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Contribution of fish in improving micronutrients content in complementary foods for children aged 6 to 23 months in Lindi Rural District

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Lindi region has high stunting prevalence of about 35%, and one of the factors that cause stunting is inadequate intake of micronutrients for children under 2 years old. This study aimed at assessing contribution of fish in improving micronutrients, specifically vitamin A, zinc and iron contents in complementary foods for children aged 6 to 23 months old children in Lindi Rural District. A cross-sectional study was done; interviews were conducted on 212 caregivers with children aged 6 to 23 months at Mchinga Ward. Information collected includes demographic information and commonly consumed complementary foods for targeted children through the use of 24 h dietary recall. Also, laboratory analysis for zinc, iron, vitamin A contents and proximate composition were done for commonly consumed foods. About 89.2% of children were given fish-based complementary foods. On average, fish-based complementary foods had higher vitamin A concentrations (279 µg RE/100 g serving) compared to non-fish-based complementary foods (4 µg RE/100 g serving), but low in iron and zinc concentrations (0.66 and 0.067 mg/100 g serving, respectively) than non-fish-based complementary foods (0.74 and 0.074 mg/100 g serving respectively). Furthermore, fish-based complementary foods had higher proximate composition (except for % moisture content) compared to non-fish-based complementary foods.

Key words: Lindi, fish, complementary foods, children, micronutrients.

INTRODUCTION

Undernutrition is still a problem in developing countries, especially high prevalence of stunting which signifies chronic under nutrition in general. The number of stunted children has steadily increased from 50.6 million in 2000 to 58.7 million in 2017 (Development Initiatives, 2018). Undernutrition can permanently impair a child's physical and cognitive development. The damage often leads to poorer school performance, hence future income reductions. These children are also at increased risk of illness and disease in their adulthood (Wells et al., 2020).

In developing countries dietary energy forms the biggest proportion of complementary foods for children, but with

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low micronutrients levels causing micronutrient deficiency (Abeshu et al*.,* 2016). Meeting micronutrients requirements during the early days of life contributes to preventing and correcting stunting (Shafique et al*.,* 2016). Among others, adequate intake of vitamin A, zinc, iron and universal promotion of iodized salt is essential in stunting reduction (Dewey, 2016). Adequate intake of zinc has a positive effect on size growth, especially in children under 2 years of age (Liu et al*.,* 2018). Iodine and iron are known to be essential for metabolic rate, development of body structures and neuronal maturation, in case of deficiency in early life stages it can lead to brain damage in children (Georgieff, 2017). Deficiency of iron may also lead to anemia. Vitamin A intake is essential for the immune system and reduce the child's risk of contracting and dying from infections like measles, and diarrheal illnesses (Huang et al*.,* 2018). These micronutrients can be accessible to the child through breast milk and the complementary foods when breast milk alone is no longer sufficient to meet nutritional requirements. Hence, appropriate complementary foods can promote good nutritional status and growth in infants and young children (Aguayo, 2017). Also, complementary feeding strategies have been linked with a reduction in stunting in food insecure populations (Martinez, 2018). In Tanzania, unfortunately most complementary foods are usually cereal-based served with little or no vegetables, and often lacking animal proteins hence low in micronutrient levels (Makori et al*.,* 2018).

In coastal areas, fish is the major source of animal protein. It is an irreplaceable animal source especially for the species that are consumed as whole such as sardines (*dagaa*) as they provide essential nutrients including the micronutrients of high bioavailability which are found in limiting amounts in the diet (Tilami and Sampels, 2017). Some of the micronutrients available in fish include vitamin A, vitamin D, selenium, phosphorus, calcium, iron and zinc. Also they consist of polyunsaturated n-3 fatty acids which are essential in human nutrition as they are involved in many metabolic functions. Due to its availability and accessibility in coastal regions, promotion of fish-based complementary foods is important and its consumption can be used as an effective food-based strategy to enhance micronutrient intake in fishing communities. The main objective of this paper is to assess the micronutrient contribution of fish-based complementary foods compared to non-fish complementary foods commonly offered to children of age 6-23 months at Lindi. Lindi region is one among other coastal regions in Tanzania practicing fishing activities as part of their livelihood and has high prevalence of stunting of 35.2% for under-five years children which is more than the national prevalence of 34.7% (National Bureau of Statistics and ICF Macro, 2015). For all of the above, we assessed iron, zinc and vitamin A contents in fish and non-fish-based commonly used complementary foods in Lindi Rural District.

MATERIALS AND METHODS

A cross-sectional study was conducted in villages practicing fishing activity Mchinga A and Mchinga B, which are located along the Indian Ocean in Lindi Rural District at Mchinga Ward. A total of 212 mother-child pairs with children aged 6-23 months were randomly selected. Interviews were conducted among the selected mother-child pairs with the use of questionnaires as tool for data collection. The study involved mothers, since in Tanzanian culture, they are expected to be the ones who are responsible for planning meals and feeding their children. The questionnaire consisted of semi structured questions aimed at obtaining socio-demographic information of the mother and her child, and types of complementary foods consumed by children (both fish-based and non-fish-based) using the 24 h dietary recall for children through their caregivers. Mothers' socio-demographic information was important as they have influence on the choices they do for their children's feeding practices. Through interactive 24 h dietary recall, caregivers not only mentioned all foods and fluids consumed by their children but also ingredients and amounts used in meal preparation and quantities of consumed foods or drinks.

Sample identification, preparation and nutrient determination of common fish-based and non-fish-based complementary foods

The common types of fish-based and non-fish-based complementary foods consumed by the children aged 6-23 months were obtained from the 24 h dietary recall data. From this, information on foods with highest frequency for both fish-based complementary foods (Figure 2) and non-fish-based complementary foods (Figure 3) was obtained. About 17 food samples were prepared by 10 randomly recruited mothers using various locally obtained ingredients (Table 1) with amounts, preparation and cooking methods obtained from the 24 h dietary recall data.

Samples were then collected and transported to the Department of Food Technology, Nutrition and Consumer Sciences Laboratory in Sokoine University of Agriculture, Morogoro, Tanzania. Upon arrival, samples were stored in the laboratory freezer (-40°C) for 12 h. Samples were then ground to ensure homogeneity and subjected into procedures for (i) proximate analysis following Association of Official Analytical Chemists (1995) method No 925.10, (ii) for minerals content (iron and zinc) determination following Association of Official Analytical Chemists (1995) method No. 968.08, by Atomic Absorption Emission Spectrophotometer (AA 630-12) and total vitamin A for both β-carotene and retinol content were determined using ultra-violet visible spectrophotometer. Each analysis was conducted in duplicate.

Mineral contents

Minerals (zinc and iron) were analyzed following AOAC (1995) method No 925.10. 5 g of the homogenized water bath warmed sample was mixed with 10 ml concentrated nitric acid, slowly boiled and evaporated down to 5 ml on a hot plate and left to cool. The sample was then filtered using No. 1 Whatman filter paper into volumetric flask and diluted to 100 ml mark using distilled water. The samples were analyzed for iron and zinc using Shimadzu Atomic Absorption Spectrophotometer (AAS) UNICAM 919, England.

Vitamin A (Retinol)

10 ml of homogenized water bath warmed oil sample was taken

Table 1. Summary of cooked food samples for laboratory analysis.

