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Research Article

Diets of Fish-Based Recipes for the Under-Five Children, First 1000 Days of Life, and Adolescents in Malawi

Msiska OV[2]*, Manani TA[1], Lowore T[1] and Makwinja R[2]

[1]*Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi*

[2]*Worldfish, Golden Court Office Park, Lilongwe, Malawi*

***Corresponding author**

Orton Msiska, WorldFish, Golden Court Office Park, Area 11, Office Block 3, P.O. Box 31294, Capital City, Liongwe, Malawi

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Abstract

The nutrient profiles of small fish species were used in the formulation of children's diets in Malawi which conformed to minimum food standards stipulated by WHO. This could be a panacea for the reduction of malnutrition and stunting among children during their first 1000 days of growth, if well promoted. Apart from satisfying nutrient requirements, these new diets were found to be organoleptically and physically acceptable. There is need to develop and test diets for these vulnerable groups in Malawi, so far only soya bean based recipes are locally available. Meanwhile, this adds value to low quality fish species like Usipa (Engraulicypris sardella), Utaka (Copadichromis) and Matemba (Barbus) commonly found in local markets, whose significant quantities are going to waste. The fish recipes could serve as substitutes for imported food formulas. Biscuits were fortified by incorporating 5% or 7% fish powders from Usipa and Utaka, respectively, processed from either solar dried or solar dried plus roasting or parboiled fish powder. Incorporating fish powders in biscuits greatly increased micronutrient content; roasted Utaka containing 5% fish powder increased zinc by 6.1%, iron 511%, calcium 29.8% and magnesium 33.5%. Roasting and parboiling affected the intensities of sensory properties of fishy flavor, colour and shininess. Meanwhile, roasting reduced fishy flavour and increased intensity of brownness resulting in higher mean scores to 2.90 (7%) and 3.05 (5%), in biscuits enriched with powder from Utaka. The intensity of shininess of biscuits was reduced regardless of the type of fish powder being incorporated. Parboiling of Usipa reduced bitterness in biscuits registering an intensity of 1.65. Overall, consumer's prefered biscuits enriched with 7% fish powder of roasted Utaka (4.03) and 7% fish powder of parboiled roasted Usipa (3.90) and 5 % fish powder of roasted Utaka (3.90). The shef-life of biscuits was estimated to be about 5 months. Fish sausages made from fresh fish and dried fish of Usipa and Utaka were significantly different ($p<0.05$) in moisture content from sausages made from fresh fish and dry fish. Protein content was higher in sausages made from Usipa than from Utaka, while fat content was higher in sausages made from fresh fish than from dry fish. Sausages of dry Usipa and Utaka were shinier by 3.50 and 3.77, respectively, compared to sausages from fresh Usipa and Utaka. Dry fish produced sausages with higher brownness intensities of 3.83 (Usipa) and 3.97 (Utaka); they carried a tingling odour, absorbed more oil and were grainier. Sausages from dry and fresh fish and stored at 40 C had a shelf-life of 24 hours and 12 hours, respectively. Sausages made from dry fish and fresh fish kept at ambient temperatures had a much reduced shelf life of 12 hours and 6 hours.

INTRODUCTION

In spite of a reported decline in the prevalence of under-nutrition among children under the age of 5 years in Malawi, the prevalence of stunting of 37% [1], is still relatively high and of public health concern. Malnutrition in children is manifested through a high prevalence of under-nutrition (protein-energy deficiency) and micronutrient deficiencies (hidden hunger). According to the Malawi Demographic Healthy Survey (MDHS) report (2015-2016), rates of anemia were at 62.6%, while rates of zinc deficiency were around 60% for different population groups such as pre-school children (60.4%), school going children (60.2%), non-pregnant women of reproductive age (62.5%) and even men (65.7%). Under-nutrition is also high (12.9%) among adolescent girls aged 15 to 19 years and this creates a vicious cycle of malnutrition as children who are born to these mothers are likely to be stunted [2].

In Malawi, malnutrition is caused by interaction of multiple factors including national and household food insecurity, poor mother care practices, poor nutrition of mothers [3] and suboptimal child feeding practices and inadequate dietary intakes [4]. Therefore, dietary diversification using locally available food sources is one of the most sustainable interventions promoted by the Malawi National Multi-Sector Nutrition Strategy (2018-2022) and avoids dependence on imported processed foods, whose nutritional quality may not necessarily meet the nutritional requirements of this target population and may not be readily accessed by families in rural areas. Of the locally available foods, fish is the commonest source of animal protein; accounting for about 45% of animal protein consumed in Malawi [5,6]. Fish is mostly (33%) consumed by children of 6 to 23 months old in Malawi [7]. Furthermore, fish is rich in minerals like iron, calcium and zinc that are essential to healthy development. Fish is also a good source of long chain omega-3 fatty acids that contribute to cognitive development; hence it crucial in the early stages of child brain development. The bioavailability of minerals from other foods is enhanced where is added which is particularly important for Malawians whose traditional diets are monotonous and dominated by plant-based rations [8].

