

**MODIFICATION OF LOCAL DIETS TO IMPROVE
VITAMIN A, IRON AND PROTEIN CONTENTS FOR CHILDREN
AGED 6 TO 23 MONTHS IN KAGERA, TANZANIA**

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ABSTRACT

The banana-based farming system of Kagera region of Tanzania has good edible food diversity. However, households still consume monotonous diets, which are mainly energy dense and have inadequate content of micronutrients. To enrich the preferred energy-rich diets, this study formulated dishes with improved content of vitamin A, iron and protein for children aged between 6 to 23 months. Mothers (n = 50) were randomly selected from Izimbya ward and participated in a recipe development exercise whereby five recipes modified from the traditional banana based 'katogo'/'matoke' and three types of porridges were developed using locally available foods such as bananas, beans, amaranths, red palm oil, pumpkin, groundnut, maize and orange-fleshed sweet potato (OFSP). Mothers were asked to give options of improving the porridge intended to be fed to children as well as to propose means of improving the local banana diets. Vitamin A was increased by red palm oil, OFSP, pumpkin fruit and leaves in the modified recipes. Red kidney beans formed a good source of iron, protein and energy when incorporated in complementary foods. The family dishes and children's local popular dishes were modified to improve the consistency by making a purée to increase food intake and, therefore, vitamin A, iron and protein. Based on the food composition table, the developed recipes contained more than 100% of vitamin A and protein and between 61% to 99% of the iron recommended dietary allowance (RDA) for children 6-23months. The conversion factor of 12:1 for beta-carotene was used. Vitamin A, iron, protein and energy content in modified recipes ranged from 108-2768 RAE, 6-17 mg, 28-56 g and 697-1635 kcal, in 500g consumption portion, respectively. The created recipes based on locally available and affordable ingredients have a potential to meet RDAs of vitamin A, iron and protein for children aged 6 to 23 months in the banana-based system and other communities in Africa with the same settings. The communities need to establish home gardens so as to use vegetables and foods which are cheap and good sources of micronutrients and protein.

Key words: Dietary modification, local diets, children, vitamin A, iron, protein



INTRODUCTION

Malnutrition is a preventable problem if nutrition education and food-based approach strategies are effectively emphasised from the village level to the national level. In many rural farming communities of developing countries, challenges facing nutrition have partially or inadequately been addressed. Deficiencies of iron and vitamin A and protein energy malnutrition (PEM) are among the nutritional problems with serious consequences [1, 2]. It is estimated that iron deficiency anaemia affects two billion people globally, mostly women and children [3]. Worldwide blindness due to vitamin A deficiency affects 2.8 million children below five years of age [2]. Despite the decrease of stunting and underweight prevalence (2011 to 2016) from 42% to 34 % and 16% to 14 %, respectively in Tanzania this level remains unacceptable. Thirty five percent of children below five years of age in Tanzania are iron deficient, 58% have anaemia and 38% are vitamin A deficient [4]. Anaemia in women aged 15-49 years has increased from 40% to 45% between 2010 and 2016 in Tanzania; and 37% of women of the same age range are vitamin A deficient and 30% are iron deficient [4, 5]. Kagera region has an above average number of stunted and underweight children. About 42% of children below five years of age are stunted, 17% underweight, 51% are vitamin A deficiency and 58% are anemic in Kagera region. Furthermore, 40% of women aged 15-49 years are anemic and 43% are vitamin A deficiency in the same region [4, 5].

The banana-based farming system of Kagera region has adequate food diversity that could help ameliorate under-nutrition. However, the majority still consume monotonous diets mainly based on energy dense foods with inadequate micronutrient content. Inadequate diversity contributes to unacceptable high levels of under-nutrition, particularly PEM and low intake and risks of deficiency of essential micronutrients such as vitamin A and iron, particularly in children below five years of age [5, 6]. Dietary modification is a process of diet alteration done by nutritionists or dieticians to include or exclude certain components, such as vitamins, minerals, calories, and fat, mainly using available local foods. This process can result in new recipe creation. A recipe is a set of directions with a list of ingredients for preparing food. Consumption of a wide variety of foods across nutritionally distinct food groups increases the probability of adequate micronutrient intake [7, 8]. In addition, dietary modification based on foods available in a particular locality is more sustainable, economically feasible, and culturally acceptable, and can be used to alleviate several micronutrient deficiencies [7]. Thus, consumption of nutrient-dense complementary foods prevents deficiency in children below five years of age [9]. This study created and tailored local recipes to increase intake of vitamin A, iron and protein for children below five years of age.

MATERIALS AND METHODS

Study Area

The study was conducted in Izimbya ward of Bukoba district in Kagera region located on the western side of Tanzania bordering Uganda, Rwanda and Burundi, and to the East is Lake Victoria. The main farming system is dominated by bananas intercropped with coffee and other annual food crops including common beans, maize, sweet potatoes,



groundnut, bitter tomatoes, pumpkins, amaranths, and red palm oil. Important livestock are cattle, goats, sheep, chicken and ducks. All these crops and livestock provide important sources of micronutrients and protein at the household level.

