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Research Application Summary

Development and evaluation of cassava-based porridge as a complementary food for infants in Nkhotakota and Nkhata Bay districts of Malawi : A brief review

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Abstract

Adequate nutrition is essential in early childhood for normal growth and a healthy life. However, some developing countries are grappling with high prevalence of child acute malnutrition and micronutrient deficiencies. In Malawi, 37% of children under the age of five are stunted, and 3% are wasted. Levels of zinc and iron deficiencies are also high at 60% and 22%, respectively. This is besides the fact that only 8% of children receive complementary diets that meet minimum nutritional requirements. Cassava is a staple food in the districts of Nkhata Bay and Nkhotakota, where well over 79% of households rely on it. Consequently, cassava flour is used to prepare complementary porridge. Such porridge is often of poor nutritive value, and has negative sensory and functional attributes. Frequent consumption of cassava-based complementary porridge may exacerbate child malnutrition, unless enriched adequately. Enrichment of cassava-based complementary porridge would require a detailed documentation of complementary feeding practices, with a special focus on how cassava is used in complementary feeding. The enrichment process would further require documentation and selection of nutrient-dense foods that are easily accessible to most households. Animal-source foodstuffs and legumes need to be among the selected foods as they provide the much-needed macronutrients and micronutrients. Inclusion of animal-source foodstuffs might also result in increased content of important minerals such as iron and zinc. Evaluation of the bioaccessibility of iron and zinc in enriched porridge and other similar products would help in the refinement of the product towards high bioaccessibility of these minerals. A sensory evaluation of the complementary porridge would measure its acceptability and provide clues on how to improve the product. Overall, such a systematic approach may result in a product that meets nutritional requirements, and one that has acceptable sensory and functional attributes.

Key words: Bioaccessibility, macronutrients, Malawi, malnutrition, micronutrient deficiency, nutrient dense food

Résumé

Dans la petite enfance, une nutrition adéquate est essentielle pour une croissance normale et une vie saine. Cependant, certains pays en développement sont aux prises avec une forte prévalence de la malnutrition aiguë infantile et des carences en micronutriments. Au Malawi, 37% des enfants de moins de cinq ans ont un retard de croissance et 3% sont émaciés. Les niveaux de carences en zinc et fer sont

également élevés à 60% et 22%, respectivement. A cela s'ajoute le fait que seulement 8% des enfants reçoivent des régimes complémentaires répondant aux besoins nutritionnels minimaux. Le manioc étant un aliment de base dans les districts de Nkhata Bay et Nkhotakota, où plus de 79% des ménages en dépendent, la farine de manioc est utilisée pour préparer une bouillie complémentaire. Cependant, une telle bouillie a souvent une valeur nutritive médiocre et des attributs sensoriels et fonctionnels négatifs. La consommation fréquente de bouillie complémentaire à base de manioc peut exacerber la malnutrition infantile, à moins qu'elle ne soit enrichie de manière adéquate. L'enrichissement de cette bouillie complémentaire à base de manioc nécessiterait une documentation détaillée des pratiques d'alimentation complémentaire, avec un accent particulier sur la façon dont le manioc est utilisé dans l'alimentation complémentaire. Le processus d'enrichissement exigerait en outre une documentation et une sélection d'aliments riches en nutriments, et qui sont facilement accessibles à la plupart des ménages. Les denrées alimentaires et les légumineuses d'origine animale doivent faire partie des aliments sélectionnés car ils fournissent les macronutriments et les micronutriments indispensables. L'inclusion de ces denrées alimentaires d'origine animale pourrait également entraîner une augmentation de la teneur en minéraux importants tels que le fer et le zinc. L'évaluation de la bio-accessibilité du fer et du zinc dans la bouillie enrichie et d'autres produits similaires aiderait à affiner le produit vers une bio-accessibilité élevée de ces minéraux. Une évaluation sensorielle de la bouillie complémentaire mesurerait son acceptabilité et fournirait des indices sur la façon d'améliorer le produit. Dans l'ensemble, une telle approche systématique peut aboutir à un produit qui répond aux besoins nutritionnels et qui possède des attributs sensoriels et fonctionnels acceptables.

