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# **Sweetpotato-based complementary food for infants in Ghana**

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A thesis presented in fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Human Nutrition



Institute of Food, Nutrition and Human Health

Massey University

Palmerston North, New Zealand.

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Title: 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**

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**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  $\beta$ -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-Saharan 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  $\beta$ -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  $\beta$ -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  $\beta$ -carotene, resulting in significantly higher vitamin A content of the oven-toasted ComFa compared with enriched Weanimix (28.80 vs. 1.20  $\mu$ g retinol equivalents/100 kcal). Most of the  $\beta$ -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  $\beta$ -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  $\beta$ -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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## **Table of contents**

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Abstract .....	iv
Acknowledgements .....	vii
Table of contents .....	viii
List of papers .....	xiii
List of tables.....	xiv
List of figures.....	xv
Appendices .....	xvii
Chapter 1: General Introduction.....	1
1.1 Thesis layout .....	1
1.2 Background .....	3
1.3 Crop production in Ghana .....	6
1.4 Sweetpotato and soyabean cultivation and utilisation in Ghana.....	9
1.5 Main objective .....	13
1.5.1 Specific objectives .....	13
1.6 Development of sweetpotato-soyabean blend, an alternative to maize- legume mix as complementary food for infants in Ghana.....	14
Abstract .....	14
1.6.1 Introduction.....	15
1.6.2 Methods.....	15
1.6.2.1 <i>Ingredients used for processing complementary foods</i> .....	15
1.6.2.2 <i>Formulation and processing of sweetpotato-soyabean complementary             food</i> .....	16
1.6.2.3 <i>Processing of maize-soyabean-groundnut blend (Weanimix)</i> .....	16
1.6.2.4 <i>Nutrient analysis</i> .....	16
1.6.2.5 <i>Data analysis</i> .....	17
1.6.3 Results.....	17
1.6.3.1 <i>Nutrient composition</i> .....	17
1.6.4 Discussion .....	19
1.6.5 Conclusion.....	20
References (Paper I only).....	21
Chapter 2: Literature Review .....	23
Highlights.....	23

Abstract .....	24
2.1 Introduction .....	25
2.2 Efforts to improve the nutritional status of Ghanaian infants .....	33
2.3 Complementary foods processed using sweetpotato .....	48
2.4 Proposed formulation of sweetpotato-based complementary food .....	50
2.5 Conclusion .....	54
References .....	55
Chapter 3: Processing, Macronutrient and Phytate Levels .....	64
Highlights .....	65
Abstract .....	66
3.1 Introduction .....	67
3.2 Materials and methods .....	70
3.2.1 Description of ingredients used in the formulations .....	70
3.2.2 Preparation of cream-fleshed sweetpotato flour .....	70
3.2.3 Formulation of sweetpotato-based complementary foods (ComFa) .....	70
3.2.4 Extrusion-cooked ComFa .....	71
3.2.5 Roller-dried ComFa .....	71
3.2.6 Oven-toasted ComFa .....	72
3.2.7 Enriched Weanimix .....	72
3.3 Laboratory analyses .....	72
3.3.1 Nutritional analyses .....	72
3.3.2 Phytate analysis .....	73
3.4 Statistical analysis .....	73
3.5 Results .....	74
3.5.1 Nutrient composition of the complementary foods .....	74
3.5.2 Phytate content of the complementary foods .....	77
3.6 Discussion .....	78
References .....	81
Chapter 4: Sweetpotato-based formulation as a dietary source of vitamin A (Papers IV & V) .....	85
Highlights (Paper IV) .....	86
Abstract .....	87
4.1 Introduction .....	89