Data Collection

Mothers ($n = 50$) with children aged between 6 and 23 months were randomly selected from Rugaze and Izimbya villages and participated in the recipe formulation/development exercise. They were from four sub-villages of Kakindo and Kyelima (Izimbya village) and Rugaze A and Kikagati (Rugaze village). Each village had 25 mothers and/or caregivers recruited for the exercise. Five recipes modified from the traditional banana-based ‘katogo’/‘matoke’¹ and three types of porridges were developed to increase intake of vitamin A, iron and protein. Diet modification process included participatory techniques whereby mothers gathered at one center per village. During discussions and after receiving technical inputs from the researcher, mothers were asked to give options of improving the porridge intended to be fed to children as well as to propose means of improving the local banana diets. Focus group discussions with aide from nutrition experts identified nutrient rich foods available in the study communities. The group discussion comprised three females and three males. The total nutrient composition of each recipe was obtained by calculating the nutrient value of each ingredient and then summing all these values. The total nutrient content per 100 g cooked dish A was calculated as follows:

$$* \text{Nutrient content} = \frac{\text{Total nutrient A} \times 100}{\text{Total cooked food weight (g)}} [8]$$

The family dishes and children’s local popular dishes were modified to improve the consistency by making a purée so as to increase food intake and, therefore, vitamin A, iron and protein. Purée is a food that has been made into a thick moist paste by mashing it or blending it. Simple modification such as reducing the time between peeling or cutting and cooking; and cooking with the lid on was done. To improve nutrient intake, overall limiting of the cooking time and cooking unpeeled orange-fleshed sweet potato (OFSP) were done [10]. Local food availability and food seasonality data in Izimbya were obtained from secondary data and literature review [11]. Food ingredients for cooking modified recipes were bought from the local market in Izimbya. Data for price of food ingredients per kilogram were collected from two markets of Izimbya ward where most households buy food. A total of 40 vendors were involved. Price per portion of formulated food ingredients in kilogram was calculated to get the total cost per cooked portion, excluding cost for processing. The average cost was computed by excel software.

Participants were involved in the modification process and all the modified recipes were improved by using common household cooking methods practiced in the community. Ingredients used and their portions per recipe were calculated based on a 70:30 carbohydrate: protein ratio. Cooking methods and procedures for both modified ‘katogo’

¹ ‘katogo’or ‘matoke’ is a local recipe prepared from banana, beans and other ingredients



and porridge were described. In order to allow dietary diversity for nutrient adequacy, five recipes from banana ('katogo') and three types of porridges were developed based on cooking banana ('nshakala²) state of bean (dry and fresh) type of cooking oil (red palm oil and sunflower oil) and source of nutrients. 'Nshakala' was selected because it is the local widely available variety.

Recipe Formulation/development and Modification

Amount of nutrient per ingredient were calculated by using the Tanzania food composition tables. The recommended dietary allowance (RDA) for children aged 6-23 months for protein, iron, vitamin A and energy is 13g, 10mg, 400µgRAE and the maximum energy is 894kcal, respectively [12-14]. This amount was used during calculation of nutrient contents per diet. Recipe formulation was computed based on the US Institute of Medicine (IOM) RDAs standards [15]. Vitamin A was calculated as retinol activity equivalents (RAE) = 12µg β carotene = 24µg of other provitamin A carotenoid. Amaranths and pumpkin leaves were included in the recipes as a source of iron and vitamin A. Fresh and dry red kidney beans were included as source of iron and protein instead of other kinds of kidney beans. Red palm oil, cooking banana (white flesh, pumpkin fruit and OFSP 'kabode'³ variety were used as sources of vitamin A. Groundnuts were used because they are a good source of fat and protein; also they are source of iron. Eggs were used as a source of protein and vitamin A. Banana, beans, OFSP and oil were used as sources of energy. Maize flour was fermented to improve digestibility and increase amounts and bio-availability of nutrients [16]. Cooking time for recipes with dry and fresh red kidney beans ranged from 67 to 97 and 52 to 67 minutes, respectively. Recipes with groundnut cooked for only 27 minutes. Cooking time for porridge; OFSP, cooking banana and egg/beans was 45 to 60, 40, and 75-105 minutes, respectively. The following amount of ingredients were used during recipe creation; banana 225g, beans and groundnut 100g, amaranth and pumpkin leaves 50g, bitter tomatoes 75g, onion 16g, tomatoes 50g and cooking oil (red palm oil and sunflower oil) 13ml.

Ethical Clearance and Consenting

The community and individuals were informed about the study. A written consent to participate in the study was obtained from the mothers or the caregiver and representative from the community. Ethical clearance was obtained from the National Institute for Medical Research (NIMR) permit number NIMR/HQ/R.8a/Vol.IX2202. Permission to conduct the study was obtained from regional, district and ward authorities.

² 'Nshakala' is East African Hybrid Banana (EAHB) local variety

³'Kabode' is a Vitamin A rich sweet potato (orange-fleshed sweet potato)



RESULTS AND DISCUSSION

The Nutritional Gaps for Local Dishes

An appropriate feeding practice is often a great determinant of adequate dietary intakes in situations where there is assurance of the availability of foods in the household. Rural farming households lack proper dietary diversity due to limited knowledge and skills on food preparations despite the abundance of micronutrient rich foods in their respective communities [17, 18]. This situation was observed in Izimbya ward of Bukoba district. The local diets were missing some important food sources of iron, vitamin A and protein that lead to micronutrient deficiency due to insufficient intake from commonly available or consumed foods. The main ingredients in the common 'katogo' recipe were banana, beans and sardines. The usual practice is to cook it in a mixture of bananas, sardines and beans without mashing it to make it suitable for children to eat. Consequently, children fail to eat adequate amounts. In this study, the same recipe was mashed to make the food suitable for consumption by children. The common dishes given to children in this study area were mainly from plant sources and only 5% were from animal sources because majority of households cannot afford to buy them [11]. Therefore, diet modification was based on plant sources for availability, accessibility and affordability [19]. This study considered ways of feeding infants with foods of appropriate texture for their age by making a purée especially for children aged 6 to 23 months. It was in line with a review study by Berti *et al.*, [20], which insisted that availability and affordability of nutrient-rich foods improve nutrition and health in the long-term.