Mots clés: Bio-accessibilité, macronutriments, Malawi, malnutrition, carence en micronutriments, aliments riches en nutriments

Introduction

Adequate nutrition is essential in early childhood for normal growth, neurological and cognitive development, and a healthy life. However, levels of child malnutrition are high in most developing African countries. The term 'malnutrition' refers to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients (WHO, 2009). This broad term addresses three broad groups of conditions of under-nutrition, micronutrient-related malnutrition, and overweight and obesity. Child under-nutrition is an imbalance between nutrient requirement and intake, resulting in cumulative deficits of energy, protein, or micronutrients that may negatively affect growth, development, and other relevant outcomes (Mehta *et al*., 2013). Several forms of malnutrition are recognised, these includes stunting, which is characterised by reduced linear growth, wasting, which is characterised by low body tissue mass and other physiological abnormalities, and kwashiorkor, which is characterised by diffuse peripheral oedema (Bhutta *et al*., 2017). Malnutrition might be acute (less than 3 month's duration) or chronic (duration of three months or more). Short-term consequences of malnutrition includes impairment of the immune system, resulting in increased severity, duration, and susceptibility to infectious diseases, and a general increased risk of death (WHO, 2010). Longer-term consequences includes delayed mental development, poor school performance and reduced intellectual capacity (WHO, 2010).

Malnutrition, particularly child under-nutrition, is a major health problem in developing countries (Kramer and Allen, 2015). Statistics indicate that globally about 22.9% of children under the age of five are stunted, and 7.7% are wasted (UNICEF, WHO, and World Bank, 2017). Africa alone (particularly sub-Saharan Africa), accounts for 38% of all stunted children and 27% of the wasted

ones (IFPRI, 2016; UNICEF *et al*., 2017). The situation in Malawi is not different from that of the sub-Saharan region, as figures shows that 37% of children under the age of five are stunted, and 3% are wasted (NSO, 2016). Prevalence of zinc and iron deficiency is also high at 60% and 22% respectively (NSO, CHSU [Malawi], CDC, and Emory University, 2016). High levels of child under-nutrition in Malawi arise from a combination of poor complementary feeding practices and high prevalence of infectious diseases. Poor complementary feeding practices are characterised by poor dietary diversity and over-reliance on plant based diets with minimal inclusion of animal-source foods (USAID, 2011). Consequently, only 8% of infants in Malawi receive complementary diets that meet the minimum nutritional acceptable level (NSO, 2016). In Nkhotakota and Nkhata Bay districts, over 79% of households rely on cassava as a staple food (Kambewa and Nyembe, 2008). Cassava roots are processed into flour that is used among other things, to prepare complementary porridge (USAID, 2011). Information on the utilisation of cassava in complementary feeding in these districts is lacking, yet such diets might need to be improved. Enrichment of cassava-based complementary porridge might be necessary as they often have poor nutritive value, and negative sensory and functional attributes (Muoki *et al*., 2015). Enrichment of complementary foods with locally available nutrient-dense foodstuffs remains one of the best approaches in tackling child malnutrition (Uvere and Ene-Obong, 2013). This review therefore highlights the knowledge gaps in the utilisation of cassava in complementary feeding in Nkhotakota and Nkhata Bay districts in Malawi, with the overall aim of developing a nutrient-dense cassava-based porridge.

Methodology

This article explores knowledge gaps on utilisation of cassava in complementary feeding in Malawi. Articles on cassava-based complementary foods, child malnutrition, complementary feeding practices, and other topics were retrieved through an extensive literature search on google scholar. The articles were analysed for relevance to the topic of complementary feeding, and the necessary information was retrieved.

A brief overview of complimentary feeding. Adequate nutrition during infancy and early childhood is essential in growth, health, and development of children to their full potential. Poor nutrition increases the risk of illness, and is linked to long-term impairment in growth and health (WHO, 2009). The World Health Organization (WHO/UNICEF, 1998) recommends exclusive breastfeeding of babies from birth to the age of 6 months, in order to protect infants against gastrointestinal infections and enhance motor development. At 6 months, breast milk alone fails to meet nutritional requirements of a growing child and it becomes necessary to introduce complementary foods. Complementary foods, are any nutrient containing foods or liquids other than breast milk given to young children aged 6 to 23 months (WHO, 2009). The required nutrient density of complementary foods arises from the difference between estimated age-specific nutrient requirements of a growing child, and the nutrient density of breast milk. Adequacy of complementary feeding is thus influenced by factors such as the nutrient density of the complementary food, age of the child, and quantity of nutrients received from breast-feeding (WHO/UNICEF, 1998). In many countries, the period of complementary feeding (6-23 months) is the time of peak incidence of growth faltering, micronutrient deficiencies and infectious illnesses. Therefore, complementary foods should be nutritionally adequate, safe, and appropriately fed in order to meet the young child's energy and nutrient needs. Table 1 illustrates energy and protein requirements of children at various age groups (6-23 months). As expected, a child's energy intake from breast milk decreases progressively with age, while energy requirements from complementary foods increase correspondingly. Furthermore, a higher feeding frequency is required if the energy