The small fish species dominated by *Barbus paludinosus,*

Engraulicypris sardella and *Copadichromis virginalis* are generally considered to be of low value [9], however, they are in abundance, attract affordable prices and are acceptable to vulnerable consumers. Globally, small pelagic fish species are an integral component of people's daily diets [10]. Small fish species are nutritionally superior because they are eaten whole with fins and bones; hence they are dense in macro and micronutrients, which are important in mitigating the triple burdens of malnutrition in low and medium-income countries in Africa. While these fish are commonly eaten by adults, children to chew dried fish. They are instead fed the watery broth depriving them of the flesh and bones, which are main sources of protein and minerals.

PROJECT OBJECTIVES

While the main aim was to promote incorporation of small fish species into diets of children aged 6-23 months and adolescents and specific objectives were formulated in support of the same;

i. To determine profiles of fish-based diets focusing on their micronutrients following processing and preservation;

ii. To access sensory acceptability and nutritional value of fish-based products for children of 6 - 23 months;

iii. To determine microbial load and shelf life of fish –based recipes,

iii. To introduce and promote consumption of fish-based recipes for children of low income/poor families.

MATERIALS AND METHODS

Fish sample Collection and Processing

The local fish species known as Usipa (*(Engraulicypris sardella)* and Utaka *(Copadichromis spp)* were bought from fishermen in Mangochi district at two different beaches. *Usipa* samples were bought during early mornings at Msaka beach at Monkey Bay while *Utaka* samples were bought at Cape Maclear. These samples were preserved and dried in solar tent (Figure 1) on the same day. Meanwhile, some samples of Usipa were parboiled (Figure 2) before solar drying while *Utaka (Diplochromis spp) was* immediately solar dried (Figure 2).

Solar tent drying for both *Usipa (Engraulicypris sardella)* and *Utaka (Diplochromis spp)* took 8 days from 20th – 27th December 2021

Nutrient profiling of small fish species

The effect of processing methods on retention of micronutrients in Usipa *(Engraulicypris sardella),* Matemba *(Barbus spp.)* and Utaka *(Copadichromis spp)* was analysed prior to incorporation into food recipes. Similar studies were conducted on the nutrient composition of sausages to provide assurance of the reliability of their retention for children's diets.

Compilation of fish-based recipes

The project concluded with the compilation of fish-based recipes in line with the project component. The recipes developed at Lilongwe University of Agriculture and Natural Resources were classified into three categories: (i) sausage, (ii) biscuit, and (iii) porridge recipes for convenient portions ready to be served to children.

Figure 1 Processing of solar tent dried and parboiled solar tent dried Usipa. Far left: parboiling Usipa, middle: draining Usipa, far right: solar tent drying Usipa.

Figure 2 Processing of solar tent dried *Utaka*.

Recipe Calculations

The computations of nutrient composition in recipes followed a procedure that was described by Vásquez-Caicedo, Bell & Hartman [11], involving eight (8) steps using the formula derived from the Malawi food composition table. The food composition databases were benchmarked on similar tables from neighbouring countries, also termed borrowed values. The book contains tables on weight yield or Yield Factors (YF) of food and retention factors (RF) of food constituents to for the calculation of nutrient composition of cooked foods (dishes). Since recipe calculation is based on the weight of the ingredients and one teaspoon of different ingredients weighs differently, therefore an excel spread sheet was developed containing a collection of ingredients weight conversion for the dry, fresh, liquid and oily ingredients that were sourced from articles and recipes. With that information, the nutrient composition from a given recipe of any composite dish or meal can be calculated. However, the recipe calculation process involves 8 steps with different formulas. Nevertheless, to reduce the labour and time spent on each recipe, the universal formula in an excel spread sheet was developed which only requires 3 steps to complete the calculations.