Women in rural areas are burdened by household activities as well as farming activities leading to time shortages for preparation of children's foods. The study considered this by reducing cooking time and preparing nutrient-dense food for children and the whole family at once. Thus, mothers could cook food for the whole family and take a portion for a child and mash it into a purée. Moreover, during banana purée preparation ingredients were added within the cooking time of beans that is why it took less time (27-97 minutes) to cook when compared to the time used to cook the local banana diet (99-128 minutes) [11]. However, porridge with beans took more time (75-105 minutes) to cook because dry beans need to cook for 60-90 minutes to be tender before mashing. The diet modification was done in four different sites which had differences in cooking time that depend on heat intensity. While nutrient requirements for children increase at the age of six months and above, mothers in Bukoba district prepare thin porridge for their children made only from maize flour and water and thus having little or no micronutrients.

Contribution of food items/ingredients to RDA

Recipe 1N had a total 229% of RDA for vitamin A and 163% (650µgRAE/529 g) was contributed by red palm oil. Recipe 2N had a total 117% of RDA for vitamin A and pumpkin leaves contributed 69% (275µgRAE/529g) of total RDA for vitamin A. Red kidney beans contributed 75% of RDA for iron and 182% of RDA for protein more than other ingredients in banana puree recipe 1N/3B and recipe 2N/4B in 526g cooked amount. 'Katogo' recipe 5N with 566g cooked amount had 375% RDA for protein and 78% RDA for iron whereby 199% and 46% contributed by groundnut flour respectively.



'Katogo' recipe 5N with 566g cooked amount had 375% RDA protein and 78% RDA iron whereby 199% and 46% was contributed by groundnut flour respectively. Pumpkin fruit in the same recipe contributed half (201 μ gRAE) of vitamin A RDA. It was noted that beans are a good source of iron, protein and energy. Therefore, common beans can be considered a good source of iron and help fight anaemia in low-income populations, especially in infants and lactating and pregnant women. This study does not differ from other studies conducted in Ethiopia and Brazil which showed that beans are a good source of iron, protein and energy [12, 16]. The Tanzania Food Composition Tables (TFCT) shows that fresh red kidney beans have more iron compared to dry red kidney beans. During the season when fresh beans are available it is recommended to consume more fresh beans to have higher intake of iron.

All porridge recipes were fermented. In recipe 6OFSP, 149% of protein (25.8g) and 34.5% of iron (3.45mg) were contributed by groundnut flour, while vitamin A contributed by OFSP exceeded RDA by more than three-fold (1467 μ gRAE) in a cooked amount of 265g. About 46% of iron and 199% of protein were contributed by groundnut flour and cooking banana' contributed about 62.5 μ gRAE/290g to white-fleshed banana porridge in recipe 7B. Egg and beans contributed 58% and 73% of protein respectively to recipe 8E with 179% RDA protein (Table 2). Red palm oil and OFSP are a cheap source of vitamin A in the study area when compared to animal and other plant sources. However, this needs more studies on bioavailability of beta-carotene in red palm oil, OFSP. In addition, the nutrient content for banana reported in this study are those of the local cooking banana which is white-fleshed. Earlier studies by Englberger et al [21] and additional recent studies by Ekesa et al [22, 23] have confirmed the existence of banana varieties rich in vitamin A that can not only flourish in Eastern Africa but are also acceptable. Therefore, if the banana in this recipe was replaced by the vitamin A rich banana there would be significant change in the recipe's vitamin A content. It is important to promote consumption of locally available foods including fruits in the diet to increase intake of micronutrients and protein.

MODIFICATION PROCESS TO ENRICH DIET WITH IRON, VITAMIN A AND PROTEIN

Soaking and fermentation

Modification was done in such a way that quality, quantity and the cooking process enable bioavailability of micronutrients. In Bukoba rural district, beans that were mixed with banana were boiled without soaking in water. This hindered bioavailability of the nutrients such as iron due to presence of phytate. Similar cases were reported from other studies [16, 17, 24, 25] where they observed that soaking beans reduced phytate and resulted in improved bioavailability of iron. Cooking beans for a long time at high temperatures can destroy protein [17]. Soaking of beans reduced time for cooking by 15.3–30.8 minutes and reduced antinutrients from 50-78%. The process also tended to increase absorption of minerals in legumes by 50-100% [16, 26-29]. In addition, soaking enhances the bioavailability of micronutrients and improving overall digestibility in plant-based diets [30]. By soaking beans, mothers will save time, cooking fuel and



increase nutrient intake. The correct processing knowledge at the household level is very important to fight micronutrient deficiency such as iron and vitamin A deficiency. In this study, two porridge recipes were made from fermented maize flour. It has been documented that fermentation reduces the levels of toxic/carcinogenic mycotoxins by 76.5–100% in cereals, improves digestibility of cereals due to enzymic degradation of carbohydrate into smaller units, thereby increasing the surface area of the substances for a facilitated digestion, reduces the levels of antinutrients in cereals, increases food palatability in cereals by developing improved flavours and textures, and increases the amount and bioavailability of iron and protein in cereals [31, 32]. Knowing these health benefits of fermentation, the study fermented whole maize flour and prepared thick porridge rich in vitamin A, iron and protein.

