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Nutrient content of complementary foods for children in Kilimanjaro, Tanzania

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Complementary feeding is an effective strategy in reducing the levels of malnutrition among children aged 6-23 months. Little is known about the preparation and nutrient content of locally made complementary foods in Tanzania. This study was carried out with the aim of analysing nutrient content of the frequently used complementary foods for children of age 6 to 23 months. A cross-sectional study was conducted in three randomly selected villages in Rombo district, Kilimanjaro region, Tanzania. Information on the types of complementary foods was collected using semi-structured and 24-h dietary-recall questionnaires. Seven samples of frequently consumed complementary foods (banana, rice and maize-based porridges) were collected and analysed for proximate, vitamins and minerals composition. The results were as follows: Energy 317.98-379.23 kcal, vitamin A 81.32-971.05 µg RE, vitamin C 3.48-9.56 mg, iron 2.48-22.86 mg, zinc 0.92-9.57 mg, calcium 73.13-400.58 mg and iodine 10.18-200.93 µg/100 g dry-weights. Conclusively, the amount of vitamin C, iron, zinc, calcium and iodine of the frequently used complementary foods in the study area was low as compared to what is recommended by World Health Organization. It is important to develop recipes that may either fill or narrow this gap by using low-cost, locally available and culturally acceptable ingredients.

Key words: Complementary foods, nutrient content, energy, micronutrients, porridge.

INTRODUCTION

The first 1000 days of life, from conception until the child's second birthday, are considered the critical window of opportunity for preventing under nutrition and its long-term consequences (Hemalatha et al., 2018). Poor breastfeeding patterns, low nutrient density and poor quality of complementary foods account for nutrient deficiency, illness and infections in children, leading to

malnutrition at an early age (Singh et al., 2019). This in turn prevents children from reaching their full physical and mental potential later in life. This is due to delayed physical growth and motor development, low intellectual quotient (IQ), greater behavioural problems, deficient social skills as well as their increased susceptibility to contracting diseases (Kamath et al., 2017). The common

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nutritional problems among children aged 6-23 months in many countries include protein-energy malnutrition (PEM), vitamin A deficiency (VAD) as well as iodine deficiency disorders (IDD) and iron deficiency anaemia (IDA) (IFPRI, 2016).

Globally, an estimated 156 million (23.8%) children under-five years of age are stunted, 95 million (14%) are underweight, 50 million (7.5%) are wasted and 16 million (2.4%) are severely wasted (IFPRI, 2016; UNICEF/WB/WHO, 2016). In addition, over 160 million children worldwide are vitamin A deficient with a prevalence of about 30% in all developing countries and over 293 million (47.4%) of pre-school age children are anaemic (UNSCN, 2016; Yisak et al., 2020).

In Africa, 58.5 (37%), 13.9 (28%) and 10.3 (25%) million children under the age of five years are stunted, wasted and overweight, respectively (IFPRI, 2016). TDHS-MIS (2015-2016) and IFPRI (2016) reported that Tanzania ranks 105 out of 132 countries surveyed with prevalence of stunting (34.7%), wasting (3.8%), underweight (14%), severely underweight (3%) and anaemia prevalence of about 40%.

Complementary feeding refers to the introduction of other foods and liquids to a breastfed child when breast milk alone is no longer sufficient to meet the nutritional requirements of the infant (Fewtrell et al., 2017). It is an effective strategy in reducing the levels of malnutrition among children aged 6-23 months (Kassa et al., 2016; Mitchodigni et al., 2017). Breast milk alone can be used to properly feed infants for the first six months of life, but as infants grow and become more active, breast milk alone falls short of providing the full nutritional requirements and the gap keeps expanding with increasing age of the infants and young children; hence complementary feeding plays critical role in bridging these gaps (Abeshu, 2016). Major problems at this stage include poor timing of introducing complementary foods (too early or too late), poor food preparation and feeding practices, the use of complementary foods with low energy and nutrient density, low nutrients' bioavailability as well as poor processing methods and all of these are exacerbated by poverty and food insecurity (Arikpo et al., 2018; Oladiran and Emmambux, 2020)

Kilimanjaro region, just like other regions of Tanzania has malnourished children of which 20, 9.6 and 1.5% of children less than five years of age are stunted, underweight, and wasted, respectively (TFNC, 2019). About 48.9% of children under this age group are also anaemic while 34.2% are vitamin A deficient (TDHS-MIS, 2015-2016). One of the possible explanations for malnutrition could be inadequate nutrient intake from the commonly consumed foods.

In Rombo district, studies on the nutrient content of the frequently used complementary foods for children aged 6-23 months are very limited. The few available previous studies were on mycotoxins level in complementary foods

as well as prevalence and predictors of exclusive breastfeeding among breastfeeding women (Shirima et al., 2000; Mgongo et al., 2013). The specific objectives of the present study were to identify the frequently used complementary foods as well as their nutrient contents. The results will help other food and nutrition stakeholders in planning diet modification studies to improve nutrient content of commonly used complimentary foods.