Fish Biscuits and Sausages Development

Fish sausages and biscuits were being developed by undergraduate students using both fresh and dry small fish species. Sundried Usipa, Matemba and Utaka fish were purchased from Lilongwe market. Fresh Utaka was also purchased from the same market while fresh Usipa was purchased from Monkey Bay in Mangochi. The fresh samples were transported to the Foods laboratory in buckets filled with ice. The sun-dried Usipa, Utaka and Matemba and parboiled sun-dried Usipa were split into two groups: roasted and unroasted. The fish were roasted using the electric oven and then milled into powder using a blender. Fine powder was obtained by sieving the milled fish powders which were then used to enrich porridges that were bake into fish biscuits (Table 3) and fish sausages using their respective

developed recipes (Table 4). Fresh Usipa sausage was made by firstly removing the gut, and then crushing into a paste using the blender. Fresh Utaka sausage was made by removing the scales, the gut and then scraping off the flesh parts then finally, ground into a pasted using the blender. After mixing all the ingredients of the sausages, the sausage was made by using the sausage filler machine into a casing. All the sausages were first boiled in water for 5-8 minutes and then fried in oil until the brown colour formed.

Nutrient composition of biscuits fortified with fish powders

The proximate analysis of sausages was conducted on sausages using standard methods outlined by AOAC [12]. The same was done for moisture and mineral content of biscuits were determined according to procedures including calcium, iron, magnesium and zinc.

Formulation Experiment of Fish Recipes

Recipe formulation trials were done in collaboration with the Malawi Department of Fisheries in two phases; firstly, using laboratory based-analysis and secondly by conducting field trials Fish samples (fresh and dry) were purchased from the Lilongwe market. The recipe formulation and trial experiments of the recipes were done between August and September 2021. Field trials of the recipes were conducted in the month of October through cookery demonstrations, and recipe modifications were done concurrently with sensory evaluation. Cooking demonstration workshops took two weeks and was conducted in all the four regions of Malawi as follows: Northern region at Mzuzu Aquaculture Centre (Mzuzu), Central region at Mponela RTC (Mponela, and Southern region at Kasinthula Fish Farm (Chikwawa) and in the Eastern Region at National Aquaculture Centre (Zomba). Results from these were then used to modify and refined for adoption by community front line workers.

Sensory Evaluation of Fish Sausages and Biscuits

Sensory evaluation was conducted according to procedures outlined by Lawless and Heymann (2010), that identify flavour, brownness, shininess, sweetness, saltiness, bitterness, sourness, aftertaste, hardness, brittleness and grainy among the major attributes that could be scientifically evaluated. Thus, sensory evaluation of the developed fish biscuits, dry and fresh sausages was conducted to characterize the attributes of the products regarding factors known to influence consumer acceptability and buying power. A panel of students was selected from LUANAR campus comprising of year 4 Food Science and Technology; and Nutrition and Food Science students. The scores of the products by the sensory panellist were recorded using a descriptive questionnaire. Tem panellists with good sensory acuity were selected after screening many interested volunteer candidates. They underwent training that equipped them with descriptive sensory analytical skills to rate the degree of intensity of the attributes using a scale of 1-5, where 1 indicates lowest while 5 was highest intensity.

Use of secondary school children as Proxies in testing recipes

Recognising that children cannot score and evaluate the suitability of fish-based recipes, it was decided to use secondary school children aged between 10-25 years. One hundred and twenty (120) were children were used to conduct evaluation of acceptability of fish enriched biscuits. The demographic of the test panellists are given in Table 5. The group was composed mostly of adolescents of 10-19 years old (97.5%), of which 90% were Christians coming from non-fishing districts. As in the previous study, panellists were asked to score using a 5- point Hedonic scale where 1 represented "dislike very much" while 3 is "like slightly' and 5 is 'like very much". The panellists were asked to rate attributes of appearance, aroma, taste, and texture and overall acceptance as outlined in Table 6.

Microbial load and shelf Life

Bacterial growth on the recipes was determined monthly for up to 5 months after production. Standard methods were used to determine bacterial count using MBS procedures [13]. This assisted in determining the shelf life of products, which stipulates that shelf life is reached when total bacterial count exceeds $6\log_{10}$ CFU/g. The same criterion was used to assess sausages in line with recommendations by ICMSF [14].

RESULTS

The proportions of ingredients in biscuits are given in Table 1, at different inclusion levels of the fish powder. Fish powder addition into biscuits varied from 0%, 5% and 7%, and samples are shown in Figures 2. Generally, biscuits produced were dry foods with low moisture content as shown in Table 2. Biscuits from roasted Utaka containing 5% fish powder increased zinc content by 6.1 %, iron by 511%, calcium by 29.8 % and magnesium by 33.5%. Fish powder increased iron content from 0.85 to 5.83 mg/100 g in solar dried Utaka fortified at 7%. At <5% incorporation, fish powder did not appreciably increase zinc content but fish powders at high proportions increased micronutrient content, however, sensory properties were compromised due to increase of fish flavour which was shunned by consumers.