4.2	Materials and Methods .....	93
4.2.1	Ingredients for processing the complementary food .....	93
4.2.2	Processing of complementary foods .....	93
4.3	Nutrient composition analyses .....	94
4.4	Data analysis.....	95
4.5	Results and discussion.....	96
4.5.1	Product description for cereal-based infant food in the Codex Commission Standard .....	96
4.5.2	Energy density.....	96
4.5.3	Protein .....	97
4.5.4	Carbohydrate.....	99
4.5.5	Lipids .....	102
4.5.6	Calcium.....	103
4.5.7	Vitamin A .....	104
4.6	Conclusion .....	106
	References .....	107
	Highlight (Paper V) .....	110
	Abstract .....	111
4.7	Introduction .....	113
4.8	Materials and Methods .....	115
4.8.1	Preparation of the sweetpotato-based complementary food .....	115
4.8.2	Storage container .....	115
4.8.3	Storage study under simulated temperature and humidity .....	115
4.8.4	Sampling.....	116
4.8.5	Moisture analysis.....	117
4.8.6	$\beta$ -carotene analysis .....	117
4.9	Statistical analysis.....	118
4.10	Results and Discussion .....	119
4.10.1	Provitamin A precursor retention.....	119
4.10.2	Moisture uptake by the oven-toasted ComFa from the different containers	120
4.11	Conclusion .....	125
	References .....	126
	Chapter 5: Estimation of Calcium, Iron and Zinc Availability .....	129
	Highlights.....	129

Abstract .....	131
5.1 Introduction .....	132
5.2 Materials and methods .....	135
5.2.1 Calcium, iron and zinc analysis .....	135
5.2.2 Phytate analysis .....	136
5.2.3 Total polyphenols analysis .....	136
5.2.4 $\beta$ -carotene analysis .....	137
5.2.5 Calculation of phytate: mineral molar ratio .....	137
5.3 Statistical analysis .....	137
5.4 Results .....	138
5.5 Discussion .....	143
5.6 Conclusion .....	146
5.7 Data from an <i>in vitro</i> digestion/Caco-2 model iron uptake study .....	147
References .....	150
Chapter 6: Nutritional Implications of Functional and Sensory Properties .....	156
Highlights .....	156
Abstract .....	157
6.1 Introduction .....	159
6.2 Material and methods .....	162
6.2.1 Processing of complementary food formulations .....	162
6.2.2 Extrusion-cooked ComFa and roller-dried ComFa .....	162
6.2.3 Oven-toasted ComFa .....	162
6.2.4 Enriched Weanimix .....	162
6.3 Chemical and physical properties analyses .....	162
6.3.1 Carbohydrate composition .....	162
6.3.2 Viscosity measurement .....	163
6.3.3 Water solubility index .....	164
6.4 Consumer sensory evaluation .....	164
6.5 Statistical analysis .....	165
6.6 Results .....	167
6.7 Discussion .....	175
6.8 Conclusion .....	179
References .....	180

Chapter 7: General Summary and Conclusion .....	183
Chapter 8: Limitations, Recommendations and Future Perspectives.....	188
References: Chapters 1, 7 & 8.....	190
Appendices .....	201

## List of papers

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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.  $\beta$ -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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*International Journal of Food Sciences and Nutrition*. Copyright © 2012, Informa Healthcare (Paper V).

## **List of tables**

---

---

Table 1.1 Major crops grown in the different agro-ecological zones of Ghana .....	9
Table 1.2 Macronutrient composition of stove-top cooked ComFa and Weanimix as complementary food formulations <sup>a</sup> .....	17
Table 1.3 Calcium, iron and zinc densities of stove-top cooked ComFa and Weanimix as complementary food formulations compared to average desired densities <sup>a</sup> .....	18
Table 2.1 Breastfeeding practices* (%) among Ghanaian infants.....	31
Table 2.2 Types of complementary foods (%) given to infants using a "24-hour" period (yesterday and last night) recall .....	32
Table 2.3 Complementary food formulations developed for Ghanaian infants..	38
Table 2.4 Nutritional intervention trials in Ghana using complementary food for infants and young children .....	42
Table 2.5 Ingredients and estimated levels of macronutrients of proposed sweetpotato-based complementary food .....	53
Table 3.1 Macronutrient composition of sweetpotato- and maize-based complementary foods.....	75
Table 3.2 Estimated daily nutrient intakes from sweetpotato- and maize-based complementary foods against recommended daily requirements for 6 to 8 month-old breastfeeding infants in developing countries <sup>a</sup> .....	76
Table 3.3 Fructose and phytate levels of sweetpotato- and maize-based complementary foods <sup>a</sup> .....	77
Table 5.1 Levels of phytate, calcium, iron and zinc (mg/kg) in sweetpotato- and maize-based CFs* .....	138
Table 5.2 Phytate: calcium, iron and zinc molar ratios of sweetpotato- and maize-based CFs*.....	140
Table 5.3 Levels of total polyphenols (an inhibitor of iron absorption) and $\beta$ -carotene (a possible enhancer of iron absorption) in sweetpotato- and maize-based CFs .....	141
Table 6.1 Carbohydrate composition <sup>1</sup> (g/100 g dry matter basis) of sweetpotato- and maize-based complementary foods .....	168
Table 6.2 Correlation coefficient <sup>1</sup> between carbohydrate composition, apparent viscosity and solubility.....	170