MATERIALS AND METHODS

Study area

This study was conducted in Kilimanjaro region, Rombo district, Tanzania Mainland. Rombo district is one of the six districts in Kilimanjaro region. The district is bordered to the North and East by United Republic of Kenya, to the West by the Hai district and to the South by Moshi Rural district (URT, 2017). The district receives annual rainfall ranging from 500 to 1000 mm per annum and the mean monthly temperature is 22 to 26°C with maximum temperatures of 35°C. The main economic activity practiced in Rombo district is agriculture. This carries about 90% of the total activities while 7% of the residents are doing small businesses and 3% are the employed workers (URT, 2017). Food crops include banana, maize, sorghum, sweet potatoes, cassava and legumes, fruits and vegetables; whereas the main cash crop is coffee.

Study design and sample size

A cross sectional study was conducted in three randomly selected villages of Urauri, Kibaoni and Kikelelwa in November to December when the residents were planting crops. The study population comprised mothers/caregivers and their children who were 6 to 23 months old during data collection period. Children who were under special nutritional therapies and those with medical disorders or chronic health conditions were excluded from the study. The sample size was obtained from the general stunting percentage (18.3%) for children less than 5 years in Kilimanjaro region (TNNS, 2018). The formula used was adopted from SMART (2012) and a total of 230 respondents were involved in this study.

Data collection

Identification of the frequently used complementary foods was done by using semi-structured questionnaires using 24 h dietary recall. The information collected included social and demographic characteristics of the mother/caregiver and the child, types of complementary foods and how they were prepared.

Before administration of the questionnaires, five enumerators were enlightened on the main and specific objectives of the research and familiarized with data collection instruments. Pre-testing of the questionnaire was done at Mazimbu in Morogoro region before the beginning of data collection in a randomly selected sample of 10 individuals who were not included in the study but had similar characteristics to the study sample. After pre-testing the questionnaires, corrections were made to avoid misleading information, ambiguous sentences and repeated questions.

Before the beginning of the interview, the enumerators introduced themselves, explained the purpose of the study as well as the potential benefits and risks and then the respondents were

asked to voluntarily sign the consent form. For those respondents who were unable to read and write, they were helped by a closer relative, neighbour or the enumerator and give their oral consent. The questionnaire was administered through face to face interview. The children who were not living with their mothers were represented by their caregivers and most of them were their grandmothers. This is because some of the young mothers tend to leave their children with their grandmothers and go to big towns to work.

Collection of food samples and laboratory analysis

Seven samples of frequently used complementary foods which were collected using 24 h dietary recall questionnaire (Table 2) were taken to the laboratory for analysis of proximate composition and vitamin A, vitamin C, iron, zinc, calcium and iodine contents.

Before collection of cooked samples, there was a focus group discussion with ten women who came to clinic (RCH unit) at Tarakea Health Centre on preparation methods of the selected complementary foods. When the common procedures, ingredients, amounts, preparation and cooking methods were agreed, the ingredients such as meat, fish, milk, onions, tomatoes, rice, pumpkins and bananas were purchased at Tarakea market (it is the market that was used by most of the respondents). Complementary food samples were prepared by seven randomly selected mothers/caregivers (one for each recipe) at different households in the three villages. Mothers/Caregivers from Urauri prepared banana porridge with meat and with fish while those from Kibaoni village prepared banana porridge with pumpkin and with milk. Mothers/Caregivers from Kikelelwa village prepared maize, rice and composite flour porridges. This was done without the interference from the researcher. The task of the researcher was only to provide ingredients and record the procedures.

During preparation of complementary foods, the ingredients (name and amount used) were recorded first before cooking and then the mother/caregiver prepared and cooked the food while the researcher was observing and recording the procedures. When the food was ready, it was left to cool and then served in clean tight plastic food containers, weighed again and then stored in a cool box with iced water tightened in plastic bag then transported for analysis at Sokoine University of Agriculture laboratory on the next day. The remaining foods and ingredients were given to the mothers/caregivers who prepared the foods. CAMRY kitchen weighing scale (Model: EK3651, Max. 5000 g/11 lb, Japan) was used to weigh the ingredients and cooked samples.

Sample preparation

The cooked food samples were stored in the freezer for five days waiting for analysis at Sokoine University of Agriculture, Morogoro. During analysis, the food samples were thawed in running water and then mixed thoroughly (homogenization) while maintaining its representativeness (without changing its original composition and form). Nutrient composition analysis was done in duplicate for all seven samples and the results were presented in grams (g), milligrams (mg) or micrograms (μg) per hundred grams.

Laboratory analysis

The proximate composition of each of the frequently used complementary food samples were determined by using the standard methods of AOAC (2000) and the results were presented as an average of the duplicate determinations. Crude protein was

determined by Kjehdahl method (AOAC, 2000, official method 925.09), total fat by using Soxhlet system (HT model 1043-extraction unit AB, Sweden) following the procedures shown in AOAC (2000; official method 4.5.01.) while Ancom fibre analyser (Model ANCOM 220, USA) was used to determine crude fibre content as outlined by AOAC (2000) in official method 962.09. Moisture and ash contents were determined using oven drying (AOAC, 2005; method 925.09) and (AOAC, 2000; method 923.03), respectively for 5 h. The ash content of the samples was calculated as the difference between weight of the sample before and after incineration. Energy values of all the complementary food samples were determined by calculation using Atwater's conversion factors (FAO, 2003).

Vitamin A (Beta carotene) content was determined using UV-Visible Spectrophotometer following the procedures described by Rodriguez-Amaya and Kimura (2004). A conversion factor of 6 μg of β -carotene equivalent to 1 μg of Retinol Equivalent (RE) was used. Retinol was determined following the procedures described by Lietz et al. (2000), Rutkowski and Grzegorczyk (2007) and Kandar et al. (2012). Vitamin C determination was done following AOAC (2000) procedures using method No. 985.33 by titration. Iron, zinc, calcium and iodine contents were determined using the AOAC (2000) procedures, method No. 985.35 by using atomic absorption spectrophotometer.