Modified local dishes to meet RDAs for children

Table 3 presents the diet modification based on the maximum nutrient and energy requirements by children below five years. The nutrient composition in the dishes is based on secondary data from the Tanzanian food composition table. The IOM standard reference used for vitamin A, protein and iron is 400 μ gRAE, 13g, 10 mg and 894kcals per day, respectively [12-15]. The same table shows that the average breast milk intake for children aged 6 to 23 months range from 600mls to 674mls per day with the amount decreasing with age. Daily requirement of complementary food for children aged 6 to 23 months is 500g and 600ml of breast milk [13]. Therefore, RDAs required by children of age 6-23 months were calculated based on the gastric capacity. Contribution of iron, vitamin A, protein, and energy to RDA for children ranged from 61-99%, 110-217%, 219-331% and 78-86%, respectively in 500g consumption size per day. The 5N (*katogo*) recipe had the highest percentage of protein while IN (banana puree) recipe had highest percentage of vitamin A. The percentages of energy and iron were only slightly different between the three recipes. For the modified porridge the same calculation was used and the contribution of iron, vitamin A, protein, and energy to RDA for children ranged from 98-135%, 27-692%, 394-432% and 139-227%, respectively in 500g consumption size. The RDA percentage of vitamin A was highest in 6OFSP and lowest in 7B-white-flesh banana porridge.

As per the TFCT, the developed recipes contained more than 100% RDA for vitamin A and protein. The RDA for iron ranged from 61% to 99%. This does not differ with PAHO/WHO, whereby they documented that recommended intakes of iron are unlikely to be met by complementary foods [14]. When average breast-milk intake is assumed, the vitamin A, iron, protein and energy needed from complementary food range from 63-400 RAE, 5.8-9.1 mg, 1.9-6.2 g and 200-474 kcal per day, respectively [13, 23]. Vitamin A, iron, protein and energy content of modified recipes ranged from 108-2768 RAE, 6.1-16.8 mg, 28.4-56.2 g and 697-1635 kcal, in 500g consumption size, respectively. These levels could meet the RDA's for breastfed and non-breastfed children. When a child consumes 500g of the modified dishes per day, she/he will meet the RDA of the nutrients [26].



Nutrient content in 100g of modified recipes

The modified recipes included banana puree (recipe 1N), which had a high amount of vitamin A (173 μ gRAE/100g), iron (1.9mg/100g) and protein (5.8g/100g), with contribution of 43.3%, 19.7% and 44.8% RDA of children, respectively, in a cooked amount of 529g. Banana puree (recipe 2N) showed high amounts of vitamin A (87 μ gRAE/100g), iron (1.8 mg/100g) and protein (5.7g/100g), with contribution of 22.2%, 43.8% and 18.1% RDA of children, respectively, in 529g cooked amount. 'Katogo' recipe 5N showed a high amount of vitamin A (88 μ gRAE) with high RDA of about 22% per 100g in a total cooked amount of 566g. While in the same recipe iron and protein content were 1.2mg/100 g and 8.6g/100g, respectively, with RDA of children of 14% and 66%, respectively. All the 'katogo' recipes had energy more than 80% kcal of RDA children per consumption size of 500g (Fig. 1).

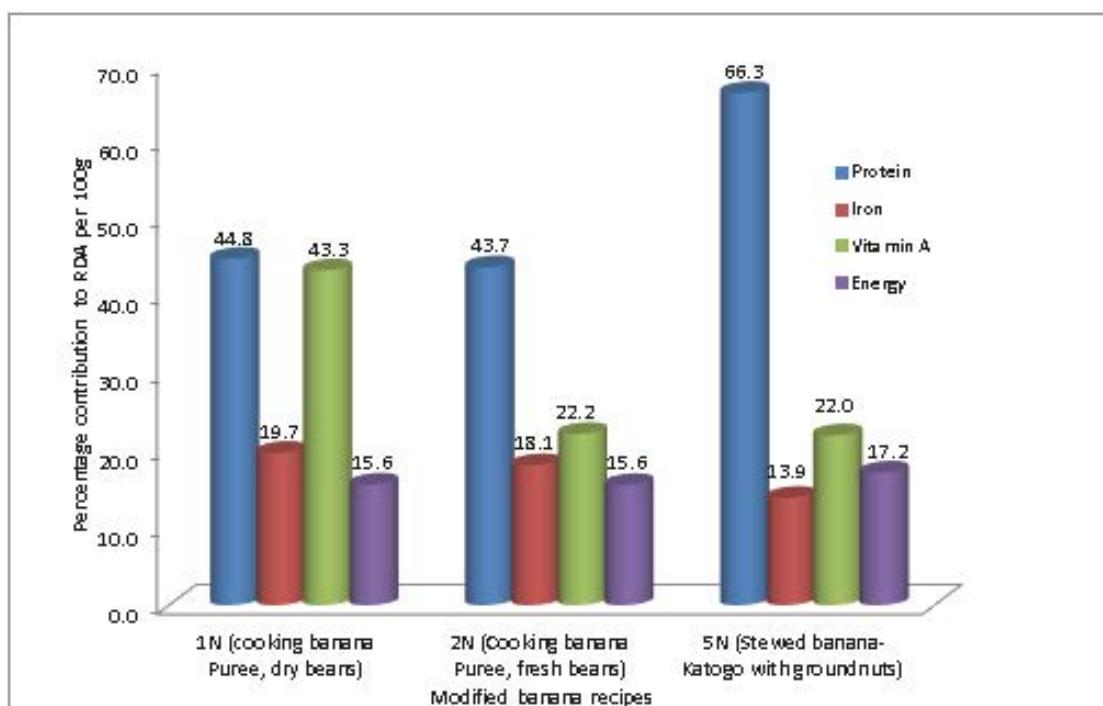


Figure 1: Nutrient contents by percentage RDA children for 12-23 months per modified 'katogo' recipe per 100g (ingredients per modified recipe are given in Table 1)