Number of samples	Food sample
1	Unrefined maize porridge (UM)
2	Cassava porridge (C)
3	Refined maize porridge (RM)
4	Unrefined maize porridge, millet, beans and rice (UMMBR)
5	Unrefined maize porridge, millet, groundnuts and rice (UMMGR)
6	Boiled fish (*Dagaa*) with water and salt (BF-S)
7	Boiled fish (*Tasi*) with water and salt (BF-T)
8	Boiled fish (*Kibua*) with water and salt (BF-K)
9	Refined maize flour and water for stiff porridge with fish (*Dagaa*), tomatoes, coconut cream, onions and salt for stew (FSSP-S)
10	Refined maize flour and water for stiff porridge with fish (*Tasi*), tomatoes, coconut cream, onions and salt for stew (FSSP-T)
11	Refined maize flour and water for stiff porridge with fish (*Kibua*), tomatoes, coconut cream, onions and salt for stew (FSSP-K)
12	Fish (*Dagaa*) with irish potatoes, tomatoes, coconut cream, onions, salt and water (PTF-S)
13	Fish (*Tasi*) with irish potatoes, tomatoes, coconut cream, onions, salt and water (PTF-T)
14	Fish (*Kibua*) with irish potatoes, tomatoes, coconut cream, onions, salt and water (PTF-K)
15	Fish (*Dagaa*) with green banana, coconut cream, tomatoes, onions and salt (BNF-S)
16	Fish (*Tasi*) with green banana, coconut cream, tomatoes, onions and salt (BNF-T)
17	Fish (*Kibua*) with green banana, coconut cream, tomatoes, onions and salt (BNF-K)

**Dagaa* (*lupapa* type) - English named as Indian oil sardine (*Sardinella longiceps*); **Tasi* - English named as Rabbit fish (*Siganus sutor*); **Kibua* - English named as Indian mackerel (*Rastrelliger kanagurta*) (Food and Agriculture Organization, 1983); *The abbreviations will be used in the text.

into 22 ml screw cap test tube; then 1 ml of 5% pyrogallol with 1% ascorbic acid was added followed by 2 ml of 50% alcoholic potassium hydroxide solution and vortex mixed for 15 s followed by the ultrasonic agitation for 60 min at 45°C. Further, 2 ml of distilled water was added followed by the addition of 2 ml extraction mixture of n-Hexane: Ethyl acetate (90%:10%). The mixture was then vortex mixed for 15 s. The organic phase was transferred into another clean test tube (Lietz et al*.,* 2001). The extraction was repeated twice and organic phases combined which were then washed with 2 ml solution of sodium sulfate. The organic phase was then transferred to a clean test tube and evaporated to dryness. The dried extract was eluted with 2 ml absolute alcohol, vortex mixed for 15 min and absorbance read at 325 nm using X-Ma 3000 UV spectrophotometer. Sample concentrations were calculated using the following equation (Craft, 2008);

$$Rc = \frac{A \times El \times 10000}{E \times S \times Et}$$

Where; Rc = Retinol concentration (mg/L)
A = Sample absorbance as read at 325 nm using UV-Visible spectrophotometer (The machine calibrated using pure ethanol as blank sample)
El = Elution volume
E = Extinction coefficient of retinol in ethanol (1850)
S = Amount of sample taken for analysis
Et = Extraction volume.
10000 = conversion factor from % to mg/l

Vitamin A (β-carotene)

A measurement of 10 ml of water bath was warmed at 40°C. The samples were extracted with 150 ml cold acetone and poured into 30 ml petroleum ether (BP 40-60°C) layer, then washed with distilled water until free from any acetone (Rodriguez-Amaya and Kimura, 2004). Samples were then saponified for 12 h with 30 ml 60% Methanolic potassium hydroxide, washed with distilled water until free from potassium hydroxide by controlling the washings using phenolphthalein indicator. The clear extracted carotenoids were then passed through the activated anhydrous sodium sulphate, and collected into volumetric flask. Absorbencies were read at 450 nm sin UV-Visible spectrophotometer. Standard calibration plot was prepared by dissolving 10 mg of standard β-carotene into 100 ml dry petroleum ether, and actual concentration of the obtained standard solution was determined. From this, serial distributions were prepared and their absorbency read at 450 nm which were used to construct a standard plot. Sample concentrations were calculated using the obtained linear regression equation.

Data analysis

Collected data was entered and subjected to statistical analysis using Statistical Product and Service Solutions (SPSS) version 20 to compute for descriptive and inferential statistics. Descriptive statistics were computed including the frequencies, means and modes. Analysis of variance (ANOVA) was done for the laboratory results at 95% confidence interval (P≤0.05) to assess significance difference of vitamin A, iron and zinc among fish-based and non-fish-based complementary foods. Furthermore, contribution of commonly used complementary foods for children on meeting the recommended daily intake (RDI) for vitamin A, iron and zinc was assessed through percentage determination of vitamin A, iron and zinc concentration per serving contributed to the total RDI respectively.

RESULTS

Socio-demographic information of mother-child pair

A big proportion (98.1%, n = 206) of respondents were the biological mothers of the children (Table 2). Most

Table 2. Socio-demographic information of the mother-child pair.

Variable	Frequency	Percent
Age group distribution		
<20	29	13.9
20-29	97	47.1
30-39	66	31.7
<40	15	7.2
Child-caregiver relationship		
Mother	206	98.1
Others	4	1.9
Area of residence		
Mchinga 1	122	57.5
Mchinga 2	90	42.5
Marital status		
Married (monogamous)	121	57.1
Married (polygamous)	15	7.1
Widowed	1	0.5
Divorced	21	9.9
Single	54	25.5
Occupation		
Housewife	41	19.3
Farmer	145	68.4
Formally Employed	1	0.5
Self-employed	14	6.6
Farmer and self-employed	6	2.8
Farmer and livestock keeper	4	1.9
Average income per month (TSh)		
0	23	10.8
<100000	122	57.5
100000-199999	32	15.1
200000-299999	9	4.2
300000-399999	21	9.9
>=400000	5	2.4
Level of education of the caregiver		
Never gone to school	71	33.5
Primary school	121	57.1
Secondary school	19	9.0
High school	1	0.5
Age of within which caregivers finished their education		
Within 2 years	11	9.0
Within 3 to 5 years	33	27.1
More than 5 years	78	63.9
Sex of the children		
Male	100	47.2
Female	112	52.8

Table 2. Contd.

Age of the children		
6 to 8 months	51	24.2
9 to 11 months	48	22.7
12 to 23 months	112	53.1

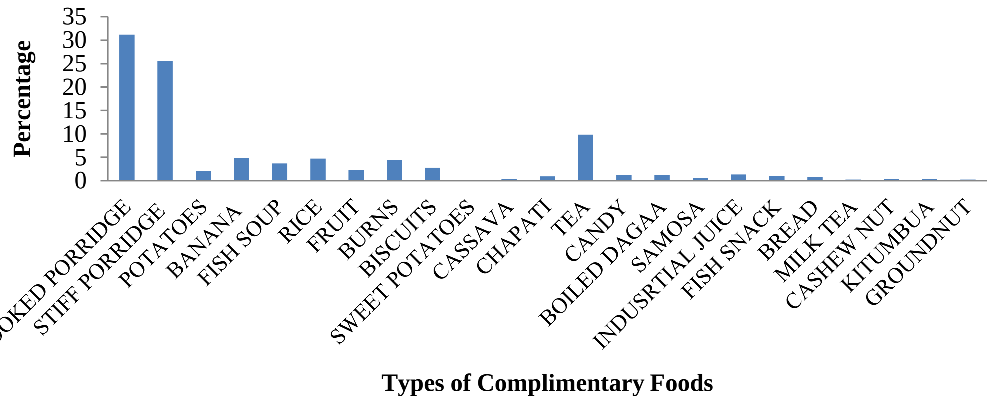

Figure 1. Frequency of type of complementary foods and snacks consumed by the children aged 6-23 months for the past 24 h in percentage (n=212).

mothers (78.8%) had an age range of 20-29 years with mean age of 27.9±0.8. Single parenting also existed in the area (25.5% single mothers), and the majority of the women were married in monogamous while a small proportion of respondents (7.1%) were married in a polygamous type of marriage. In terms of occupation levels, the majority (68.4%) were farmers, with most of them having their income less than 100,000 Tanzanian shillings (TSh) per month. The illiterate rate among the respondents was also high (33.5%) and the majority had just primary education (57.1%) with 78% having finished their education more than 5 years ago. Also, the mean household size was 4.9 ± 1.8 (range 2 to 12), with 68.6% of the households having members equal or less than 5. The mean age of the children is 13.9 ± 5.1 months with the age range of 12 to 23 months (53.1%, n = 212). More than half (52.6%) of these children were female.