Figures 2-4 displayed visual characteristics reflecting fish powder content from different fish species.

Table 3 displays mineral content of biscuits incorporated with Usipa and Utaka.

Figure 3 a-c: a-c: Biscuits made from roasted fish: Matemba (a) Utaka (b) and Usipa (c). Biscuits made from sundried fish: Matemba (d) Utaka (e) and Usipa (f).

Table 1: Fish powdered biscuit recipe.

Ingredients	Quantity Ingredients		
	0% Fish powder	**5% fish powder**	**7% fish powder**
Wheat flour	180g	171g	167.4g
Fish Powder	0	9g	12.6g
Sugar	50g	50g	50g
Margarine	125g	125g	125g
Baking Powder	¼ tsp	¼ tsp	¼ tsp
Vanilla	2tsp	2tsp	2tsp

Table 2: Moisture content of biscuits containing fish powders at varying proportions.

Fish species	Treatment	5% proportion fish powder	7% proportion fish powder
		Moisture content (%)	
Usipa	Parboiled and roasted	1.41±0.05^{a}	1.90±0.03^{c}
	Parboiled and solar tent dried	2.09±0.02^{e}	2.77±0.06^{f}
	Solar tent dried	2.20±0.04^{e}	1.80±0.02^{c}
	Solar tent dried & roasted	1.95±0.05^{c}	1.60±0.07^{b}
Utaka	Solar tent dried	2.66±0.08^{f}	3.21±0.09^{g}
	Roasted	3.12±0.11^{g}	2.16±0.04^{e}

Values with different superscripts are significantly different ($p < 0.05$) within columns and in rows.

Table 3: Mineral content (mg/100g) of the biscuits incorporating Utaka and Usipa fish powder.

Fish type	Proportion (%) of fish powder & Treatment	Zn	Fe	Ca	Mg
No fish	Zero (control)	0.31 ± 0.14^{a}	0.85 ± 0.07^{a}	31.20 ± 2.20^{a}	12.24 ± 0.37^{a}
Utaka	5 % Solar tent dried & roasted	0.33 ± 0.01^{a}	5.20 ± 0.13^{e}	40.50 ± 1.04^{abcd}	16.34 ± 0.77^{def}
	5 % Solar tent dried	0.31 ± 0.01^{a}	4.97 ± 0.15^{e}	33.13 ± 1.40^{ab}	13.11 ± 0.48^{ab}
	7 % Solar tent dried & roasted	0.37 ± 0.031^{ab}	5.83 ± 0.66^{e}	39.51 ± 2.74^{abcd}	15.10 ± 0.18^{cd}
	7 % Solar tent dried	3.10 ± 0.02^{c}	5.60 ± 0.38^{e}	38.35 ± 1.73^{abc}	16.25 ± 0.03^{def}
Usipa	5 % Parboiled solar tent dried	0.54 ± 0.00^{b}	1.10 ± 0.15^{ab}	54.47 ± 1.41^{cd}	14.82 ± 0.08^{cd}
	5 % Parboiled solar tent dried & roasted	0.31 ± 0.03^{a}	1.60 ± 0.05^{ab}	57.09 ± 0.29^{cd}	14.38 ± 0.21^{bc}
	5 % Solar tent dried & roasted	0.31 ± 0.02^{a}	1.80 ± 0.31^{abc}	50.24 ± 3.63^{abcd}	13.06 ± 0.13^{ab}
	Solar tent dried	0.43 ± 0.02^{ab}	2.71 ± 0.40^{cd}	40.18 ± 1.34^{abcd}	15.92 ± 0.40^{def}
Usipa	7 % Parboiled solar tent dried	0.34 ± 0.01^{a}	1.42 ± 0.00^{ab}	53.12 ± 1.67^{bcd}	15.22 ± 0.16^{cd}
	7 % Parboiled solar tent dried & roasted	0.34 ± 0.04^{a}	1.94 ± 0.10^{bcd}	59.24 ± 2.98^{d}	17.22 ± 0.33^{f}
	7 % Solar tent dried & roasted	0.41 ± 0.03^{ab}	1.89 ± 0.02^{abcd}	54.72 ± 2.41^{cd}	16.78 ± 0.15^{ef}
	7 % Solar tent dried	0.42 ± 0.01^{ab}	2.94 ± 0.12^{d}	43.76 ± 3.45^{abcd}	15.41 ± 0.75^{cde}

Note: Reported values represent the mean and standard deviation, the means with different superscripts in a column were statistically different ($p < 0.05$)

Table 4 provides the results of sensory tests conducted by panelists.