**List of figures**

---

---

Figure 1.1 Global prevalence of vitamin A deficiency (based on serum retinol <0.70 µmol/l) in populations at risk 1995–2005 .....5

Figure 1.2 Worldwide prevalence of anaemia (based on haemoglobin concentration of <110 g/l) 1993–2005 .....5

Figure 1.3 Agro-ecological zones in Ghana indicating major economic crops ....8

Figure 2.1 Percentage of infants under 12 mo classified as malnourished using height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) Z-scores .....27

Figure 2.2 Percentage of infants under 12 mo classified as malnourished using height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) Z-scores .....28

Figure 4.1 Energy density of household-level processed complementary foods .....97

Figure 4.2 Protein density of household-level processed complementary foods .....98

Figure 4.3 Amino acid score of household-level processed complementary foods.....99

Figure 4.4 Fructose density of household-level processed complementary foods ..... 100

Figure 4.5 Carbohydrate (glucose + fructose contents) density of household-level processed complementary foods ..... 101

Figure 4.6 Fat density of household-level processed complementary foods... 102

Figure 4.7 Calcium density of household-level processed complementary foods ..... 103

Figure 4.8 Vitamin A density of household-level processed complementary foods..... 104

Figure 4.9 The three storage containers (A) and Contherm precision environmental chamber (B) ..... 116

Figure 4.10 Loss of  $\beta$ -carotene content in oven-toasted ComFa in different storage containers under simulated tropical temperature and humidity# .....119

Figure 4.11 Uptake of moisture by the oven-toasted ComFa in the different storage containers under simulated tropical temperature and humidity# .....121

Figure 4.12  $\beta$ -carotene content in oven-toasted ComFa over a year in storage# .....122

Figure 5.1 Uptake of radioactive iron (in percentages) across cells per total radioactive iron added from different complementary food .....148

Figure 6.1 Viscosity during cooking (peak viscosity), at serving (“consume viscosity”) and during storage (final viscosity) of porridge from the complementary foods .....169

Figure 6.2 The water solubility index of the complementary foods.....170

Figure 6.3 Diagrammatic presentation of product liking for sensory attributes and choice to give the formulations as complementary food to infants by female sensory participants.....172

Figure 6.4 Diagrammatic presentation scoring for sweetness intensity of the complementary food formulations on just-about-right scale .....174

Figure 6.5 Diagrammatic presentation scoring for saltiness intensity of the complementary food formulations on just-about-right scale .....174

Figure A-1 Study design. Evaluating the effect of the consumption of sweetpotato- and maize-based complementary foods on the nutritional status of infants from 6 months and followed up to 9 months in the Kassena Nankana District, Ghana .....209

**Appendices**

Appendix 1: Summarised information of the human ethics application as a study protocol for conducting feeding trial on infants in Ghana. ....202

Appendix 2: Information sheet .....220

Appendix 3: Participant screening form .....223

Appendix 4: Participant consent form .....224

Appendix 5: Questionnaire (baseline & weekly) for dietary and health information for infant feeding trial .....225

Appendix 6: Questionnaire for consumer preference test .....229

Appendix 7: Approval of human ethics application (Southern A Application-09/58).....233

Appendix 8: Statement of contribution to doctoral thesis containing publications .....234