24 h dietary recall

Porridge was found to be the main dish consumed by most of the children (31%) followed by maize stiff porridge with different relish (26%), but mostly fish relish (Figure 1). The higher the age the more varieties of foods consumed by the children. Children aged 6 to 8 months consumed a total of 24 varieties of complementary foods and snacks, those aged 9 to 11 months consumed 28 varieties of foods and snacks while those at age of 12 to 23 months consumed 32 varieties of foods and snacks. Among all varieties of food consumed, many children had consumed fish for the past 24 h, with *kibua*, *tasi* and *dagaa* being reported as the variety of fish mostly consumed (Figure 4). It was also observed that types of fish consumed increases as the age of the children increases. According to mothers and caregivers, about89.2% of children are fed with fish in their diets. Only few children were not given fish and age of the child was found to have association with fish consumption ($p < 0.05$), where large proportion of these children had the age of 6 to 8 months.

Many children (86.7%) were being served with fish-based complementary foods during the main meal, which is lunch and dinner. Only 0.5% of the children were served fish-based complementary food as a snack. Only 39% of the households had household members who are involved in any fish business, which has no association with child's fish consumption (p>0.01).

Proximate analysis

The analysis involved the food analysis for percentage protein, fiber, fat, ash, dry matter and moisture content. Carbohydrate percentage and total energy (kcal) was calculated based on the results obtained from the analyzed proximate parameters. In average fish-based complementary foods had higher proximate parameters mean values than non-fish-based complementary foods (Table 3).

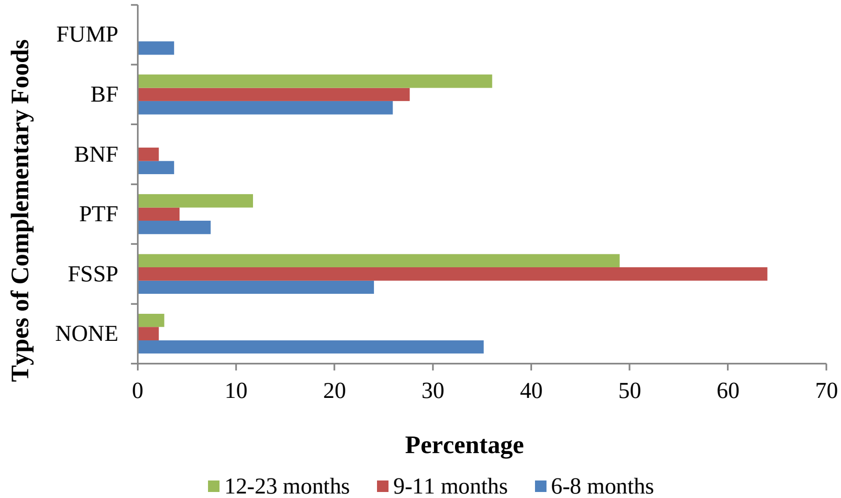

Figure 2. Percentage of children aged 6-23 months consuming various forms of fish based complementary foods (n=212). NONE= Not consuming any type of fish, FSSP= Fish with stiff porridge, PTF= Fish with Irish potatoes, BNF= Fish with green bananas, BF= Fish soup, FUMP= Fish with unrefined maize porridge.

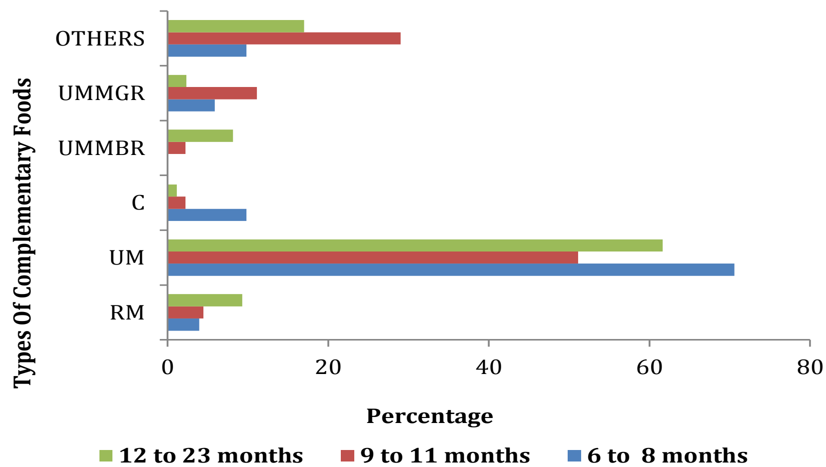

Figure 3. Percentage of children aged 6-23 months consuming various types of non-fish based complementary foods (n=212). RM = Refined maize porridge, UM = Unrefined maize porridge, C = Cassava porridge, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined complementary foods.

Vitamin A concentration in cooked food samples

Mean vitamin A concentration in fish-based complementary foods was higher (279 µ RE) than in non-fish-based complementary foods (4 µ RE). High vitamin A concentration on fish-based complementary foods was more contributed by the retinol content from the fish. Significant difference ($p < 0.05$) of vitamin A concentration was observed between fish-based and non-fish-based complementary foods. Also, significant difference ($p < 0.05$) of vitamin A concentration was observed among non-fish-based complementary foods (UMMGR, UMMBR, C, RM and UM) and among fish-based complementary foods (FSSP, BF, PTF and BNF) (Table 4).

Iron concentration in cooked food samples

Iron was significantly higher on non-fish-based complementary foods (0.74 mg) than on fish-based complementary foods (0.66 mg). There was significant

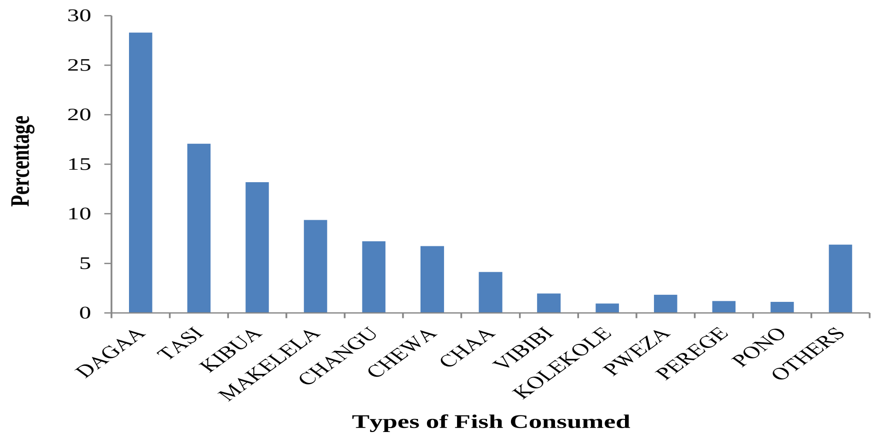

Figure 4. Frequency of type of fish consumed by the children aged 6-23 months in percentage (n=189).