Data analysis

Data was cleaned to adjust for inconsistent, conflicting and implausible responses and carefully subjected to the descriptive analyses using the computer Microsoft Office Excel 2007, Statistical Products and Service Solution software (SPSS) version 20.0. Means were calculated for continuous variables and for categorical variables frequencies and percentages were used. For laboratory results of the nutrient content of the frequently used complementary foods, each determination was carried out in duplicate and results were reported as an average value (mean \pm standard deviation (SD)). Turkeys Honest Significant Difference test was used for multiple mean comparison tests. Statistical significance was set at $p<0.05$.

Ethical clearance

The study protocol was approved by the National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/2362). Also, Sokoine University of Agriculture and Rombo District Executive Director provided us with the written permit to conduct research in the area. Written informed consent was obtained from all mothers/caregivers who took part in this study as well as the village leaders who issued a letter of acceptance for the research. All the participants were ensured of confidentiality and autonomy and that the information obtained will not be misused.

RESULTS

Social and demographic characteristics of the study participants

Table 1 shows the socio-demographic characteristics of the 230 mothers/caregivers from three villages, namely Kikelelwa (30.4%), Kibaoni (38.7%) and Urauri (30.9%) who participated in the survey. Majority of the children

Table 1. Socio-demographic characteristics of the study participants

Variable	Number	%
Age of children (months)		
6-8	60	26.1
9-11	52	22.5
12-23	118	51.4
Age of mothers (years)		
<20	31	13.5
20-35	143	62.2
> 36	56	24.3
Marital status		
Single	63	27.4
Married	167	72.6
Education level		
Informal	10	4.3
Primary school	147	63.9
Secondary school	67	29.2
Post-secondary school	6	2.6
Occupation		
Housewife	33	14.3
Agriculture	117	50.9
Employed formal	11	4.8
Employed informal	6	2.6
Self employed	63	27.4
Number of under five children per household		
1-2	216	93.9
3 or more	14	6.1

(51.4%) were aged between 12 and 23 months at the time of data collection. Most of the mothers/caregivers (95.65%) were able to at least read and write their names. The mean age was 27 years, 63.9% had completed primary school education and 50.9% were involved in agriculture. The average number of people per household was 5 (53.5%). Predominantly produced food crops were cereals, legumes and banana. About 39% of the respondents reported to keep poultry in their households.

Frequently used complementary foods

Table 2 shows the frequently used complementary foods. These included banana porridge with beef (53.5%, n=123), banana porridge with fish (30.9%, n=71), maize porridge (36.2%, n=84), banana porridge with milk (37.0%, n=85), composite flour porridge (57.8%, n=133),

banana porridge with pumpkins (2.61%, n=6) and rice porridge (13.5%, n=31). Composite flour porridge was the highly consumed complementary food (57.8%, n=133) while porridge with pumpkins was the least consumed food (2.61%, n=6).

Nutrient content of the frequently used complementary foods

Proximate composition and energy content

Proximate composition of the seven frequently used complementary foods (banana porridge with beef, fish, milk or pumpkins, composite flour porridge, maize porridge and rice porridge with milk) for children 6-23 months of age in Rombo district on wet basis are shown in Table 3.

Moisture content of the samples ranged from 65.51 to

Table 2. Frequently used complementary foods selected for laboratory analysis.

Name of the food sample	Swahili name (Local name)	N	%
Banana porridge with beef	<i>Mtori wa nyama</i>	123	53.5
Banana porridge with fish	<i>Mtori wa samaki</i>	71	30.9
Maize porridge (with sugar and cooking oil)	<i>Uji wa mahindi wenye sukari na mafuta (Uji)</i>	84	36.5
Banana porridge with milk	<i>Mtori wa maziwa (kitawa/ kena)</i>	85	37.0
Composite flour porridge	<i>Uji wa unga mchanganyiko / lishe</i>	133	57.8
Banana porridge with pumpkins	<i>Mtori wa maboga (mtori wa masidi)</i>	6	2.6
Rice porridge (with milk)	<i>Uji wa mchele/wali madida (Mshele)</i>	31	13.5

N=Number of children who consumed the food, % =percentage of children who consumed the food.

Table 3. Proximate composition of frequently used complementary foods (g/100 g dry weight).