There was a significant fishy flavour according to enrichment of fish powder. Biscuits enriched with 5% and 7% unroasted Utaka powder displayed high fish flavor intensity than the rest of the recipes, recording 3.05 and 3.00 values, respectively. On the other hand, the score of roasted fish powder was between 1.25-1.50 regardless of type of fish but these differences were not statistically significant. Roasting also affected brownness of biscuits resulting in high mean scores of 2.90 for 7% and 3.05 for 5% fish powder incorporation. The intensity of shininess was reduced by inclusion of both Usipa and Utaka powders. On the other hand, sweetness, sourness and saltiness were not significantly affected. However, when parboiled, bitterness taste in Usipa-based biscuits was reduced.

The consumer acceptance of Biscuits is given in the Table below (Table 5).

There were no significant differences in acceptance, however, biscuits enriched with 7% roasted Utaka had higher mean score (4.03) than others; the same biscuits were rated to have

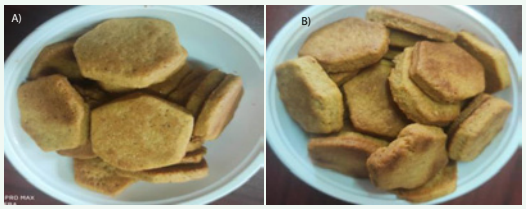

Figure 4 Biscuits made from parboiled Usipa fish: Unroasted Usipa (a) roasted Usipa (b).

Table 5: Demographic characteristics of participants in the consumer acceptance test.

Characteristics	Categories	Frequency	Percentage (%)
Age (years)	10 – 15	31	25.83
	16 – 20	87	72.5
	21 – 25	2	1.67
Gender	Male	60	50
	Female	60	50
Class/Form	1	31	25.8
	2	28	23.3
	3	30	25
	4	31	25.8
Religion	Christianity	108	90
	Muslims	8	6.67
District of origin	Fishing District	4	3.33
	non-fishing District	116	96.67

There were few missing values as 4 panellists did not want to indicate religion affiliation.

the highest intensity of brownness. There was no significant difference recorded regarding taste. Enriched Usipa powder biscuits recorded a higher score of 3.93; concurring with previous panellists. There was no difference recorded in texture. Nevertheless, biscuits enriched with 7% roasted Usipa and 7% roasted Utaka powders registered high mean scores of 3.88 and 4.13, respectively; indicating better acceptance than the rest. Overall high acceptability was recorded for biscuits enriched with 7% roasted Utaka (4.03) and 7% parboiled roasted Usipa (3.90) and 5% roasted Utaka (3.90).

According to Figures 6 and 7, there was virtually no bacterial growth during the first month of storage of biscuits with 5-% enrichment. After two months, microbial levels were virtually the same, and 5 months none of the samples had reached a threshold of 6 Log_{10} CFU/g. This implies that after 5 months' storage biscuits were still fit for consumption (Tables 6,7).

There were significant differences in moisture content between sausages made from dry fish and wet fish powder as shown in Table 8. Fat content was higher in sausages made from fresh fish than from dry fish.

Ten trained panellists recorded that sausages made from dry Usipa and dry Utaka had higher intensity of shininess compared to the fresh forms of fish. They had higher brownness intensities of 3.83 and 3.97, respectively, higher tingling odour and absorbed more oil and were grainier.

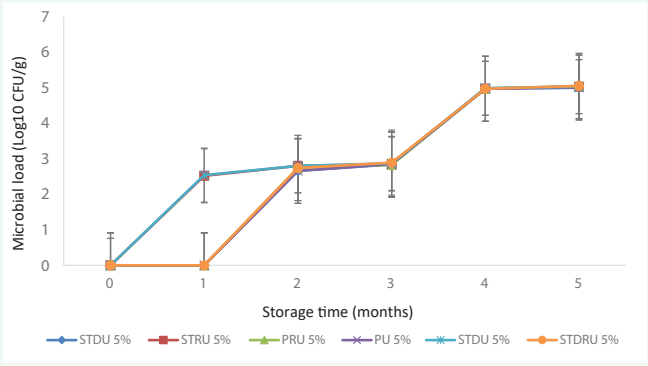

Figure 5 Bacterial growth on biscuits enriched with 5% Usipa and Utaka powder.