Table 3. Proximate composition of commonly used complementary foods (per 100 g wet matter).

Sample name	% Crude Protein	% Crude Fiber	% Fat	%Ash	%Moisture Content	% Dry Matter	% Carbohydrate	Energy (Kcal)
Fish-based complementary foods								
BF-K	5.3±1.6^{abc}	4.8±0.7^{ab}	2.4±0.4^{a}	4.7±0.5^{a}	78.9±0.7^{efg}	21.1±0.7^{efg}	4.0±0.1^{abcd}	58.3±10.1^{cd}
BF-S	5.5±0.5^{ab}	3.6±0.6^{ab}	0.2±0.1^{bc}	3.6±0.1^{bc}	86.1±0.3^{d}	13.9±0.3^{h}	1.1±0.3^{d}	28.5±4.2^{efg}
BF-T	5.5±0.5^{ab}	5.6±0.1^{ab}	0.7±0.1^{b}	3.6±0.1^{b}	80.5±0.2^{e}	19.51±0.2^{g}	4.1±1.0^{abcd}	44.2±1.3^{def}
BNF-K	8.7±2.4^{a}	2.3±0.1^{b}	4.1±0.5^{de}	1.6±0.0^{de}	74.4±0.2^{j}	25.7±0.2^{b}	8.9±1.7^{abcd}	107.2±1.2^{a}
BNF-S	4.2±1.4^{abc}	3.4±1.1^{ab}	3.2±0.6^{d}	1.9±0.0^{d}	78.5±0.3^{efgh}	21.5±0.3^{defg}	8.9±3.4^{abcd}	80.4±2.6^{abc}
BNF-T	2.8±0.4^{bc}	3.0±0.1^{ab}	2.3±1.1^{d}	2.2±0.4^{d}	77.5±0.9^{fghi}	22.5±0.6^{cdef}	12.2±2.0^{ab}	80.8±3.1^{abc}
FSSP-K	4.5±2.4^{abc}	6.6±0.2^{ab}	3.2±0.1^{cd}	2.5±0.5^{cd}	75.8±0.4^{ij}	24.2±0.4^{bc}	7.4±3.3^{abcd}	76.0±4.9^{bc}
FSSP-S	3.6±1.6^{bc}	4.6±2.5^{ab}	0.3±0.3^{ab}	4.3±0.6^{ab}	79.6±0.7^{ef}	20.4±0.7^{fg}	7.7±3.4^{abcd}	47.7±8.9^{de}
FSSP-T	4.0±2.5^{abc}	7.2±0.7^{a}	2.8±1.3^{cd}	2.5±0.0^{cd}	71.3±0.6^{k}	28.7±0.6^{a}	12.3±2.6^{ab}	90.3±11.9^{ab}
PTF-K	2.9±0.8^{bc}	4.4±1.0^{ab}	0.9±0.0^{d}	2.3±0.1^{d}	76.9±0.6^{ghi}	23.1±0.6^{cde}	12.5±2.4^{a}	70±6.8^{bcd}
PTF-S	3.6±0.5^{bc}	4.5±1.3^{ab}	5.1±2.3^{d}	2.4±0.0^{d}	78.5±0.1^{efgh}	21.5±0.1^{defg}	5.9±3.1^{abcd}	84±6.5^{abc}
PTF-T	1.3±0.2^{bc}	5.5±1.7^{ab}	2.9±0.0^{d}	2.3±0.0^{d}	76.8±0.1^{hi}	23.2±0.1^{cd}	11.2±1.7^{abc}	76.4±6.8^{bc}
Non-fish-based complementary foods								
C	0.4±0.0^{c}	1.9±0.5^{b}	0.1±0.2^{f}	0.5±0.1^{f}	94.3±0.1^{a}	5.7±0.1^{k}	2.8±0.5^{c}	14±0.6^{g}
RM	1.3±0.5^{bc}	3.6±3.1^{ab}	0.2±0.0^{ef}	0.8±0.1^{ef}	90.3±0.6^{c}	9.8±0.6^{i}	3.8±3.7^{abcd}	22.4±17^{efg}
UM	3.4±0.8^{bc}	2.7±0.7^{ab}	0.1±0.1^{f}	0.1±0.0^{f}	92.5±1.2^{ab}	7.5±1.2^{jk}	1.1±1.1^{d}	19.2±0.0^{fg}
UMMBR	3.6±0.9^{abc}	1.9±0.1^{b}	0.1±0.2^{ef}	0.8±0.1^{ef}	90.1±0.4^{c}	9.9±0.4^{i}	3.5±0.5^{bcd}	29.0±0.3^{efg}
UMMGR	2.7±0.5^{bc}	2.7±0.1^{ab}	0.3±0.1^{de}	1.7±0.1^{de}	90.9±0.1^{bc}	9.1±0.1^{ij}	1.6±0.6^{d}	20.1±0.4^{efg}

BF = Fish soup, BNF = Fish with mashed bananas, FSSP = Fish with stiff porridge, PTF = Fish with mashed Irish potatoes, C = Cassava porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua*. Results are presented as means and standard deviations. Analysis of variance (ANOVA) was used to find significant difference between samples (P<0.05). Means with a column with same superscripts are not significantly different from each other. %Carbohydrate = 100 - (%Crude protein + %Crude fibre + %Crude fat + %Ash content + %Moisture content) Energy (Kcal) = (fat x 9) + (protein x 4) + (carbohydrate × 4)

difference (p<0.05) of iron concentration among the non-fish-based complementary foods and among the fish-based complementary foods.

UM porridge contained the highest amount of iron concentration (1.25 mg ± 0.01 per 100 g) than the rest, while PTF-S contained the lowest quantity of iron content (0.22 mg ± 0.02 per 100 g). Unlike vitamin A, iron concentration was found to be in higher quantities on non-fish-based complementary foods compared to the fish-based complementary foods (Table 5).

Table 4. Difference of vitamin A concentration of commonly used complementary foods (µg /100 g wet basis).

Sample name	β-Carotene (µg /100 g RE)	Retinol (µg /100 g RE)	Vitamin A (µg 100 g RE)
Fish-based complementary foods			
BF-S	0.0	109.3	109.3±0.5[k]
BF-T	0.0	103.3	103.3±0.5[l]
BF-K	0.0	212.1	212.1±0.6[i]
BNF-S	80.9	337.8	418.7±0.1[b]
BNF-T	53.0	256.9	149.2±0.7[j]
BNF-K	54.3	534.9	311.2±0.6e
FSSP-S	129.8	135.9	265.7±0.1[g]
FSSP-T	69.1	429.5	498.6±0.0[a]
FSSP-K	52.5	316.8	369.3±0.5[d]
PTF-S	70.0	317.7	387.7±0.9[c]
PTF-T	66.2	151.7	217.9±0.8[h]
PTF-K	54.3	252.4	306.7±0.6[f]
Average			279.1
Non-fish-based complementary foods			
C	4.9	0.0	4.9±0.1[n]
RM	1.5	0.0	1.5±0.3[o]
UM	7.6	0.0	7.6±0.3[m]
UMMBR	2.5	0.0	2.5±0.3[o]
UMMGR	2.9	0.0	2.9±0.3[o]
Average			3.9

BF = Fish soup, BNF = Fish with mashed bananas, FSSP = Fish with stiff porridge, PTF = Fish with mashed irish potatoes, C = Cassava porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua*.