Parameter	Banana porridge with beef	Banana porridge with fish	Maize porridge	Banana porridge with milk	Composite flour porridge	Banana porridge with pumpkin	Rice porridge with milk
Energy	317.98±16.49 ^b	348.14±10.55 ^{ab}	334.51±12.88 ^{ab}	373.44±22.34 ^a	379.23±7.51 ^a	333.29±5.31 ^{ab}	345.79±10.10 ^{ab}
Protein	9.74±2.48 ^c	8.34±2.57 ^c	13.47±1.07 ^c	8.33±1.48 ^c	13.84±1.58 ^{bc}	23.65±5.02 ^{ab}	25.12±1.27 ^a
Fat	3.59±1.08 ^c	2.71±0.25 ^c	6.55±1.93 ^{bc}	10.66±2.77 ^b	20.72±0.97 ^a	1.05±0.37 ^c	2.36±0.02 ^c
CHO (available)	61.67±0.76 ^{ab}	72.61±5.76 ^a	55.41±2.20 ^b	61.05±0.82 ^{ab}	34.34±2.48 ^c	57.31±4.51 ^b	56.01±3.79 ^b
Moisture	72.36±1.34 ^b	67.72±0.84 ^{bc}	81.66±1.43 ^a	65.51±1.32 ^c	79.72±0.58 ^a	71.44±2.78 ^b	68.67±1.14 ^{bc}
Ash	2.71±0.25 ^b	2.10±0.01 ^c	1.05±0.02 ^e	1.68±0.07 ^{cd}	3.54±0.19 ^a	1.47±0.05 ^{de}	1.89±0.003 ^{cd}
Fibre	22.28±3.04 ^{ab}	14.25±2.93 ^c	23.52±0.83 ^{ab}	18.28±2.18 ^{ab}	27.55±2.90 ^a	16.52±0.92 ^c	14.61±2.53 ^c
Dry matter	27.64±1.34 ^b	32.28±0.84 ^{ab}	18.34±1.43 ^c	34.49±1.32 ^a	20.28±0.58 ^c	28.56±2.78 ^b	31.33±1.14 ^{ab}

Values are means ± SD of duplicate determinations. Values with different superscripts in a row differ significantly ($p<0.05$).

81.66%. Banana porridge with milk had significantly lower moisture content than the rest of the formulations. The lower moisture content could be attributed to the addition of milk instead of plain water during stirring. Maize porridge had higher moisture content but it was not significantly ($p>0.05$) different from composite flour porridge. Banana porridge with beef, banana porridge with fish, banana porridge with pumpkins and rice porridge were not significantly different ($p>0.05$) in terms of moisture content.

The value of ash content for all the formulations ranged from 1.05 to 3.54%. Composite flour had significantly higher ash content (3.54) ($p < 0.05$). Milk based samples (banana porridge with milk and rice porridge with milk) had similar levels of ash content. Maize porridge had the lowest ash content followed closely by banana porridge with pumpkins and they were not significantly different from one another.

Banana porridge with fish, rice porridge with milk and banana porridge with pumpkins had lower total fibre content (14.25, 14.61 and 16.52%, respectively). The values of fibre content ranged from 14.25 to 27.55%. The highest fibre content was found in composite flour porridge followed by banana porridge with beef.

Protein content ranged from 8.33 to 25.12%. There was no significant difference in protein content among the samples. Porridge made from composite flour as well as banana porridge with milk had significantly higher fat content than other formulations ($p<0.05$). Fat content for all the samples ranged from 1.05 to 20.72 g/100 g (dry weight). Banana porridge with pumpkins had the lowest fat score followed by rice porridge with milk and banana porridge with fish.

Available carbohydrate ranged from 34.34 to 72.61%. Banana porridge with fish had relatively higher carbohydrate content compared to the rest of the samples. The lowest carbohydrate content was reported in composite flour porridge.

Energy content of the frequently used complementary foods ranged from 317.98 to 379.23 kcal per 100 g (dry weight). Composite flour and banana with milk porridges were characterised by the highest levels of energy as compared to the rest of the analysed complementary food samples. Banana porridge with beef had the lowest energy value (317.98 kcal). Energy content of banana porridge with fish, banana porridge with pumpkins and maize porridge were not significantly different ($p > 0.05$) from one another.

Table 4. Vitamins A and C composition of the frequently used complementary foods in Rombo district (g/100 g dry weight basis).

Complementary foods	B-carotene (µg/100 g RE)	Retinol (µg/100 g)	Total vitamin A (µg/100 g)	Vitamin C (mg/100 g)
Banana porridge with beef	170.13±11.45 ^{de}	582.62±49.22 ^a	752.75±60.67 ^{bc}	3.48±0.12 ^c
Banana porridge with fish	143.73±0.22 ^{de}	401.02±9.21 ^b	544.76±8.98 ^d	7.02±0.31 ^a
Maize porridge	195.83±16.77 ^{cd}	0.00 ^c	195.83±16.77 ^f	5.23±0.52 ^b
Banana porridge with milk	105.30±3.93 ^e	76.01±37.84 ^a	81.32±33.91 ^b	5.62±0.18 ^b
Composite flour porridge	971.05±10.75 ^a	0.00 ^c	971.05±10.75 ^a	9.56±0.23 ^b
Banana porridge with pumpkin	401.49±39.05 ^b	0.00 ^c	401.489±39.05 ^e	6.46±0.58 ^b
Rice porridge with milk	262.66±9.54 ^c	387.51±10.34 ^b	650.17±0.80 ^{cd}	6.05±0.36 ^a

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$). The sample with 0.00 were from plant sources and therefore retinol was not analysed.

Table 5. Mineral composition of frequently used complementary foods for children aged 6-23 months at Rombo district (g/100 g dry weight).