Key: STDU 7% = biscuit enriched with 7% solar tent dried *Utaka*, STRU 7% = biscuit enriched with 7 % solar tent dried *Utaka,* PRU 7% = biscuit, enriched with 7 % solar tent parboiled roasted *Usipa*, PRU 7% = biscuit enriched with 7% solar tent parboiled *Usipa,* STDU 7% = biscuit enriched with 7% solar tent dried *Usipa* and STDRU 7% = biscuit enriched with 7% solar tent dried and roasted *Usipa.*

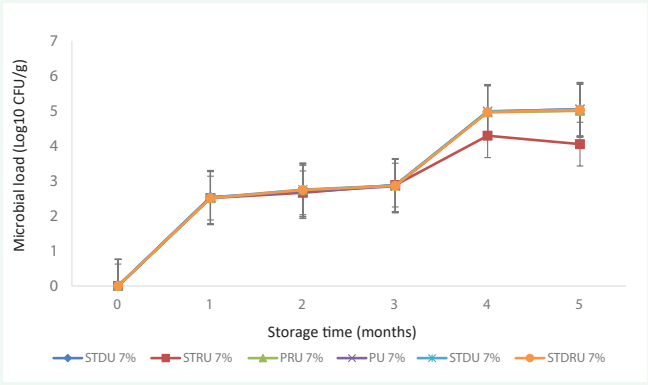

Figure 6 Bacterial growth on biscuits enriched with 7% Usipa and Utaka powder.

Key: STDU 5% = biscuit enriched with 5% solar tent dried *Utaka*, STRU 5% = biscuit enriched with 5% solar tent dried roasted *Utaka,* PRU 5 % = biscuit enriched with 5% solar tent dried parboiled roasted *Usipa*, PU 5% = biscuit enriched with 5% solar tent dried parboiled *Usipa,* STDU 5% = biscuit enriched with 5% solar tent dried *Usipa* and STDRU 5% = biscuit enriched with 5% solar tent dried and roasted *Usipa.*

Figure 7 Sausages made from Usipa and Utaka powder.

With respect to sourness, bitterness and tingling odour, Usipa sausages recorded lower intensity scores of 1.33, 1.23 and1.7, respectively.

The shelf life of sausages ranged between 4.51-4.82 $\log_{10}$ CFU/g (Figures 8,9). Significant differences were recorded on sausages made from fresh and dry fish. Those made from fresh fish demonstrated higher microbial counts than from dried fish (Table 9).

A short shelf life was observed for sausages stored at ambient temperature. Meanwhile the microbial counts were significantly different in all samples and at all times except up to 12 hours. Sausages made from dry fish remained within acceptable limits up to 12 hours while sausages from fresh fish maintained acceptable limits only up to 6 hours (Figures 8,9).

DISCUSSION

This study successfully formulated fish-based recipes in the form of biscuits and sausages that could provide essential nutrients for vulnerable groups of 6 to 23 months and

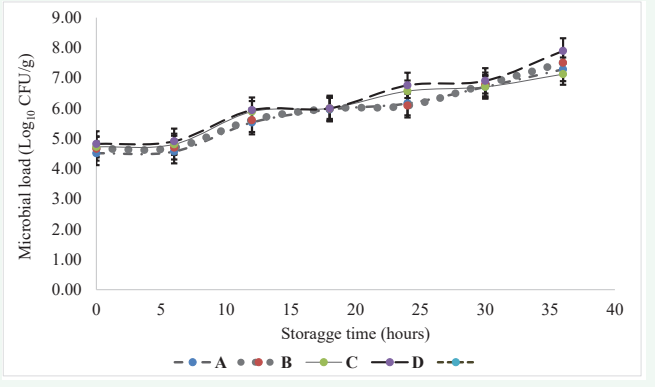

Figure 8 Microbial load of fish sausages stored at refrigeration temperature.
Key: A = Dry *Utaka*, B = Dry *Usipa*, C = Fresh *Utaka* and D = Fresh *Usipa*

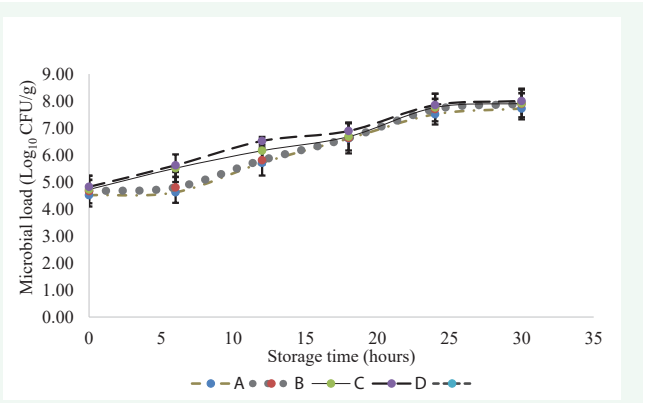

Figure 9 Microbial load (TVC) stored at ambient temperature.
Key: A = Dry *Utaka*, B = Dry *Usipa*, C = Fresh *Utaka* and D = Fresh *Usipa*