Zinc concentration in cooked food samples

Zinc concentration was found to be higher on non-fish-based complementary foods (0.077 mg/100 g) than on fish-based complementary foods (0.073 mg/100 g). Significance difference ($p<0.05$) between fish-based complementary foods and non-fish-based complementary foods for zinc concentration was observed. Furthermore, significant differences ($p < 0.05$) of zinc concentration among the non-fish-based complementary foods and among the fish-based complementary foods were obtained. Non-fish-based complementary foods had higher amount of zinc except for sample C and RM. Also, sample UM, FSSP-T and BNF-S had the highest amount of zinc content than the rest of the complementary foods (Table 5).

Contribution of commonly used complementary foods for children on meeting the recommended daily intake (RDI) for vitamin A, iron and zinc

On average, all fish-based complementary foods met the vitamin A RDI for children aged from 6 to 23 months correspondingly, by either consumed once, twice or thrice per day unlike the non-fish-based complementary foods (Table 6). Only one fish-based complementary food BNF-S was able to meet the iron RDI while three non-fish-based complementary foods met the iron RDI, unrefined maize porridge (UM); unrefined maize, millet, beans and rice porridge (UMMBR), and unrefined maize, millet, groundnuts and rice porridge (UMMGR) (Table 7). For the mentioned complementary foods to be able to meet the iron RDI, they must be fully consumed two times a day, except for BNF-S and UMMGR which are supposed to be consumed three times a day (Table 7). Zinc was observed to be very low in both fish-based and non-fish-based complementary foods as no complementary food was able to meet zinc RDI (Table 8).

DISCUSSION

Demographics and 24 h dietary recall

Different studies (Mekonnen et al., 2017: Udoh and Amodu, 2016) showed the existence of demographic characteristics effect towards child's feeding practices. Many caregivers had only primary education with most of them having completed primary school 5 years ago. Low education level among the female caregivers is also associated with child's exclusive breastfeeding, meal

Table 5. Difference of iron and zinc concentration among commonly used complementary foods (mg/100 g wet basis).

Sample name	Iron (mg/100 g) ± standard deviation	Zinc (mg/100 g) ± standard deviation
Fish-based complementary foods		
BF-S	0.53±0.05 [de]	0.06±0.01[bcd]
BF-T	0.34±0.02 [fg]	0.04±0.02[cd]
BF-K	1.26± 0.01[a]	0.11±0.01[a b]
BNF-S	0.31±0.02 [gh]	0.04±0.00[cd]
BNF-T	0.95±0.03 [b]	0.13±0.05 [a]
BNF-K	0.83±0.01 [c]	0.09±0.01[abcd]
FSSP-S	0.36±0.04 [fg]	0.05±0.01[cd]
FSSP-T	0.82±0.04 [c]	0.09±0.00[abc]
FSSP-K	1.26±0.02[a]	0.13±0.02[a]
PTF-S	0.22±0.02 [hi]	0.03±0.01[d]
PTF-T	0.55±0.03 [d]	0.07±0.00[abcd]
PTF-K	0.55±0.03 [d]	0.03±0.00 [cd]
Average	0.66	0.07
Non-fish-based complementary foods		
C	0.19±0.01[i]	0.03±0.00 [cd]
RM	0.44±0.03[ef]	0.04±0.00 [cd]
UM	1.25±0.01[a]	0.13±0.00 [a]
UMMBR	1.03±0.00[b]	0.11±0.04[ab]
UMMGR	0.78±0.02[c]	0.08±0.00[ab]
Average	0.74	0.08

BF = Fish soup, BNF = Fish with mashed bananas, FSSP = Fish with stiff porridge, PTF = Fish with mashed irish potatoes, C = Cassava porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua.*

diversification and meeting the recommended minimum number of meals (Duan et al*.,* 2018). Even though no significant association was observed between the caregivers' average income and feeding practices, caregivers' poor accessibility to foods in markets which may be due to low household income less than 100,000 TSh per month can also affect the child's feeding practices, since availability and accessibility of various food materials is important for diversification of foods.

All the children under the study were already introduced to complementary foods as expected since they are all from the age of 6 months and above (Pan American Health Organization, and World Health Organization, 2003). It is also recommended for complementary foods to be provided 2-3 times per day at 6-8 months of age and 3-4 times per day at 9-11 and 12-24 months of age, with additional nutritious snacks (such as a piece of fruit) offered 1-2 times per day, as desired for the average healthy breastfed infant. If energy density or amount of food per meal is low, or the child is no longer breastfed, more frequent meals may be required. On average, all age groups tend to be fed three times per day as required. But those aged 12 to 23 months did not meet the recommendations as they were not given healthy snacks between meals. During this period, they need more frequency of eating nutritious foods including the health snacks like fruits so as to satisfy the nutrients demands for their growth and health in general.

In different studies (Abeshu et al*.*, 2016: Kulwa et al*.,* 2015), it has been reported that porridge is most common used form of complementary food in developing countries. This has been observed at Mchinga as well, the commonly consumed form of complementary food is porridge with the addition of salt in it. In which, unrefined maize porridge (UM) found to be the most commonly used kind of complementary food for children aged 6 to 23 months. Followed by cassava porridge (C) for the children aged 6 to 8 months, porridge containing a mixture of unrefined maize, millet, groundnuts and rice flour for children aged 9 to 11 months, and porridge containing a mixture of unrefined maize, millet, beans and rice flour for the children aged 12 to 23 months. Then followed by the consumption of stiff porridge (*ugali*) with other side dishes, and very few who consumed bananas, potatoes and rice. All food materials used to prepare the porridge for the children are cereals as reported in other developing countries that dietary energy forms a big proportion of complementary foods (Abeshu et al*.,* 2016). The feeding practice at the study area may be influenced by agricultural production as it is reported that cassava,

Table 6. Percentage of vitamin A content contributed by fish-based complementary foods and non-fish-based complementary foods on meeting the RDIs.

RDI (mcg RE)	6-8 Months 350			9-11 Months 350			12-23 Months 400		
Sample	Average weight of food consumed per meal (g)	Vitamin A Concentration from 1 serve (µg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Vitamin A Concentration from 1 serve (µg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Vitamin A Concentration from 1 serve (µg)	% Contribution to RDIs from 1 Serve
Fish-based complementary foods									
BF-S	60.9	161.79	46	90.2	239.63	68	151.4	402.22	101
BF-T	61.9	308.65	88	90.2	449.76	129	151.4	754.93	189
BF-K	62.9	232.27	66	90.2	333.08	95	151.4	559.07	140
BNF-S	128	139.91	40	178	194.56	56	230	147.56	37
BNF-T	135	139.45	40	180	185.93	53	229	142.55	36
BNF-K	138	292.73	84	182	386.06	110	236	301.21	75
FSSP-S	111	430.34	123	178	690.10	197	240	930.47	233
FSSP-T	125	272.40	78	182	396.61	113	256	557.87	139
FSSP-K	130	398.69	114	185	567.37	162	275	843.39	211
PTF-S	115	481.46	138	160	669.85	191	212	887.56	222
PTF-T	132	196.98	56	178	265.62	76	228	340.23	85
PTF-K	137	426.28	122	186	578.74	165	235	731.21	183
Non-fish-based complementary foods									
UMMBR[2]	187.1	4.74	1	227.4	5.76	2	295.0	7.47	2
UMMGR[2]	187.1	5.41	2	227.4	6.57	2	295.0	8.53	2
RM[2]	187.1	2.74	1	227.4	3.33	1	295.0	4.32	1
UM[2]	187.1	14.16	4	227.4	17.20	5	295.0	22.32	6
C[2]	187.1	9.15	3	227.4	11.12	3	295.0	14.42	4

FSSP = Fish with stiff porridge, BF = Fish soup, PTF = Fish with mashed irish potatoes, BNF = Fish with mashed bananas, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, C = Cassava porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua*.

maize, sorghum and pulses (pigeon and cowpeas) are common food crops produced at Lindi, with few people engaged in livestock keeping while fishing is for only those living along the coast (Jones, 2017).