Complementary foods	Iron (mg/100 g)	Zinc (mg/100 g)	Calcium (mg/100 g)	Iodine (µg/100 g)
Banana porridge with beef soup	22.86±1.09 ^a	9.57±0.85 ^a	400.58±40.22 ^a	10.18±4.23 ^d
Banana porridge with fish soup	5.99±0.17 ^d	1.17±0.02 ^{bc}	82.73±1.47 ^d	40.24±4.54 ^{cd}
Maize porridge with sugar and oil	9.12±1.24 ^b	2.53±0.15 ^b	149.75±5.11 ^{bc}	42.04±8.66 ^{cd}
Banana porridge with milk	4.88±0.39 ^{cd}	1.38±0.12 ^{bc}	194.56±6.19 ^b	56.86±9.46 ^{bc}
Composite flour porridge	9.21±0.53 ^b	1.05±0.12 ^c	111.55±6.84 ^{cd}	200.93±15.34 ^a
Banana porridge with pumpkin	2.58±0.40 ^d	0.92±0.05 ^c	135.15±11.37 ^{bcd}	31.73±10.52 ^{cd}
Rice porridge with milk	2.48±0.24 ^d	1.36±0.35 ^{bc}	73.13±3.77 ^d	85.12±6.52 ^b

Values are means ± SD of duplicate determinations. Values with different superscripts in a column differ significantly ($p<0.05$).

Vitamins A and C composition of the complementary foods

Table 4 shows values of vitamins A and C of the seven frequently used complementary food samples in Rombo district. Vitamin A content ranged from 81.32 to 971.05 µg/100 g (dry weight). The lowest vitamin A content was observed in banana porridge with milk. Food samples with animal products such as meat, fish and milk had relatively higher vitamin A contents.

Vitamin C content ranged from 3.48 to 9.56 mg/100 g dry weight, with the highest contents found in composite flour porridge and banana porridge with fish; and the lowest in banana porridge with beef. Milk based complementary food samples (banana porridge with milk and rice porridge with milk) as well as maize porridge and banana porridge with pumpkins had relatively similar levels of vitamin C.

Iron, zinc, calcium and iodine content of the complementary foods in Rombo

Iron content ranged from 2.48 to 22.86 g/100 g of the dry

sample shown in Table 5. There was no significant difference in iron content between banana porridge with fish and banana porridge with milk. Banana porridge with beef had significantly ($p<0.05$) higher iron content as compared to the rest of the sample. Banana porridge with pumpkins had lowest iron content.

With regard to zinc content, samples had zinc content below the minimum recommended levels for complementary foods with the exception of banana porridge with beef. It ranged from 0.92 to 9.57 mg/100 g (dry weight). Banana porridge with beef had the highest zinc content (9.57) as compared to banana porridge with pumpkin which had less than 1 mg/100 g (Table 5). Banana porridge with pumpkin had the lowest zinc content but it was not significantly different from composite flour porridge, banana porridge with fish and banana porridge with milk.

Calcium levels ranged from 73.13 to 400.58 mg shown in Table 5. Banana porridge with beef had significantly ($p<0.05$) higher calcium content than the rest of the samples. The lowest calcium content was reported in rice porridge with milk (73.13 mg/100 g dry weight).

Composite flour porridge had significantly ($p<0.05$) higher iodine content (200.93 µg/100 g dry weight) while

banana porridge with beef had the lowest score (10.18 µg/100 g dry weight). The rest of the sample had almost similar iodine levels.

DISCUSSION

This study aimed at assessing the nutrient content of frequently used complementary foods in Rombo district. Maize porridge had significantly higher moisture content when compared with the rest of the recipes. This means that a child needs to eat a lot of food in order to meet the nutrient needs because the food is more energy and micronutrient-dilute. The moisture content of the porridges was similar to the findings of Kulwa et al. (2015) but lower than that of Mandha et al. (2021). High moisture content in food products have also been associated with increased growth of microorganisms, which in turn causes spoilage and low nutritional qualities of the food products (Tapia et al., 2020).

The ash content reported in the present study was lower than what was reported by Tiencheu et al. (2016) but similar to that of Ezeokeke and Onuoha (2016). The lower values of ash content in the samples used in this study may probably indicate lower mineral contents. Composite flour porridge had higher ash content relative to other foods due to the presence of variety of ingredients such as maize, rice, soya beans, groundnuts and finger millet that may have more minerals (particularly iron, zinc and calcium) relative to other samples.

The findings from this study revealed that most of the complementary foods in Rombo district meet the recommended amount of protein needed from complementary foods. Even the foods that could not meet WHO recommendations (banana porridge with fish and banana porridge with milk); they were still able to provide at least 50% of the amount of protein needed from complementary foods (Abeshu et al., 2016). The higher protein content in rice porridge may be contributed by the addition of milk which is a good source of protein.

In order to meet the amount of energy, essential fatty acids and uptake of fat soluble vitamins by lipids, fat from complementary foods should provide approximately 30 to 45% of the total energy required by infants and young children based on their age and development stage (Khor and Lee, 2021). Fat content of the complementary food samples ranged from 1.05 to 20.72 g/100 g (dry weight). Composite flour porridge had significantly higher fat content relative to the rest of the complementary food samples ($p<0.05$). The high fat content in composite flour may be due to the inclusion of oily seeds such as groundnuts and soya beans and whole grains as well as addition of vegetable oil during cooking. Also addition of whole milk in banana porridge may have contributed to the high fat content of the sample.

The carbohydrate (excluding fibre) contents of the

complementary food in this study were in the range of 34.34 to 72.61%. The carbohydrate values of maize and banana-based complementary foods are similar to what was reported by Ezeokeke and Onuoha (2016) as well as Okoye and Egbujie (2018). This could probably be due to the addition of other ingredients such as milk or preparation methods of the ingredients that may have reduced losses during peeling or de-hulling.