Table 7. Ingredients used for making the sausages

Ingredient	Proportion (%)	Quantities in g or ml
Fish	51	1000
Salt	1.5	30
Textured soy protein (TSP)	25.7	500
Ground pepper	1.03	20
Ground garlic	0.5	10
white egg yolk	1.03	20
Hot water for softening TSP (Textured Soy Protein)	12.85	250
Sugar	0.77	15
Vegetable oil	5.14	70 – 100
Monosodium glutamate	0.1	2

Table 8. Proximate composition (g/100g) of the Utaka and Usipa fish sausages

Sample	Moisture	Protein	Fat	Carbohydrate
Fresh Usipa	40.84 ± 0.26^{d}	53.26 ± 0.25^{b}	21.96 ± 0.19^{d}	14.26 ± 0.44^{b}
Dry Usipa	18.61 ± 0.07^{b}	66.30 ± 0.45^{d}	8.28 ± 0.23^{a}	12.73 ± 0.15^{a}
Fresh Utaka	38.44 ± 0.13^{c}	57.09 ± 47^{c}	18.35 ± 0.05^{c}	13.32 ± 0.21^{a}
Dry Utaka	10.56 ± 0.40^{a}	43.81 ± 0.29^{a}	12.46 ± 0.08^{b}	14.27 ± 0.07^{b}

Values represent Means and SDs where those in the same column with different superscripts are significantly different ($p < 0.05$)

Table 6. Attribute and overall consumer acceptance of the fish enriched biscuits

Fish type	Levels	Aroma	Appearance	Taste	Texture	Overall Acceptance
Parboiled Usipa	5 % roasted	3.15 ± 1.44^{ab}	3.60 ± 1.11^{a}	3.30 ± 1.27^{a}	3.33 ± 1.29^{a}	3.53 ± 1.36^{a}
	7 % roasted	3.70 ± 1.20^{ab}	3.53 ± 1.30^{a}	3.93 ± 1.00^{a}	3.88 ± 1.14^{a}	3.90 ± 1.13^{a}
	5% unroasted	3.23 ± 1.54^{ab}	3.28 ± 1.34^{a}	3.13 ± 1.44^{a}	3.53 ± 1.40^{a}	3.60 ± 1.41^{a}
	7% unroasted	3.25 ± 1.34^{ab}	3.80 ± 1.29^{a}	3.40 ± 1.37^{a}	3.30 ± 1.44^{a}	3.33 ± 1.42^{a}
Dried Usipa	5% unroasted	3.68 ± 1.44^{ab}	3.53 ± 1.18^{a}	3.55 ± 1.30^{a}	3.73 ± 1.22^{a}	3.88 ± 1.34^{a}
	7% unroasted	3.60 ± 1.30^{ab}	3.55 ± 1.50^{a}	3.38 ± 1.46^{a}	3.83 ± 1.43^{a}	3.68 ± 1.47^{a}
	5 % roasted	3.53 ± 1.30^{ab}	3.45 ± 1.20^{a}	3.60 ± 1.11^{a}	3.40 ± 1.36^{a}	3.73 ± 1.04^{a}
	7 % roasted	3.65 ± 1.19^{ab}	3.85 ± 1.15^{a}	3.75 ± 1.26^{a}	3.65 ± 1.31^{a}	3.80 ± 1.14^{a}
Dried Utaka	5 % unroasted	3.18 ± 1.39^{ab}	3.10 ± 1.37^{a}	3.30 ± 1.40^{a}	3.33 ± 1.42^{a}	3.10 ± 1.43^{a}
	7 % unroasted	3.00 ± 1.36^{a}	3.75 ± 1.30^{a}	3.55 ± 1.13^{a}	3.20 ± 1.40^{a}	3.55 ± 1.09^{a}
	5 % roasted	4.03 ± 1.19^{b}	3.70 ± 1.40^{a}	3.30 ± 1.29^{a}	3.73 ± 1.47^{a}	3.90 ± 1.32^{a}
	7 % roasted	3.80 ± 1.27^{ab}	4.03 ± 1.25^{a}	3.78 ± 1.35^{a}	4.13 ± 1.32^{a}	4.05 ± 1.30^{a}

Values represent the Mean and SD; where means in the column with different superscripts were statistically different ($P < 0.05$)

Table 9. Descriptive sensory properties of fish sausage (dry and fresh Usipa and Utaka fish)