Fish consumption

World Health Organization (2004) advised meat, poultry, fish or eggs to be eaten daily or as often as possible, since they are rich sources of many nutrients such as iron and zinc. At Mchinga generally, almost all households consume fish, only very few households do not consume fish due to economic reasons. Children are being provided with both fish-based and non-fish-based complementary foods. They consume fish mostly in forms of relish or soup. Children's fish consumption in fishing communities has been observed to be higher as reported in several studies (Bandoh and Kenu, 2017; Wake and Geleto, 2019), compared to other reports of fish consumption studies among children in developing countries (Gibson et al., 2020; Mekonnen et al., 2017). Therefore, high fish consumption in this study area could be attributed to the fact that it is a fishing community. Furthermore, age of the child was found to have significant association with child's fish consumption. Hence, few numbers of

Table 7. Percentage of iron content contributed by fish-based complementary foods and non-fish-based complementary foods on meeting the RDIs.

	6-8 Months			9-11 Months			12-23 Months		
RDI (mg)	11			11			6		
Sample	Average weight of food consumed per meal (g)	Iron Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Iron Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Iron Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve
Fish-based complementary foods									
BF-S	60.9	0.50	5	90.2	0.74	7	151.4	1.24	21
BF-T	61.9	0.78	7	90.2	1.14	10	151.4	1.91	32
BF-K	62.9	0.22	2	90.2	0.32	3	151.4	0.54	9
BNF-S	128	0.43	4	178	0.60	5	230	0.45	8
BNF-T	135	1.70	15	180	2.27	21	229	1.74	29
BNF-K	138	0.73	7	182	0.96	9	236	0.75	13
FSSP-S	111	0.61	6	178	0.98	9	240	1.32	22
FSSP-T	125	0.68	6	182	1.00	9	256	1.40	23
FSSP-K	130	0.29	3	185	0.41	4	275	0.61	10
PTF-S	115	1.09	10	160	1.52	14	212	2.02	34
PTF-T	132	1.09	10	178	1.47	13	228	1.89	32
PTF-K	137	0.43	4	186	0.59	5	235	0.74	12
Non-fish-based complementary foods									
UMMBR[2]	187.1	1.47	13	227.4	1.78	16	295.0	3.02	50
UMMGR[2]	187.1	1.92	17	227.4	2.33	21	295.0	2.31	39
RM[2]	187.1	0.82	7	227.4	1.00	9	295.0	1.30	22
UM[2]	187.1	2.34	21	227.4	2.85	26	295.0	3.69	62
C[2]	187.1	0.36	3	227.4	0.44	4	295.0	0.57	10

FSSP = Fish with stiff porridge, BF = Fish soup, PTF = Fish with mashed Irish potatoes, BNF = Fish with mashed bananas, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, C = Cassava porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua*.

children aged 6-8 months were reported not to consume fish-based complementary foods due to the fear of accidental fish bone eating which will result in injuries. They instead provide them with other foods especially the staples. Most mothers cannot provide fish meals to their children especially when they are not in season because of limited availability and high cost of the fish during that season. Unfortunately, this is also the case even when they are in season, that fish may be available but the household economy may be low so they cannot purchase them.

Proximate composition

In general, fish-based complementary foods had more percentage of energy content per 100 g serving compared to the non-fish-based complementary foods (Table 3). Fat content has contributed much to the total energy in fish-based complementary foods which might be due to the presence of fish and coconut milk as ingredients. Types of fish used in this study especially *Dagaa* (*Sardinella longiceps*) have been reported to have adequate amount of fat content (Mohanty et al., 2019), as well as coconut cream has been

Table 1. Percentage of zinc content contributed by fish-based complementary foods and non-fish-based complementary foods on meeting the RDIs.

RDI (mg)	6-8 Months			9-11 Months			12-23 Months		
	5			5			6.5		
Sample	Average weight of food consumed per meal (g)	Zinc Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Zinc Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve	Average weight of food consumed per meal (g)	Zinc Concentration from 1 serve (mg)	% Contribution to RDIs from 1 Serve
Fish-based complementary foods									
BF-S	60.9	0.06	1.1	90.2	0.08	1.7	151.4	0.14	2.2
BF-T	61.9	0.08	1.6	90.2	0.12	2.3	151.4	0.19	3.0
BF-K	62.9	0.03	0.6	90.2	0.04	0.9	151.4	0.07	1.1
BNF-S	128	0.05	1.1	178	0.07	1.5	230	0.10	1.5
BNF-T	135	0.16	3.1	180	0.21	4.2	229	0.27	4.1
BNF-K	138	0.09	1.7	182	0.11	2.3	236	0.15	2.3
FSSP-S	111	0.08	1.6	178	0.13	2.5	240	0.17	2.6
FSSP-T	125	0.04	0.9	182	0.06	1.3	256	0.09	1.4
FSSP-K	130	0.03	0.7	185	0.05	1.0	275	0.07	1.1
PTF-S	115	0.15	3.0	160	0.21	4.2	212	0.28	4.2
PTF-T	132	0.11	2.3	178	0.15	3.1	228	0.20	3.0
PTF-K	137	0.06	1.1	186	0.08	1.5	235	0.10	1.5
Non-fish-based complementary foods									
UMMBR[2]	187.1	0.21	4.2	227.4	0.25	5.1	295.0	0.33	5.1
UMMGR[2]	187.1	0.14	2.9	227.4	0.18	3.5	295.0	0.23	3.5
RM[2]	187.1	0.07	1.3	227.4	0.08	1.6	295.0	0.10	1.6
UM[2]	187.1	0.24	4.8	227.4	0.29	5.9	295.0	0.38	5.9
C[2]	187.1	0.06	1.2	227.4	0.08	1.5	295.0	0.10	1.5

FSSP = Fish with stiff porridge, BF = Fish soup, PTF = Fish with mashed Irish potatoes, BNF = Fish with mashed bananas, UMMBR = Unrefined maize, millet, beans and rice porridge, UMMGR = Unrefined maize, millet, groundnuts and rice porridge, RM = Refined maize porridge, UM = Unrefined maize porridge, C = Cassava porridge, -S = *Dagaa*, -T = *Tasi*, -K = *Kibua*.

reported to have high-fat content per 100 g serving (Ahmed et al., 2019). Also, high carbohydrate contents in fish-based complementary foods might have contributed to non-fish food materials since fish has very low carbohydrate content (Moxness, 2019).

Protein is an important nutrient for proper growth of children; thus, it is essential to ensure it is consumed in required amounts. BNF-K has the highest amount of protein followed by fish soup (BF) dishes. It has been reported in different studies (Sonavane et al., 2017; Moxness, 2019) that among other fish from Indian ocean *Kibua (Rastrelliger kanagurta*) has high amount of protein (19.2%).

The high amount of proteins may be highly contributed by the fish variety used as well as amount of fish contents on those foods (Bogard et al., 2015). Generally, the fish-based complementary foods had higher amounts of all proximate parameters with most of them complying with standards set by Food and Agriculture Organization and World Health Organization (2017) except for moisture content than the non-fish-based complementary foods (Table 3).