The recommended energy intake from complementary foods varies according to the age of child, amount of breast milk consumed, fat content in breast milk and the frequency of feeding (Feyisa et al., 2020). For children aged 6-8, 9-11 and 12-23 months and are breastfed, it is recommended that they take 202, 307 and 548 kcal per day, respectively (Abeshu et al., 2016). Studies conducted in Tanzania revealed that, most of the complementary foods are bulky but with lower energy and micronutrient concentrations (Ogbo et al., 2018). The findings from this study support this review because the energy content of all the samples of the frequently used complementary food were below the recommended amount of energy need from complementary foods. The energy content of the samples ranged from 317.6 to 379.23 kcal/100 g (dry weight) and banana porridge with beef had the lowest score. This means that, mothers should be advised to reduce water content (dilution) in complementary foods and increase frequency of feeding in order to meet the recommended dietary allowance.

In this study, total vitamin A content of all the samples was higher than the range reported by Isingoma et al. (2015), with the exception of maize porridge. Samples that contained animal products such as meat, milk and fish had higher vitamin A which is supported by Eggersdorfer and Wyss (2018). Maize porridge had the lowest vitamin A content which is in agreement with what was reported by Jemberu et al. (2016). The observed lower than recommended vitamin A content in the maize porridge which is one of the frequently used complementary food in Tanzania, encourages the formulation complementary foods using more nutritious ingredients. Examples of ingredients include orange-fleshed sweet potatoes, carrots, legumes and seeds as well as using improved traditional processing methods such as fermentation, soaking, germination/malting and de-hulling (Jemberu et al., 2016).

Studies have shown that most homemade complementary foods in Ethiopia have low vitamin C content (Abeshu et al., 2016). This is not different from what has been reported by this study whereby vitamin C content of the frequently used complementary foods in Rombo district ranged from 3.48 to 9.56 mg/100 g of dry sample. Composite flour porridge and banana porridge with fish had the highest vitamin C content relative to the rest of the complementary food samples. This may be due to the addition of fish at the end of cooking which reduced the cooking time of fish since ascorbic acid is

heat labile. Carletti et al. (2017) and Idris et al. (2019) recommend addition of vitamin C rich ingredients such as citrus fruits, tomatoes, green, yellow and red peppers as well as green leafy vegetables to home-made complementary foods.

Iron, zinc, and calcium have always been reported as limiting nutrients in unfortified plant-based complementary foods commonly used in developing countries (Gibson et al., 2010; Abeshu et al., 2016). Similarly, most of locally used complementary foods in Tanzania were poor in iron, zinc and calcium because they are mainly plant-based with little or no addition of animal products. The findings from this study have also shown lower than recommended amount of iron, zinc and calcium in the frequently used complementary foods in the study area.

Banana porridge with beef was the only sample that was able to provide more than the amount of iron needed from complementary foods assuming moderate bioavailability. With the exception of banana porridge with milk, banana porridge with pumpkin and rice porridge with milk, all the other samples were able to provide at least half of the recommended iron intake from complementary foods according to WHO recommendations. Several studies have suggested addition of animal products, the use of commercial infant formulas (Idris et al., 2019) as well as micronutrient powders (Solomon et al., 2017) to improve iron status of infants and young children in developing countries. In order to increase iron content and reduce anti-nutrients such as phytates, some studies suggested soaking and germination of cereals and legumes prior to processing (Mihafu et al., 2017).

According to (FAO/WHO, 2017) complementary foods should provide 86 to 100% of zinc based on the age and breastfeeding status of the child. With the exception of banana porridge with beef, all the other samples of frequently used complementary foods in Rombo district had less than 3 mg/100 g of zinc. This value is lower than what is recommended by World Health Organization (WHO, 2011). Even though they are lower than the recommended amount, they are still higher than the findings of Yanmife et al. (2020) in Pakistan and Kulwa et al. (2015) in Tanzania. The higher zinc content in banana porridge with meat could be due to the presence of meat, which was a good source of zinc.

The recommended amount of calcium (196-353 mg/day) needed from complementary foods for children aged 6-23 months could not be met by plant-based complementary foods in Rombo district. Only banana porridge with beef had the calcium value above the recommended range. Even the milk containing foods such as rice porridge and banana porridge with milk had lower calcium values relative to beef-containing foods. This could be due to the fact that only a small amount of milk is added to complementary foods and sometimes the milk over-diluted. Another study conducted by Laryea et

al. (2018) have also reported lower than recommended amount of calcium in complementary foods.

The lowest iodine concentration was found in banana porridge with beef (10.18 µg/100 g dry weight) and the highest was found in composite flour porridge (200.93 µg/100 g dry weight). With the exception of banana porridge with beef, iodine content of all other samples were above the recommended intake of 19, 30 and 51 µg/day from complementary foods for infants and young children aged 6-8, 9-11 and 12-23 months, respectively (Laryea et al., 2018). The reason for low iodine concentration in banana porridge with beef might be the use of poorly stored and expired salt.