Attributes	Fresh Usipa	Dried Usipa	Fresh Usipa	DryUtaka
Tingling odour	1.70 ± 0.95[a]	4.20 ± 0.81[b]	1.83 ± 0.99[a]	4.10 ± 1.00[b]
Shininess	1.93 ± 0.91[a]	3.50 ± 1.28[b]	2.47 ± 1.38[a]	3.77 ± 1.31[b]
Brownness	1.97 ± 1.10[a]	3.83 ± 1.12[c]	2.97 ± 1.10[b]	3.97 ± 1.13[c]
Sweetness	2.70 ± 1.26[b]	1.23 ± 0.50[a]	2.23 ± 1.14[b]	1.47 ± 0.78[a]
Saltiness	2.23 ± 0.97[ab]	3.10 ± 1.16[c]	2.03 ± 0.81[a]	2.80 ± 1.35[c]
Sourness	1.33 ± 0.71[a]	2.43 ± 1.31[b]	2.33 ± 1.27[b]	2.43 ± 1.50[b]
Bitterness	1.23 ± 0.50[a]	2.83 ± 1.51[b]	1.77 ± 1.01[a]	2.73 ± 1.66[b]
Hardness	2.27 ± 1.02[a]	2.47 ± 1.55[a]	2.23 ± 1.01[a]	2.57 ± 1.31[a]
Oiliness	1.67 ± 0.88[a]	4.17 ± 0.79[b]	1.73 ± 0.58[a]	4.33 ± 0.76[b]
Grainy	2.33 ± 1.21[a]	3.10 ± 1.16[ab]	2.37 ± 1.30[a]	3.27 ± 1.20[a]

Reported values represent the Means and SD, the means in the same row with different superscripts are significantly different ($p < 0.05$)
Key: A 5-point scale was used where 1 = low intensity to 5 = high intensity.

adolescents in Malawi; these are the groups commonly afflicted by malnutrition and stunting.

Nutritional and sensory evaluations of the recipes were found to be acceptable to all age groups using the standard Hedonic scale. Crude protein ranged from 43-66% in sausages and inclusion of fish powder at 5% led to an increase of zinc (6.1%), iron (511%), calcium (29.8%) and magnesium (33.5%) content. Thus, fish processing, preservation and inclusion into fish diets did not appreciably compromise the quality of the diets but raised nutrient availability. The recipes produced could be substitutes for imported food stuffs. It now remains for the promotors to upscale these into commercial outlets and convenient shops. There was an increase in nutrient value in terms of content and the value as fish powder content increased to 7%. Iron, zinc, calcium and magnesium were fortified and increased due to fish powder; however, this was capped off at 7% due to objectionable fish flavour. Apart from malnutrition, children also suffer from anaemia; therefore, the availability of iron in these fish-diets is critical. While nutrient profiles of all products were known, the analysis needs a profiling of fatty acids and their value could be further enhanced by adjusting to cater for adults and lactating mothers since vulnerable groups include the elderly [15]. Production of the fish-based diets discussed in this paper would first help address nutritional challenges among children below the age of five and curtail wastage of aquatic foods and thereby contribute to reducing the challenge of emissions of greenhouse gases (GHGs). Secondly, production of these diets will enhance value addition of the aquatic foods in Malawi and improve the contribution of aquatic foods to the country's gross domestic product (GDP) and employment creation. This study confirms results of a previous study by Mumba and Jose [8] that demonstrated high protein (58.22; 57.78%), fat (25.2; 22.80%) and energy (24086; 22204 J/g) content for *Engraulicypris* and *Copadichromis* species, respectively. Regarding availability of Usipa, this sardine-like species has become the mainstay of the fishery of Lake Malawi forming 76% of overall catches and has recently made inroads into Lake Malombe, due to a complex of reasons including habitat and climate change [16,17]. From annual catches of 10,000 tonnes in 1993, Usipa catches are now more than 70,000 tonnes according to the 2015 statistics [18]; besides large amounts are poorly processed and go to waste. The promotional aspects of the diets need to be up-scaled and provide competition to more established organisations like Mary's Meals designed for schools, hence there is need for a more creative marketing strategy of the products.

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

By converting small fish species into biscuits and sausages, small underutilised fish species have an added value. This could reduce imports of children's food and offer diversity of food on the market. Further research is required on fatty acid content and how best to increase their shelf life. Packaging needs to be improved as well to keep the integrity of the processed foods. Since Soya pieces are already popular in Schools and colleges, the inclusion of soya bean meal should be explored in a blend of vegetable animal protein.

Results of the study should be promoted among care givers and market chain shops so that access is enhanced.

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