Porridge recipe 6OFSP contained high amounts of vitamin A (554 μ gRAE/100g) and protein (10.2g/100g) followed by iron (2.5mg/100g) with contributions of 138%, 25% and 79% to RDA of children, respectively, in 265g cooked amount. In the cooked amount of 290g banana porridge recipe (7B) recorded 11.2g/100g protein, 2.7mg/100g iron and 21.6 μ gRAE/100g, with the RDA contribution of 86%, 27% and 5.4% for children, respectively. Egg porridge recipe 8E had 11.7g/100g of protein, 3.4mg/100g of iron and 78.6 μ gRAE/100g of vitamin A with contribution of 83%, 20% and 20% RDA for children, respectively in 215g cooked amount (Fig. 2).

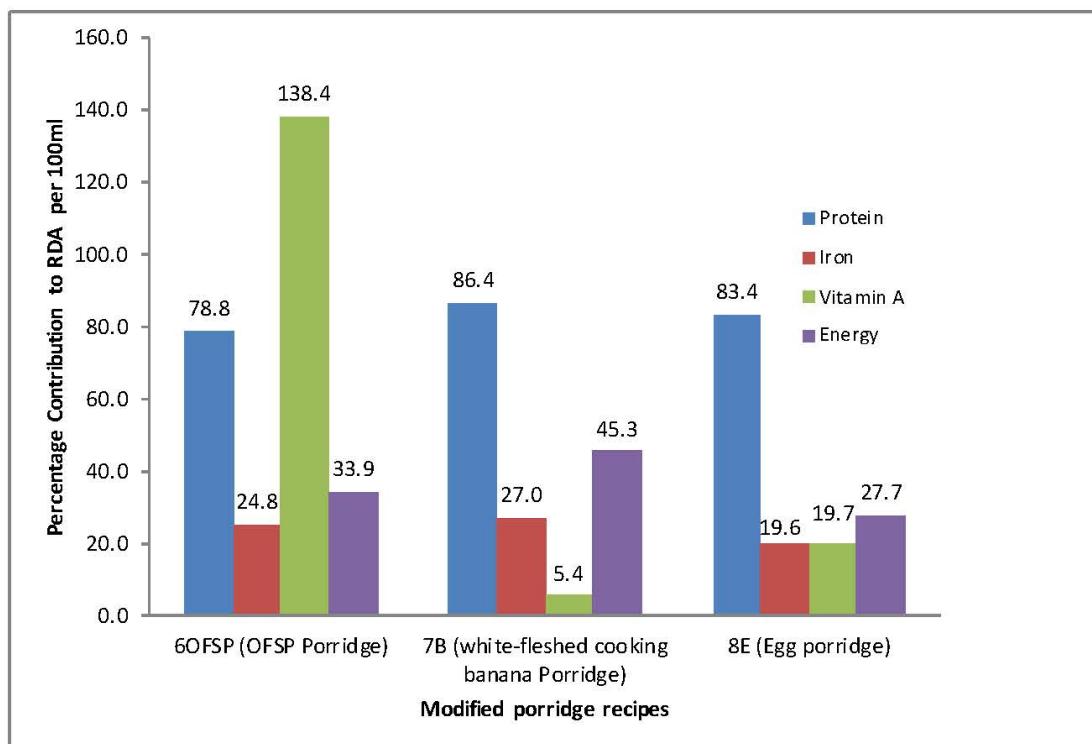


Figure 2: Nutrient content by percentage RDA for children for 12-24 months of the modified porridge recipe per 100ml (ingredients per modified recipe are given in Table 1)

Carvalho *et al.*, [26] reported that a food can be labeled as the ‘source’ of a nutrient when 100g of the product presents more than 15% of the dietary reference intake (DRI) for the desired nutrient. In 100g of food, all the modified complementary diets had more than 15% of the RDA for iron, vitamin A and protein. Except for recipe 5N (‘katogo’ recipe) and recipe 7B (cooking banana porridge), which had 12% RDA iron and 5.4% RDA vitamin A, respectively, in 100g. Regardless of the gastric capacity of children, the recipes still meet the RDA, thus breastfed children will get vitamin A, iron and protein from breast milk. Moreover, a breastfed child aged 6-9 months and 9-24 months is recommended to eat 2-3 and 3-4 meals, while all non-breastfed children 6-23 months are advised to eat 4-5 times a day. Although there is still room to ensure the varieties in the recipes and from species that are of higher nutrition value i.e. banana, all developed recipes are suitable for feeding children aged 6 – 23 months.