Conclusion

Most of the frequently used complementary foods were found to contain lower than recommended amount of energy, protein, vitamin C, iron, zinc, calcium and iodine. Therefore, this study provides a benchmark for educating mothers on the importance of including nutrient-dense ingredients and proper preparation methods for complementary foods.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

- Abeshu MA, Azeb L, Geleta B (2016). Complementary feeding : Review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries - Lessons from Ethiopia. *Frontiers in Nutrition* 3(41):1-12.
- Arikpo D, Edet ES, Chibuzor MT, Odey F, Caldwell DM (2018). Educational interventions for improving primary caregiver complementary feeding practices for children aged 24 months and under. *Cochrane Database of Systematic Reviews* (5):1-120.
- Association of Official Analytical Chemists (AOAC) (2000). *Official Methods of Analysis of Association of Official Analytical Chemists International*. (17th Ed.), Association of Official Analytical Chemists Inc., Washington DC. pp. 117-132.

- Association of Official Analytical Chemists (AOAC) (2005). Official Methods of Analysis of Association of Official Analytical Chemists International (18th Ed.), Association of Official Analytical Chemists Inc., Maryland 128 p.
- Carletti C, Pani P, Monasta L, Knowles A, Cattaneo A (2017). Introduction of complementary foods in a cohort of infants in northeast Italy: Do parents comply with WHO recommendations? *Nutrients* 9(1):1-11.
- Eggersdorfer M, Wyss A (2018). Carotenoids in human nutrition and health. *Archives of Biochemistry and Biophysics* 652:18-26.
- Ezeokeke CT, Onuoha AB (2016). Antioxidant Activity and Anti-Hyperglycemic Effect of *Lagenaria Siceraria* Fruit Extract. *Journal of Food Science and Engineering* 6(1):139-148.
- Food and Agriculture Organization (FAO) (2003). Food Energy: Methods of analysis and conversion factors. Report of a Technical Workshop, 3 - 6 December, 2002. Food and Nutrition Paper No. 77. Rome. 93 p.
- FAO/WHO (2017). Guidelines on Formulated Complementary Foods for Older Infants and Young. Geneva, Switzerland pp. 1-10.
- Fewtrell M, Bronsky J, Campoy C, Domellöf M, Embleton N, Mis NF, Hojsak I, Hulst JM, Indrio F, Lapillonne A, Molgaard C (2017). Complementary feeding: A position paper by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) committee on nutrition. *Journal of Pediatric Gastroenterology and Nutrition* 64(1):119-132.
- Feyisa BB, Tefera GM, Endris BS, Asayehu TT, Gebreyesus SH (2020). Feeding practice, energy, and nutrient intake adequacy among children aged 6-23 months in Southern Ethiopia: A community based cross-sectional study. *Food Science and Nutrition* 8(12):6680-6690.
- Gibson RS, Bailey KB, Gibbs M, Ferguson EL (2010). A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. *Food and Nutrition Bulletin* 31(2):134-146.
- Hemalatha R, Radhakrishna KV, Kumar NB (2018). Undernutrition in children critical windows of opportunity in Indian context. *Indian Journal of Medical Research* 148(11):612-620.
- Idris OA, Wintola OA, Afolayan AJ (2019). Comparison of the proximate composition, vitamins (ascorbic acid, α-tocopherol and retinol), anti-nutrients (phytate and oxalate) and the GC-MS analysis of the essential oil of the root and leaf of *Rumex Crispus* L. *Plants* 8(51):1-15.
- International Food Policy Research Institute, IFPRI (2016). *Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030*. International Food Policy Research Institute, Washington DC. 112pp.
- Isingoma BE, Samuel M, Edward K, Maina G (2015). Improving the nutritional value of traditional finger millet porridges for children aged 7-24 months in Bujenje County of Western Uganda. *African Journal of Food Science* 9(8):426-436.
- Jemberu Y, Zegeye M, Singh P, Abebe H (2016). Formulation of maize - based complementary porridge using orange - fleshed sweet potato and bean flour for children aged 6-23 months in Kachabira Woreda. *International Journal of Food and Nutrition Engineering* 6(4):87-101.
- Kamath SM, Venkatappa KG, Sparshadeep EM (2017). Impact of nutritional status on cognition in institutionalized orphans: A pilot study. *Journal of Clinical and Diagnostic Research* 11(3):CC01-CC04.
- Kandar R, Novotná P, Drábková P (2012). Determination of retinol, alpha tocopherol, lycopene and beta-Carotene in human plasma using HPLC with UV-Vis detection: Application to a clinical study. *Journal of Chemistry* 2013:1-7.
- Kassa T, Meshesha B, Haji Y, Ebrahim J (2016). Appropriate complementary feeding practices and associated factors among mothers of children age 6-23 months in Southern Ethiopia. *BMC Pediatrics* 16(1):1-10.
- Khor GL, Lee SS (2021). Complementary foods and milk-based formulas provide excess protein but suboptimal key micronutrients and essential fatty acids in the intakes of infants and toddlers from urban settings in malaysian. *Nutrients* 13(7):1-17.
- Kulwa KBM, Mamiro PS, Kimanya ME, Mziray R, Kolsteren PW (2015). Feeding practices and nutrient content of complementary meals in rural central Tanzania: implications for dietary adequacy and nutritional status. *BioMedical Centre Pediatrics* 15(171):1-11.
- Laryea D, Wireko-Manu FD, Oduro I (2018). Formulation and characterization of sweetpotato-based complementary food. *Cogent Food and Agriculture* 4(1):1-15.
- Lietz G, Henry CJK, Mulokozi G, Mugyabuso J, Ballart A, Ndossi G, Lorri W, Tomkins A (2000). Use of red palm oil for the promotion of maternal vitamin A status. *Food Nutrition Bulletin* 21(2):215-218.
- Mandha J, Shumoy H, Matemu AO, Raes K (2021). Valorization of mango by-products to enhance the nutritional content of maize complementary porridges. *Foods* 10(7):1-14.
- Mgongo M, Mosha MV, Uriyo JG, Msuya SE, Stray-pedersen B (2013). Prevalence and predictors of exclusive breastfeeding among women in Kilimanjaro region, Northern Tanzania: a population based cross-sectional study. *International Breastfeeding Journal* 8(12):1-8.
- Mihafu F, Laswai H S, Gichuhi P, Mwanyika S, Bovell-Benjamin AC (2017). Influence of soaking and germination on the iron, phytate and phenolic contents of maize used for complementary feeding in rural Tanzania. *International Journal of Nutrition and Food Sciences* 6(2):111-117.
- Mitchodigni IM, Amoussa HW, Ntandou-Bouzitou G, Avohou H, Termote C, Kennedy G, Hounhouigan DJ (2017). Complementary feeding practices: determinants of dietary diversity and meal frequency among children aged 6-23 months in Southern Benin. *Food Security* 9(5):1117-1130.
- Ogbo FA, Ogeleka P, Awosemo AO (2018). Trends and determinants of complementary feeding practices in Tanzania, 2004-2016. *Tropical Medicine and Health* 46(1):1-13.
- Okoye JL, Egbujie AE (2018). Nutritional and Sensory Properties of Maize-Based Complementary Foods Fortified with Soybean and Sweet Potato Flours. *Discourse Journal of Agriculture and Food Sciences* 6(3):17-24.
- Oladiran DA, Emmambux NM (2020). Locally available african complementary foods: nutritional limitations and processing technologies to improve nutritional quality—A Review. *Food Reviews International* 2020:1-31.
- Rodriguez-Amaya DB, Kimura M (2004). HarvestPlus Handbook for Carotenoid Analysis. Harvestplus Technical Monograph 2. International Food Policy Research Institute, Washington DC. 63 p.
- Rutkowski M, Grzegorczyk K (2007). Modifications of spectrophotometric methods for antioxidative vitamins determination convenient in analytic practice. *Acta Scientiarum Polonorum Technologia Alimentaria* 6(3):17-28.
- Shirima R, Greiner T, Kylberg E, Gebre-medhin M (2000). Exclusive breast-feeding is rarely practised in rural and urban. *Public Health Nutrition* 4(2):147-154.
- Singh S, Srivastava S, Upadhyay AK (2019). Socio-economic inequality in malnutrition among children in India: An analysis of 640 districts from National Family Health Survey (2015-16). *International Journal for Equity in Health* 18(1):1-9.
- Solomon D, Aderaw Z, Tegegne TK (2017). Minimum dietary diversity and associated factors among children aged 6-23 months in Addis Ababa, Ethiopia. *International Journal for Equity in Health* 16(1):1-9.
- Standardized Monitoring and Assessment of Relief and Transitions, SMART (2012). Emergency Nutrition Assessment: Guidelines for field workers. Save the Children, United Kingdom. 34 p.
- Tapia MS, Alzamora SM, Chirife J (2020). Effects of water activity (aw) on microbial stability as a hurdle in food preservation. In Barbosa-Cánovas GV, Fontana AJ, Schmidt SJ, Labuza TP (Eds.). *Water activity in foods: Fundamentals and applications*. John Wiley and Sons pp. 323-355.
- TDHS-MIS (2015-2016). *Tanzania Demographic and Health Survey and Malaria Indicator Survey Dar es Salaam, Tanzania, and Rockville, Maryland, USA* pp. 177-180.
- Tiencheu B, Achidi AU, Fossi BT, Tenyang N (2016). Formulation and nutritional evaluation of instant weaning foods processed from maize (*Zea mays*), pawpaw (*Carica papaya*), red beans (*Phaseolus vulgaris*) and mackerel fish meal (*Scomber scombrus*). *African Journal of Food Science and Technology* 4(5):149-159.