density of complementary foods is low. Beyond the age of 6-9 months, breast milk alone does not supply enough iron to meet requirements, and thus adequate amounts should be supplied through complementary foods (WHO/UNICEF, 1998). Where complementary foods contains iron of low bioavailability, and where the child consumes average amounts of breast milk, the recommended daily intake of iron is 20.8 mg, and 11.8 mg for the 6-11 months and 12-23 months age groups, respectively (WHO/UNICEF, 1998). If complimentary foods contain iron of medium bioavailability, the requirements are lower, at 10.8 mg and 5.8 mg for the 6-11 months and 12-23 months age groups, respectively. Only 6.8 and 3.8 mg of iron is required from complementary foods if the iron is of high bioavailability. Daily requirement of zinc from complementary foods is 2.2 mg for the 6-8 months age group, 2.3 mg for the 9-11 months group, and 2.4 mg for the 12-23 months age groups (WHO/UNICEF, 1998). These figures assumes average intake of breast milk.

Complementary feeding practices in Malawi. In most developing sub-Saharan countries, complementary foods are prepared from plant-based foodstuffs such as maize, cassava, sorghum, and legumes (Uvere and Ene-Obong, 2013; Borresen *et al*., 2017). Consumption of complementary foods from these sources is mostly monotonous, with negligible addition of animal source foods. In Malawi, complementary feeding is supposed to start at six months, however, some infants start receiving a light maize porridge before this age (USAID, 2011). Almost all infants feed on a light maize porridge at the age of 6-8 months. The porridge is prepared separately from the family's meal using either refined or unrefined maize flour. Most caregivers regard porridge as the most appropriate food for young children, although other family members often eat a thicker version as a morning meal (USAID, 2011). At around eight months, some infants start receiving nsima (a stiff preparation made from refined or unrefined maize flour and water) made for the entire family but diluted with broth for the baby. At the age of 9-11 months, infants mostly receive a combination of porridge and *nsima*. The porridge for this age group is of thicker consistency when compared to that of the 6-8 months group, and in some cases it has groundnut flour, soy flour, or oil added (USAID, 2011). In this age group, infants also feed on foods such as beans, fish, milk, fruits (bananas, oranges, avocado pears, and papayas), and some vegetables. In the 12-23 months age group, children continue with the dietary pattern established in the 9-11 months age group. Principal foods includes a combination of porridge (perhaps fed once a day), and *nsima*. Children feed on *nsima* frequently (twice a day) and receive more foods from the family diet. Overall, maize-based complementary porridges for the entire age range of 6-23 months are usually prepared with negligible quantities of animal source foods, and contains high levels of phytic acid that limits the bioavailability of important minerals such as non-haem iron and zinc (Uvere and Ene-Obong, 2013). In the predominantly cassava growing regions of Malawi, children are fed porridge prepared from cassava flour (USAID, 2011). Such porridge has limitations that are worth revising.

Limitations of cassava-based complementary porridge. Cassava-based complementary porridge is unsuitable for complimentary feeding because of poor nutritive value, high viscosity, neutral flavour, and bland taste (Muoki *et al*., 2015). The poor nutritive value emanates from the nutritional composition of cassava roots. The cassava root is mostly a physiological energy reserve with high carbohydrate content, but lower lipid and protein content (Morgan and Choct, 2016). The lipid content of cassava roots ranges from 0.1% to 0.3% on fresh weight basis (Montagnac and Tanumihardjo, 2009). Protein content is also very low with values that range from 1% to 3% on dry matter basis (Morgan and Choct, 2016). Comparatively, protein content of cassava roots is lower than that of maize and sorghum. Vitamin C content is notably high, whereas amounts of B vitamins (thiamine,

Table 1. Energy and protein requirements of infants of various age groups (6-23 months)

Source		6-8 months*			9-11 months*			12-23 months*		
		Low	Average	High	Low	Average	High	Low	Average	High
From breast milk	Energy (kcal/ day)	217.0	413.0	609.0	157.0	379.0	601.0	90.0	346.0	602.0
	Protein (g/day)	3.9	7.1	9.1	2.9	6.5	9.6	1.8	5.9	9.7
From complementary food	Energy (kcal/ day)	552.0	356.0	160.0	701.0	479.0	257.0	1,028.0	772.0	516.0
	Protein (g/day)	5.2	2.0	none	6.7	3.1	none	9.1	5.0	1.2
Desired energy and protein content of complimentary food	Energy (kcal/g)									
	1 meal/day	2.22	1.43	0.64	2.46	1.68	0.90	2.98	2.24	1.50
	2 meals/day	1.11	0.71	0.32	1.23	0.84	0.45	1.49	1.12	0.75
	3 meals/day	0.74	0.48	0.21	0.82	0.56	0.30	0.99	0.75	0.50
	4 meals/day	0.56	0.36	0.16	0.61	0.42	0.23	0.74	0.56	0.37
	5 meals/day	0.44	0.29	0.13	0.49	0.34	0.18	0.60	0.45	0.30
	Protein (g/100 kcal)	1.10	0.70	none	1.00	0.70	none	0.90	0.70	0.20