Vitamin A, iron and zinc concentrations and their contribution to RDI

Since most of the children consumed fish-based complementary foods within 24 h, fish consumption may be the main reason for the complementary foods meeting vitamin A RDI. Chakraborty et al. (2014) reported that marine fish are rich in fat-soluble vitamins, including vitamins A, D, E, and K, which are required in human metabolism. Also, fish-based complementary foods were found with higher amounts of vitamin A than non-fish-based complementary foods, mainly contributed by the retinol content as it has been also reported by Vilain et al. (2016). Furthermore, it was observed that PTF-T, PTF-S, BNF-K and BNF-S if totally consumed were able to meet the vitamin A RDI for children from 6 to 23 months in a single serving per day (Table 6). Their consumption should be emphasized to children followed by PTF-K. Also the combination of animal and plant sources of vitamin A contributes to the good result of vitamin A content in foods (Table 4), since animal source foods can fill multiple micronutrient gaps at a lower volume of intake than plant source foods (Zhang et al*.,* 2016). In addition, in different studies *dagaa* and *tasi* have also been reported with higher vitamin A content compared to *kibua*. Mohanty et al*.* (2016) reported about *dagaa* (*S. longiceps*), Wahyuningtyas et al*.* (2017) reported *Tasi (Siganus sutor)* while Moxness (2019) reported about *kibua (R. kanagurta*) having 346.4, 187.27 and 100 µg/100 g of vitamin A content, respectively.

Despite *dagaa, tasi* and *kibua* having significant amounts of vitamin A as reported by other studies, single serving of *dagaa* soup (BF-S) and *tasi* soup (BF-T) did not meet the RDI for vitamin A of the children at any age group except for *kibua* soup (BF-K) which met vitamin A RDI of for children aged 9-11 months old. Since water content is an important determinant of levels of other food components (Abeshu et al., 2016), high moisture content in fish soup samples than the other prepared food samples (Table 2) might have affected concentrations of nutrients in foods, with vitamin A included. It seems like the high proportion of water added during cooking of the soups diluted nutrients concentration of the foods. Complementary foods such as BF-S, BF-T and BF-K had no vitamin A plant source, which also contributed to their low concentration of vitamin A. Consequently, fish-based complementary foods had the best vitamin A concentration. Thus, if fish contributed high ratio in formulating a meal, it is possible to formulate complementary foods with sufficient amount of vitamin A.

Fish-based complementary foods have been observed to have high iron concentration than non-fish-based complementary foods as in some other studies. Unlike in this study, even though the iron concentration increases in complementary foods with the age, two servings per day of unrefined maize porridge (UM) and UMMGR if completely consumed can meet the iron RDI only for 12 to 23 months children while it has to be three serving per day of BF-T, UMMBR and BNF-S in order to meet iron RDI for children of that age group (Table 7). No food sample, either fish-based or non-fish-based met iron or zinc RDI on a single serving per day.

Kibua fish has been reported to have 3.2 mg/100 g of iron and 1.3 mg/100 g of zinc (Moxness, 2019). In this study, *dagaa* and *tasi* types of fish might have higher concentration of iron than *kibua* fish as it is observed on fish-based complementary foods with *dagaa* and *tasi* having higher iron concentration per 100 g serving than those complementary foods with *kibua*. *Dagaa* has been reported to have high concentration of minerals, but the concentration is highly contributed by calcium content as it is being consumed whole together with bones (Palani et al., 2014).

Among non-fish-based complementary foods, those with unrefined maize as one of their ingredients (UM, UMMBR and UMMGR) were observed to have higher iron and zinc content than those without unrefined maize (RM and C). Zinc concentration was significantly higher ($p<0.05$) in UM than RM, mainly contributed by the presence of whole maize grains which improved zinc content as explained by Suri and Tanumihardjo (2016). Large proportion of the minerals in maize tends to be lost during milling process. Milling process removes the germ with many nutrients leaving mainly the starchy, and the remainder contains only about 20% of the zinc content. Furthermore, in this study UM contained highest amount of zinc followed by UMMBR and UMMGR. Since UMMGR has the lower amount of zinc than UMMBR, there is a possibility that the high quantities of zinc in UMMBR are contributed by the presence of beans (Ramírez-Ojeda et al., 2018). However, even if there is high iron quantity, its absorption is questionable as unrefined plant-based staple foods are often rich in phytate that can bind and significantly reduce absorption of non-haem iron (Gibson et al*.,* 2018).

Having complementary foods whether fish-based or non-fish-based with high iron concentration are enough to meet the children's RDI, indicated that mothers can prepare complementary foods for their children with adequate iron content within their households. It is more efficient to promote and improve the fish-based complementary foods since legumes and cereals are accompanied with high quantities of anti-nutritional factors (Bora, 2014), unless processing of removing/reducing them is done (Suri and Tanumihardjo, 2016).

Zinc concentration in the complementary foods remains very low as indicated by the low contribution of zinc to the RDI for children based on low concentration of zinc per serving and low concentration per meal for each age group (Table 8). Zinc concentration has always been a concern in complementary foods for children since it fails to meet the RDIs (Osendarp et al*.,* 2016). Fish-based complementary foods contribute significantly on meeting the micronutrients RDI (Bogard et al*.,* 2015: Byrd et al*.,* 2020), except for zinc in this study.

Conclusion

In general, this study indicated that fish-based complementary foods contribute significantly on studied micronutrients' concentration except for zinc. Fish-based complementary foods provide adequate amount of vitamin A as required for the targeted children unlike the non-fish-based complementary foods. However, only some complementary foods if eaten twice or thrice a day can meet the iron RDI. Zinc is found to be very low in both fish-based and non-fish-based complementary foods. It is therefore possible to formulate at home fish-based complementary foods that meets iron and vitamin A RDI for the children age 6 to 23 months. For the case of zinc, fish proportion included in a meal should be increased and/or other good sources of zinc such as seeds should also be given to children in order to meet zinc RDI.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Abeshu MA, Lelisa A, 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):1-9.

Aguayo VM (2017). Complementary feeding practices for infants and young children in South Asia. A review of evidence for action post-2015. Maternal and Child Nutrition 13(2):1-13.

Ahmed S, Hoque MM, Zzaman W, Thakur MU, Hossain MM (2019). Study on physicochemical and anti-oxidant properties of coconut cream extracted from two BARI varieties. International Food Research Journal 26(1):153-160.

Association of Official Analytical Chemists (AOAC) (1995). Official Methods of Analysis. Official Association of Analytical Chemists, Washington DC. 820pp.

Bandoh DA, Kenu E (2017). Dietary diversity and nutritional adequacy of under-fives in a fishing community in the central region of Ghana. BioMed Central Nutrition 3(2):1-6.

Bogard JR, Hother AL, Saha M, Bose S, Kabir H, Marks GC, Thilsted SH (2015). Inclusion of small indigenous fish improves nutritional quality during the first 1000 days. Food and Nutrition Bulletin 36(3):276-289.

Bora P (2014). Anti-Nutritional Factors in Foods and their Effects. Journal of Academia and Industrial Research 3(6):285-290.

Byrd KA, Thilsted SH, Fiorella KJ (2020). Fish nutrient composition: a review of global data from poorly assessed inland and marine species. Public Health Nutrition 24(3):476-486.

Chakraborty K, Joseph D, Chakkalakal SJ (2014). Interannual and Seasonal Dynamics in Amino Acid, Mineral and Vitamin Composition of Epinephelus diacanthus. Journal of Biology and Earth Science 4(1):91-104.

Craft N (2008). Laboratory Procedure Manual. Craft Technologies Inc., North Carolina 45 p.

Development Initiatives (2018). 2018 Global Nutrition Report: Shining a light to spur action on nutrition. Bristol, UK: Development Initiatives Poverty Research Ltd. 166pp.

