-times, for peak, "consume" *and final viscosities), higher water solubility index (7 times), and higher consumer acceptance compared with the maize-based formulation.* ***Conclusion:*** *On the basis of the compositional, functional and sensory findings of this study, the sweetpotato-based formulations have significant advantages as complementary food compared with Weanimix due to the low level of phytate, the high levels of endogenous β-carotene and low viscosity. Importantly, the ingredients used to produce the household-level ComFa formulation could be easily accessed by caregivers in Ghana. However, there is a need to conduct field trial and consumer acceptance studies in Ghana before substantive recommendations on the use of the sweetpotato-based infant formulation could be made.* ***Limitation****: The conclusions made are based on compositional, functional and consumer acceptance studies but not on any* in vivo *experiment or randomised feeding trial among Ghanaian infants. However, because the comparisons were made between the ComFa formulations and Weanimix, the conclusions drawn in this thesis are relevant*.

Key words: Carotene, Complementary/infant food, Ghana, Maize, Phytate Sweetpotato, Vitamin A

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List of papers

The thesis is based on papers either published, under review or yet to be submitted to a journal.

Paper I. Development of sweet potato-soybean blend, an alternative to maize-legume mix as complementary food for infants in Ghana. (Conference proceedings of the Nutrition Society of New Zealand (Inc.), Vol 34, 2010).

Paper II. Complementary food blends and malnutrition among infants in Ghana–a review and a proposed solution. (Scientific Research Essays, *7*(9), 2012).

Paper III. Sweetpotato-based complementary food for infants in low-income countries. (*Food and Nutrition Bulletin, 33* (1), 2012).

Paper IV. A household-level sweetpotato-based infant food to complement vitamin A supplementation initiatives. (*Maternal and Child Nutrition*, *8*(4), 2012).

Paper V. β-carotene retention in sweetpotato-based complementary food stored in different containers under simulated tropical temperature and humidity. To be submitted to the *Journal of Science of Food and Agriculture.*

Paper VI. Sweetpotato-based complementary food would be less inhibitory on mineral absorption than a maize-based infant food assessed by compositional analysis. (*International Journal of Food Sciences and Nutrition*, DOI: 10.3109/09637486.2012.687368).

Paper VII. Carbohydrate composition, viscosity, solubility and sensory acceptance of sweetpotato- and maize-based complementary foods. Under review in *Food and Nutrition Research*. (Manuscript ID: 18717).

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