*Assumed gastric capacity (30g/kg reference body weight) is 249 g/meal at 6-8 months, 285 g/meal at 9-11 months and 345 g/meal at 12-23 months (WHO/ UNICEF, 1998). Categories low, average and high correspond to nutrient intake from breast milk: Low (mean – 2 standard deviation), Average (mean), and High (mean + 2 standard deviation). *1 kcal = 4.2 kJ

riboflavin, and niacin) are relatively lower (Montagnac *et al*., 2009). Overall, cassava roots have poor nutritive value.

Enrichment of cassava-based complementary foods. Traditionally, cassava is milled together with maize and sorghum to yield improved composite flour. The addition of maize or sorghum to cassava confers little improvement on nutritional quality of complementary foods. Such is the case because the cereals are also limited in nutritional quality. They contain low levels of some nutrients and higher levels of antinutrients (phytates) that limit the bioavailability of iron and zinc (Nuss and Tanumihardjo, 2010).

A limited number of publications have reported on enrichment of cassava-based complementary foods. Muoki *et al*. (2015) enriched cassava flour with soy flour with the purpose of increasing protein content and lowering viscosity of complementary porridges. Use of extrusion cooking helped to improve sensory and functional properties of porridges, as evidenced by high acceptance rates of the product by mothers in the cassava growing regions of Mozambique. In another study, Kalimbira *et al*. (2004) enriched cassava flour with soy and common bean flours. The resulting composite flours had improved nutritive value compared to cassava-only flour and cassava-maize blends. Germination of soybeans and common beans further improved the bioavailability of minerals owing to reduction of phytates. Onabanjo *et al*. (2008) evaluated the nutritional value of composite flours prepared from cassava root, soybean, groundnut, cassava leaves and carrot. Complementary diets prepared from the composite flours supplied required amounts of calories, proteins, fats, crude fibre, all essential amino acids, and most minerals except iron. Oyarekua (2009) took a different approach to improving nutritive value of cassava based complementary foods by co-fermenting cassava, cowpeas and

carrots, to produce a porridge known as 'ogi'. Ogi prepared from cassava alone had lower crude protein content compared to that from cassava, cowpea, and carrot. The improved ogi further had higher content of minerals such as calcium, magnesium, potassium and sodium, as well as essential amino acids. Wireko-Manu *et al*. (2016) investigated the acceptability of instant cassava-soybean based complementary food by weaning mothers in Ghana. They employed a technique known as steam blanching to produce various cassava-soy blends. It was learnt that steam blanched blends were preferred because they had better flavour and taste compared to non-steam blanched ones. Overall, the study showed that steam blanching significantly improved sensory and functional properties of cassava-based complementary foods, and that such foods met nutritional needs of children aged 9 to 11 months. In Tanzania, Swai (2013) evaluated nutritional and sensory quality of peanut-soybean-cassava composite flakes which were produced through extrusion cooking. The composite flakes supported growth in rats with a good protein efficiency ratio (PER) value of 2.32 and true protein digestibility of 93.99%. Nutritional quality of the product met requirements for use as a therapeutic food for rehabilitation of undernourished children.

Consideration for further research

The review of literature on enrichment of cassava-based complementary foods has brought to light researchable knowledge gaps. Firstly, complementary feeding practices in the predominantly cassava growing districts of Nkhata Bay and Nkhotakota have not been documented. Available literature has simply stated the use of cassava flour in the preparation of complementary porridges without elaborating how it is used. It is thus important to investigate the extent of utilisation of cassava in complementary feeding in the two districts and document how the foods are prepared. Preparation of the complementary foods needs to document how the various food materials are separately prepared, combined, and cooked. It should also document whether the foods are enriched with legumes and animal-source foods. It would also be important to investigate whether the frequency of consumption of cassava-based complementary foods correlates with the economic status of households. Such is the case because the frequency of consumption of *kondowole* (a thick preparation from cassava flour and water) was shown to correlate positively with the economic status of households in Nkhata Bay district (Chiwona-Karltun *et al*., 2000). It was noted that frequency of *kondowole* consumption was higher for households of lower economic status than those of higher status.