Cost of the diet

Based on the costs of ingredients and recipes given in Table 4, the average cost for preparing banana puree and maize porridge of 500g/500ml to meet the RDA of a child is TZS 350 equivalent to USD 0.16 and TZS 757 equivalent to USD 0.35, respectively. Banana recipes were cheaper compared to porridge recipes with the price ranging from 333-383 TZS (USD 0.153-0.176) and 482-1286 TZS (USD 0.22-0.59) in 500g/500mls, respectively. The cost for preparing porridge is high compared to banana puree cost, due to the fact that some ingredients like eggs and groundnut are relatively expensive.

However, the data were collected during off season for bean and low peak of banana harvest where the price was relatively high in which case the price drops during season. Mothers are advised to cultivate their own food for their family rather than buying, and to keep hens to have access to eggs at the household level.

Diversification and seasonality of food ingredients

To cover the nutritional needs of children, during dietary modification 7 food groups were included in the recipes per day. This diversifies the nutrients to meet the RDA for children aged 6 to 23 months. All the ingredients used to prepare the modified banana diets and porridge, are produced in the study area and available in the local market at affordable prices. During diet modification, seasonal variation in food availability was considered to give more choices to the mother and/or also to caregivers. In order to have vegetables and other food throughout the year, the community needs to be sensitized on establishing home gardens so as to use vegetables and foods which are cheap and good sources of micronutrients and protein.

CONCLUSION

The study formulated and tailored local diets to increase intake of vitamin A, iron and protein for children aged 6 to 23 months. Recipe 1N had higher amounts of vitamin A and iron than other recipes whereby red palm oil and dry red kidney beans were the main sources of vitamin A and iron in this recipe, respectively. Recipe 5N with pumpkin fruit and groundnut as the main source of vitamin A and iron had low vitamin A and iron content, respectively. Recipe 5N had a high amount of protein and recipe 2N had low protein content. Their main source of protein was groundnut and fresh red kidney beans. Porridge with OFSP was high in vitamin A content whereas recipe 7B with white-fleshed banana had the lowest vitamin A content. Recipe 7B had high iron content and recipe 8E had the lowest content. All porridge recipes had more than 78% RDA protein. The findings show that the formulated recipes have potential to meet RDAs of vitamin A, iron and protein for children aged 6 to 23. With the recently reported existence of banana varieties rich in vitamin A substituting the white-fleshed banana with the vitamin A rich banana could make significant contribution to vitamin A needs especially among communities in banana-based system and other communities in Africa with the same settings. These results might not give the true amount of some foods, because the TFCT does not differentiate the nutrient contents by food varieties. We have estimated the nutrient contents of the modified diets.

ACKNOWLEDGEMENTS

We acknowledge the Sokoine University of Agriculture for technical support and Bioversity International for both technical and financial support to this study. Support from the Ministry of Agriculture, Livestock and Fisheries, Tanzania Local Government Authority, Bukoba Rural District Council of Kagera region, farmers and participants is well acknowledged.



Table 1: Banana recipes composition and preparation technique [8]

Recipe code	Ingredients	Quantity in g	Food composition				New processing method recommended
			Total protein g	Total iron mg	Total Vitamin A in RE	Total Energy in kcal	
1N: Banana Puree	East African Highland bananas (E AHB) ('nshakala' variety)	225	1.58	1.35	141	247	Beans were sorted and washed, placed in saucepan, water was added to immerse beans, then soaked for 8-12 hour, soaking water poured out to reduce phytates [18, 33]. Soaked beans were placed in saucepan, and immersed in water, covered with lid and boiled till tender (60 to 90 minutes). While beans boiling, red palm oil fruits were cleaned placed in a saucepan with 500mls of water, covered and boiled for 10 minutes. Water was poured out and cooled. Red palm oil was pounded in a traditional mortar. About 500mls of water were added and wringed to get red palm oil. Green banana were peeled using a sharp knife and cut into two pieces per finger then were immersed in water to avoid browning. Bitter tomatoes were cut into two halves and added to the saucepan with bananas. Onions and tomatoes were cut into small pieces and kept aside. The peeled and chopped green banana, onion, tomatoes, bitter tomatoes and red palm oil were added to the boiling beans at 40-70 minutes of cooking beans. Water was added to submerge the mixture and covered with banana leaves followed by a lid and cooked covered for 20 minutes (making the 60-90 minutes). Amaranth leaves were sorted and cleaned and kept aside. To reduce surface area for
	Dry red kidney beans	100	23.60	7.50	0.00	333	
	Amaranth leaves	50	4.25	1.15	73.0	11.5	
	Red palm oil	13	0.00	0.0	650	112.1	
	Bitter tomatoes ('ntongo')	75	0.75	0.15	9.75	16.5	
	Tomatoes	50	0.45	0.25	43.5	10.5	
	Onion	16	0.21	0.03	0.00	6.40	