Dewey KG (2016). Reducing stunting by improving maternal, infant and young child nutrition in regions such as South Asia: evidence, challenges and opportunities. Maternal and Nutrition 12(1):27-38.

Duan Y, Yang Z, Lai J, Yu D, Chang S, Pang S, Jiang S, Zhang H, Bi Y, Wang J, Scherpbier RW, Zhao L, Yin S (2018). Exclusive Breastfeeding Rate and Complementary Feeding Indicators in China: A National Representative Survey in 2013. Nutrients 10(2):249

Food and Agriculture Organization (FAO) (1983). Species Catalogue. Fisheries Synopsis. Food and Agriculture Organization of the United Nations, Rome 43 p.

Food and Agriculture Organization and World Health Organization (FAO/WHO) (2017). Guidelines on formulated complementary foods for older infants and young children CAC/GL 8-1991. Available at: http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXG%2B8-1991%252FCXG_008e.pdf

Georgieff MK (2017). Iron assessment to protect the developing brain. The American Journal of Clinical Nutrition 106(6):1588S-1593S.

Gibson RS, Raboy V, King JC (2018). Implications of phytate in plant-based foods for iron and zinc bioavailability, setting dietary requirements, and formulating programs and policies. Nutrition Reviews 76(11):793-804.

Gibson E, Stacey N, Sunderland TCH, Adhuri DS (2020). Dietary diversity and fish consumption of mothers and their children in fisher households in Komodo District, eastern Indonesia. Plus ONE 15(4):e0230777.

Huang Z, Liu Y, Qi G, Brand D, Zheng SG (2018). Role of Vitamin A in the Immune System. Journal of Clinical Medicine 7(9):258.

Jones AD (2017). Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low-and middle-income countries. Nutrition Reviews 75(10):769-782.

Kulwa KBM, Mamiro P S, 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. BioMed Central Pediatrics 15(171):1-11.

Lietz G, Henry CJK, Mulokozi G, Mugyabuso JKL, Ballart A, Ndossi GD, Lorri W (2001). Comparison of the effects of supplemental red palm oil and sunflower oil on maternal vitamin A status 1 - 3. American Journal of Clinical Nutrition 74(4):501-509.

Liu E, Pimpin L, Shulkin M, Kranz S, Duggan CP, Mozaffarian D, Fawzi W (2018). Effect of Zinc Supplementation on Growth Outcomes in Children under 5 Years of Age. Nutrients 10(3):377.

Makori N, Kassim N, Matemu AO, Kinabo J (2018). Factors associated with stunting in Dodoma Region, Tanzania. African Journal of Food, Agriculture, Nutrition and Development 18(3):13842-13860.

Martinez B, Webb MF, Gonzalez A, Douglas K, Grazioso MP, Rohloff P (2018). Complementary feeding intervention on stunted Guatemalan children: a randomised controlled trial. BMJ Paediatrics Open 2(1):1-8.

Mekonnen TC, Workie SB, Yimer TM, Mersha WF (2017). Meal frequency and dietary diversity feeding practices among children 6 - 23 months of age in Wolaita Sodo town , Southern Ethiopia. Journal

of Health, Population and Nutrition 36(18):1-8.
Mohanty BP, Ganguly S, Mahanty A, Mitra T (2019). Fish in human health and nutrition. Advances in Fish Research 7:189-218.
Mohanty BP, Sankar TV, Ganguly S, Mahanty A, Anandan R, Chakrabarty K (2016) Micronutrient composition of 35 food fishes from India and their significance in human nutrition. Biological Trace Element Research 174:448-458.
Moxness AK (2019). Nutrient composition of 19 marine fish species from Sri Lanka and their potential contribution to food and nutrition security. Dissertation for Award of MSc Degree at University of Bergen, Norway pp. 44-53.
National Bureau of Statistics and ICF Macro (2015). Tanzania Demographic and Health Survey and Malaria Indicator Survey. National Bureau of Statistics, Dar es Salaam, Tanzania 65 p.
Osendarp SJM, Broersen B, van Liere MJ (2016). Complementary Feeding Diets Made of Local Foods Can Be Optimized, but Additional Interventions Will Be Needed to Meet Iron and Zinc Requirements in 6- to 23-Month-Old Children in Low- and Middle-Income Countries. Food and Nutrition Bulletin 37(4):544-570.
Palani KM, Ruba AA, Jeya SR, Shanmugam SA (2014). Proximate and major mineral composition of 23 medium sized marine fin fishes landed in the thoothukudi Coast of India. Journal of Nutrition and Food Sciences 4(1):1-7.
Pan American Health Organization, and World Health Organization (2003). Guiding Principles for Complementtary Feeding of the Breastfed Child. Pan American Health Organization, Washington DC. 40 p.
Ramírez-Ojeda AM, Moreno-Rojas R, Cámara-Martos F (2018). Mineral and trace element content in legumes (lentils, chickpeas and beans): Bioaccesibility and probabilistic assessment of the dietary intake. Journal of Food Composition and Analysis 73:17-28.
Rodriguez-Amaya DB, Kimura M (2004). HarvestPlus Handbook for Carotenoid Analysis. HarvestPlus Technical Monograph, Washington DC. 63 p.
Shafique S, Sellen DW, Lou W, Jalal CS, Jolly SP, Zlotkin SH (2016). Mineral- and vitamin-enhanced micronutrient powder reduces stunting in full-term low-birth-weight infants receiving nutrition, health, and hygiene education: a 2 × 2 factorial, cluster-randomized trial in Bangladesh. The American Journal of Clinical Nutrition 103(5):1357-1369.
Sonavane AE, Koli JM, Patange SB, Naik SD, Mohite AS (2017). Proximate composition and fatty acid profiling of indian mackerel (*Rastrelliger kanagurta*) off Ratnagiri, West Coast of India. International Journal of Pure and Applied Biosciences 5(4):920-924.
Suri DJ, Tanumihardjo SA (2016). Effects of different processing methods on the micronutrient and phytochemical contents of maize: From A to Z. Comprehensive Reviews in Food Science and Food Safety 15(5):912-926.
Tilami SK, Sampels S (2017). Nutritional Value of Fish: Lipids, Proteins, Vitamins, and Minerals. Fisheries Science and Aquaculture 26(2):1-13.
Udoh EE, Amodu OK (2016). Complementary feeding practices among mothers and nutritional status of infants in Akpabuyo Area, Cross River State Nigeria. SpringerPlus 5(1):2073.
Vilain C, Baran E, Gallego G, Samadee S (2016). Fish and the Nutrition of Rural Cambodians. Asian Journal of Agriculture and Food Sciences 4(1):2321-1571.
Wahyuningtyas LA, Nurilmala M, Sondita MFA, Taurusman AA, Sudrajat AO (2017). Nutritional profile of Rabbitfish (Siganus spp .) from the Kepulauan Seribu (Thousand Islands), Jakarta, Indonesia. International Food Research Journal 24(2): 685-690.
Wake AA, Geleto TC (2019). Socio-economic importance of Fish production and consumption status in Ethiopia. International Journal of Fisheries and Aquatic Studies 7(4):206-211
Wells JC, Sawaya LS, Wibaek R, Mwangome M, Poullas MS, Yajnik CS, Demaio A (2020). The double burden of malnutrition: aetiological pathways and consequences for health. The Lancert 395(10217):75-88.
World Health Organization (2004). Feeding the non-breastfed child 6-24 months of age. World Health Organization, Geneva. 31 p.
Zhang Z, Goldsmith PD, Winter-Nelson A (2016). The Importance of Animal Source Foods for Nutrient Sufficiency in the Developing World: The Zambia Scenario. Available at https://doi.org/10.1177/0379572116647823