Levels of under-nutrition for Nkhotakota and Nkhata Bay are not far from the national average. In Nkhotakota, 33.2% of children under the age of 5 years are stunted, 1.8% are wasted, and 13.5% are underweight (NSO, 2016). As for Nkhata Bay, 32.5% of the children are stunted, 0.1% are wasted, and 4.9% are underweight (NSO, 2016). Furthermore, in Nkhata Bay, only 9.3% of children aged 6-23 months receive complementary diets that meet minimum acceptable standards, while in Nkhotakota only 7.5% of the children does so (NSO, 2016). Levels of anaemia among children aged 6-59 months are also high, with 77.4% in Nkhata Bay, and 71.8% in Nkhotakota (NSO, 2016). Zinc deficiency in these districts is also likely as high as the national average. These statistics highlights the need to improve complementary feeding practices in this part of the country, as doing so might help reduce levels child under-nutrition. There is need for research efforts towards enrichment of cassava-based complementary foods with locally available nutrient-rich foodstuffs. A researchable knowledge gap thus exists on the types of foodstuffs that are applicable for this purpose, hence the need to document locally available nutrient-rich plant based and animal-source foodstuffs. The list of such foodstuffs may include legumes, cereals, small dry fish, edible insects, tubers, and others. Foodstuffs with greater potential of enriching cassava-based complementary foods would be selected based on the criteria of

availability, cost, and nutrient density. It would be important to include animal-source foodstuffs in the complementary food formulations as these might increase the quantities and bioavailability of critical minerals such as iron, zinc, and calcium.

After documenting and selecting the foodstuffs, the next step would be to formulate composite flours from the selected foodstuffs. This would require evaluation of nutritional value of the foodstuffs, including both the proximate and ultimate composition. It would also be important to evaluate anti-nutrient content of the foodstuffs, and where applicable reduce the content through established techniques. Overall, the aim would be to develop cassava-based complementary porridges that meet minimum nutritional standards set by the World Health Organization, and at the same time have acceptable sensory and functional attributes. It would be important to compare the nutritional quality of the enriched porridge with the local ones, and a standard porridge. The basis of comparison could be the quantity and quality of macro- and micronutrients, as well as the bioaccessibility of iron and zinc. Such an assessment would help to address the knowledge gap as to whether the selected foodstuffs improve quality of cassava-based complementary porridge, particularly, the bioaccessibility of iron and zinc. Measurement of bioaccessibility would suffice for such a study, as it is cheaper and easier to conduct compared to measurement of mineral bioavailability.

After developing the enriched porridge, it would be important to evaluate its acceptability by caregivers of children aged 6-23 months. Caregivers in focus area on Nkhotakota or Nkhata Bay would rate the porridge on sensory attributes of colour, texture, taste, and smell, on a 5-point hedonic scale (from "5" – like very much, to "1" – dislike very much). Such an activity would help to address the knowledge gap of whether the enriched cassava porridge is of acceptable sensory quality to the caregivers, who in most cases are the decision makers on the type of food a child eats. Findings from this assessment need not be conclusive, as they can also inform further refinement of the product.

Conclusion

Cassava is an important cash and food crop in Malawi, particularly, in the lakeshore districts of Nkhotakota and Nkhata Bay. In these districts, cassava roots are processed into flour, which is used to prepare a wide range of food products including complementary porridge. Utilisation of cassava in complementary feeding has only been stated and not elaborated, hence the need to document complementary feeding practices in this area with a focus on utilisation of cassava. Knowledge gathered in this process would help to guide an intervention aimed at improving the quality of the complementary foods. Enrichment of the cassava-based porridges would thus require documentation and selection of foodstuffs that are locally available in the area, and are accessible to many. Legumes and animal-source foodstuffs would help to increase levels and quality of protein and fat, and for the latter, levels of iron and zinc as well. Measurement of bioaccessibility of iron and zinc would help to refine formulation of the complementary porridge towards increased bioaccessibility of these minerals. Sensory evaluation of the enriched cassava-based porridge by caregivers would guide product refinement. Overall, it has been noted that knowledge gaps exist on the utilisation of cassava in complementary feeding, availability of nutrient-dense foodstuffs that can enrich cassava-based porridges, effect of the enriching foodstuffs on bioaccessibility of iron and zinc, and acceptance of the enriched porridge by child caregivers in the study area. These gaps should be addressed.

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