	Salt	4	0.00	0.00	0.00	0.00	<p>nutrient loss amaranths were cut into large pieces using a sharp knife. After 20 minutes amaranth were added to the boiling mixture. Salt dissolved (1 teaspoon) in $\frac{1}{4}$ cup of water and was added to the cooking food, then the ingredients were mixed by stirring and covered to cook for 7 minutes. The soup strained and kept aside. Food was mashed into a thick, smooth puree, the consistency depended on the child's age, and the strained soup was added back to the mashed food to avoid loss of nutrient.</p> <p>Total cooking time ranged from 67-97 minutes</p>
	Total per recipe	529	30.84	10.4	917	737	
	Percentage RDA per 529g	237	104	229	82.5		
2N: Banana Puree	East African Highland bananas (E AHB) (‘nshakala’ variety)	225	1.58	1.35	140.6	247.5	Fresh red kidney beans were removed from their pods, sorted, cleaned with water, and placed in a saucepan followed by addition of water. To reduce phytates, beans were boiled for 5 minutes and water poured out. Water was added to the beans and then covered with lid and boiled till tender (45 to 60 minutes. While beans boiling green banana were peeled using a sharp knife and cut into two pieces per finger then were immersed in water to avoid browning. Bitter tomatoes were cut into two halves and added to the saucepan with banana. Onions and tomatoes were cut into small pieces and kept aside. The peeled and chopped green banana, onion, tomatoes, better tomatoes and sunflower oil were added to the boiling beans at 25 to 40 minutes of cooking beans and water was added to submerge the mixture. The mixture covered with banana leaves followed by a lid and cooked covered for 20 minutes. While mixture boiling pumpkin
	Fresh red kidney beans	100	23.6	7.50	0.00	333	
	Pumpkin leaves	50	3.50	0.30	275	9.50	
	Sunflower oil	13	0.00	0.00	0.00	112	



Bitter tomatoes ('ntogo')	75	0.75	0.15	9.75	16.5		
Tomatoes	50	0.45	0.25	43.5	10.5		
Onion	16	0.21	0.03	0.00	6.40		
Salt	4	0.00	0.00	0.00	0.00		
Total per recipe	529	30.1	9.58	469	735		
Percentage RDA per 529g	231	95.8	117	82.3			
SN: 'Katog o'/'mat oke'	East African Highland bananas (E AHB) (‘nshakala’ variety)	225	1.58	1.35	141	248	Groundnut were sorted and roasted to dry. Left to cool and pounded in a mortor and sieved to get a fine groundnut flour. Green banana was peeled using a knife, cut into at least two pieces per finger and placed into a cooking saucepan with water to avoid browning. Pumpkin fruit cleaned with water, cut into small pieces and peeled with a knife. Pumpkin pieces were added into the peeled banana in a saucepan. Bitter tomatoes were into two halves added to the saucepan with banana and pumpkin pieces. Onions and tomatoes were washed, cut into small pieces and added to the mixture in a cooking saucepan and mixed well. Groundnut mixed with 1 cup of water and mixed to a thick puree. Then puree added to the mixture and mixed well using a cooking ladle/spoon. Water was added to the mixture to submerge the ingredients. The mixture was covered using banana leaves followed by a lid and cooked for 20 minutes.
Pumpkin fruit	100	20.00	0.50	201	20.0		
Groundnut	100	25.8	4.6	0.00	567		
Bitter tomatoes ('ntogo')	75	0.75	0.75	113	16.5		
Tomatoes	50	0.45	0.45	43.50	10.50		
Onion	16	0.21	0.21	0.00	6.40		
Salt	4	0.00	0.00	0.00	0.00		



Total per recipe	566	48.8	7.86	498	868	<p>One teaspoon of salt was dissolved into $\frac{1}{4}$ cup of water. After 20 minutes salt was added to the boiling mixture and cooked for 5 minutes.</p> <p>For children above 11 months the food was allowed to cool and served to the child or kept in a covered dish. Banana puree was prepared for children aged 6-11 months. Half a cup of soup from food was kept apart. One cup of food was placed in a bowl and mashed to make it soft. The remaining soup was added to the mashed food and mixed to get a thick puree.</p> <p>Total cooking time was 27 minutes</p>
Percentage RDA per 566g	375	78.1	124	97.1		



Table 2: Porridge recipe composition and preparation technique [16]

Recipe code	Ingredients	Quantity in g	Food composition				New processing method recommended
			Total protein g	Total iron mg	Total Vitamin A in RE	Total Energy in kcal	
6: OFSP Porridg e	Fermented maize flour	75	6.08	2.63	0.00	272	<p>One cup (250 mls) water and 100g of maize flour were placed in a bowl and left for 24 hours to ferment.</p> <p>Groundnut were sorted and roasted to dry, then pound in a motor to get fine groundnut flour.</p> <p>Unpeeled OFSP washed well with clean water and placed in a saucepan followed by 2 cups of water and covered with banana leaves followed by a lid. To retain nutrients OFSP boiled unpeeled for 30-45 minutes [20]. OFSP removed from heat source, hand peel, put in a dish and mashed until smooth. Water was added to the mashed OFSP to thick puree, stirred and kept aside. Four cups of water (1000 mls) were put to boil in a saucepan for 5 minutes. Groundnut flour was added into the fermented flour and stirred into a smooth paste. The smooth paste added into the boiling water slowly while stirring to avoid lumps. OFSP puree was added into the boiling mixture while stirring. The mixture simmered for 10 minutes. Sugar was added and stirred to mix well. Porridge removed from heat. Cooled and served.</p> <p>Total cooking time ranged from 45-60</p>
	Roots OFSP (<i>kabode</i>)	100	1.70	0.50	1467	103	
	Groundnut flour	75	19.4	3.45	0.00	425	
	Sugar	15	0.00	0.00	0.00	3.9	
Total nutrients per recipe		265	27.1	6.58	1467	804	
Percentage RDA per 265g			209	66	367	90	
Recipe code	Ingredients	Quantity in g	Food composition				New processing technique recommended
Total protein g	Total iron mg	Total Vitamin A in RE	Total Energy in kcal				