- TNNS (2018). Tanzania National Nutrition Survey using SMART Methodology (TNNS) (Issue June) P 32.
- UNICEF/WB/WHO (2016). Joint child malnutrition estimates. [<http://data.worldbank.org/child-malnutrition>] site visited on 20/2/2021.
- UNSCN (2016). Progress in Nutrition. Sixth Report on the World Nutrition Situation. United Nations System Standing Committee on Nutrition, Geneva 20 p.
- United Republic of Tanzania (URT) (2017). The United Republic of Tanzania Kilimanjaro Region P 60.
- World Health Organization (WHO) (2011). Guideline: Use of Multiple Micronutrient Powders for Home Fortification of Foods Consumed by Infants and Children 6 - 23 Months of Age. World Health Organization Geneva, Switzerland. 9 p.
- Yannmife OA, Onabanjo OO, Aliza H (2020). The search for sustainable solutions: Producing a sweet potato based complementary food rich in vitamin A, zinc and iron for infants in developing countries. *Stark Scientific African* 8:e00363.
- Yisak H, Elmneh R, Taklual W, Ewunetei A, Kefale B. (2020). Prevalence and associated factors of clinical vitamin a deficiency among pre-school children 1-5 years of age in rural kebeles in farta district, south gondar zone, Ethiopia: A mixed methods study. *Journal of Multidisciplinary Healthcare* 13:1191-1201.