7 B: porridge Cooking banana	Fermented maize	75	6.08	2.63	0.00	272	One cup (250 mls) water and 100g of maize flour were placed in a bowl and left for 24 hours to ferment.
	Cooking banana	100	0.70	0.60	62.5	333	Green banana were peeled, placed in a saucepan, water was added to submerge banana and covered with banana leaves followed by a lid and boil on for 25 minutes. The cooked banana was mashed while still warm using a cooking ladle till smooth.
	Groundnut flour	100	25.8	4.60	0.00	567	While banana boiling, groundnut were sorted and roasted to dry, then pounded in a motor and sieved to get fine groundnut flour.
	Sugar (optional)	15	0.00	0.00	0.00	3.90	Water was added to the mashed banana to make a thick puree and kept aside. Four cups of water (1000 mls) were put to boil in a saucepan for 5 minutes. Groundnut flour added in fermented flour, and stirred into a smooth paste. The smooth paste was added into the boiling water slowly while stirring to avoid lumps followed by banana puree and kept stirring for 10 minutes. Sugar added while stirring. Porridge removed from heat and cooled to serve the baby.
Total per recipe		290	32.6	7.83	62.5	1175	Total cooking time was 40 minutes
Percentage RDA per 290g		251	78.3	15.6	131		
Recipe code	Ingredients	Quantity in g	Food composition			New processing method recommended	
8E:			Total protein g	Total iron mg	Total Vitamin A in RE	Total Energy in kcal	



Egg porridge	Fermented maize flour	100	8.10	3.50	0.00	362	Beans were sorted, clean with water, and placed in a saucepan followed by addition of water to immerse beans and soaked for 8-12 hour to reduce phytates. Soaking water poured out and coats were removed.
	Egg	60	7.56	0.72	169	93	
	Sugar	15	0.00	0.00	0.00	3.9	
	Beans	40	9.49	3.00	0.00	133	Beans were placed in a saucepan followed by addition of water to immerse the beans. Beans covered with lid and boil till tender (60-90 minutes). Beans were mashed and ½ cup of water was added to the mashed beans and keep apart. Four cups of water (1000 mls) put to boil for 5 minutes. While waiting for water to boil, mashed beans were added into fermented maize flour and stirred into a smooth paste. The smooth paste was added into the boiling water gently while stirring and cooked for 10 minutes. One egg added to one portion of porridge for baby. This was done after beating the egg and poured it gently into the baby's portion while stirring. Sugar added as an optional.
Total cooking time ranged from 75-105 minutes							
Total per recipe		215	25.10	7.22	169	592	
Percentage RDA per 215g		179	42.2	42.3	60		

For both recipes water added but not weighed



Table 3: Energy and nutrient needs from complementary foods for breastfed children with average breast milk intake

Energy and nutrients per day	6-8.9 months	9-11.9 months	12-23.9
Average breast intake needed (ml)	674	616	600
Total energy needed (kcal)	615	686	894
Average breast intake (kcal)	413	379	420
Total protein needed (g)	9.1	9.6	10.9
Average breast intake protein (g)	7.2	5.6	4.7
Total iron needed (mg)	9.3	9.3	5.8
Total vitamin A needed µgRAE	400	400	400
Nutrients needed from complementary foods			
Energy (kcal)	202	307	474
Vitamin A (RE)	63	92	400
Iron (mg)	9.1	9.1	5.8
<i>Iron absorbed</i>	0.89	0.89	0.58
Protein(g)	1.9	4.0	6.2
Feeding frequency and gastric capacity			
Recommended daily feeding frequency (meals/snacks): breastfed children	2-3	3-4	3-4
Recommended daily feeding frequency (meals/snacks): not breastfed children	4-5	4-5	4-5
Gastric capacity (ml)	249	285	345

Source [12-14]



Table 4: Costs for Ingredients and Modified Recipes July 2016

Food ingredients	Price per 1 kg at Izimbya and Rugaze markets in TZS	Portion of ingredient used for cooking in gram (g)	Price per used ingredient	Recipe and total cooking amount	Average price in cooking amount in TZS	Average price in 500g in TZS
Banana recipes						
Cooking banana	500	225	113	1N (526 g)	353	333
Dry red kidney beans	1200	100	120			
Fresh red kidney beans	1000	100	100			
Amaranth leaves	500	50	25			
Pumpkin leaves	400	50	20			
Pumpkin fruit	800	100	80	2N: (526 g)	371	350
Ground nuts flour	2500	100	250			
Red palm oil	300	13	4			
Sun flour oil	3600	13	47			
Bitter tomatoes ('ntogo')	500	75	38	4B (526 g)	371	350
Tomatoes	600	50	30			
Onion	1500	16	24			
Salt	500	2tsp	1			
Porridge recipes						
Fermented maize flour	800	75	60	6OFSP (265 g)	255	482
Roots OFSP(kabode)	500	100	50			
Sugar	2200	15	33			
Egg	400	1	0.4			
Cooking banana	500	100	50	7B (290 g)	293	505
Dry red kidney beans	1200	40	40			
Groundnut flour	2500	100	250			



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Some food items (ingredients) used to prepare the modified dishes



Mothers participating in the preparation of the modified and new dishes



Recipe 1N: 'katogo' for child aged between 12-23 months and adult

Recipe 1N: purée for children aged 6-11 months

Porridge



Mother child pair eating after recipe preparation



Discussion with nutritionists on diet modification