FAO/CSIR-Food Research Institute

**REPORT ON**
**DEVELOPMENT OF LOW COST NUTRIENT DENSE FISH PRODUCTS BASED ON LOW VALUE FISH AND FISH BYPRODUCTS USING SMALL AND MEDIUM SCALE PROCESSING AND PRESERVATION METHODS THAT STABILIZE THE NUTRITIONAL VALUE AND ENSURE THE SAFETY OF THE PRODUCT**

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**ABSTRACT**

Fish powders were produced from edible byproducts such as tuna frames (bones), trimmings and gills from a fish processing factory, Cosmo Seafood Company Ltd in Tema and underutilized fish, burrito (*Brachydeuterus auritus*) also from Tema canoe landing beach. These raw materials were cleaned thoroughly and dried with a CSIR-FRI gas-fuelled oven at 55°C for 6 h or until dried with a moisture content of between 3.5-8.4% and Water Activity ($a_w$) between 0.6 and 0.65. The dried products were milled with hardened steel hammer mill (Jacobson Machinery Works, Minneapolis, USA. Model 160B) and sieve size of 0.5 mm and stored sealed in polyethylene bags with a gauge of 49.25 mil at ambient temperature (27 ± 2 ºC) until needed. The physical, micro-mineral and macro-mineral content of the dried fish powder showed that tuna trimmings contained 80.71 g/100 g protein while burrito contained 70.40 g/100 g protein. Lead (Pb) was not detected in Tuna trimmings whilst insignificant ($P > 0.05$) levels of 0.44, 0.33 and 0.21 mg/100 g were detected in Tuna frames, gills and Burrito respectively. All fish powders contained high levels of iron, for example, Burrito contained 16.58 mg/100 g while Tuna frames and gills also contained 16.82 and 19.54 mg/100 g respectively. Zinc levels also ranged from 0.41 mg/100 g in Tuna trimmings to 1.88 mg/100 g in Tuna gills. The fish powders were used to produce fortified products from locally known snacks as aboloo, agbelikaklo, yakeyake and mpotompoto. Physicochemical properties of the food products fortified with the fish powder showed that their protein contents were increased significant ($P < 0.05$) between 3.75 to 8.5 % depending on the powder used. The energy contents of the fortified products ranged from 104.09 to 149.04 %. Most of the fortified products also showed high values of other nutrients. All the products were acceptable as they were rated above 6 (like slightly) and they were not significantly ($P<0.05$) different from the reference samples except food products with trimmings which were not acceptable because of the bitterness. School feeding trials of abolo fortified with the powder of the fish frames was rated highly compared to those abolo fortified with other fishes. However, trimmings in yakeyake was rated high (4) in terms of overall acceptability. Mpotompoto fortified with the various fishes was rated highest in all attributes. In general fortified products were acceptable for the school feeding programe were developed. Fish powder could be stored for over long period of time when packaged under vacuum in polyethylene pouches with a gauge of 49.25 ml at refrigeration temperature of 5 ±2 ºC or freezer temperatures (-18 ±2 ºC) .

**Table of contents** **Page**

**LIST OF FIGURES**

**List of Tables**

## Introduction

This study is a collaboration between the Food and Agriculture Organization (FAO) and the Food Research Institute of the Council for Scientific and Industrial Research (FRI/CSIR). This is also follow up project on earlier project undertaken the FAO and the CSIR-Food Research Institute

Inadequate food supply in terms of meeting the energy requirements affects at least 925 million people worldwide (FAO 2010). However, more than two billion people are affected by micronutrient deficiency (WHO 2001). This condition is often referred to as “hidden hunger”. Micronutrient deficiency is in particular prevalent in poor rural and urban areas where limited economic resources prevent diversity in the diets.

The most common micronutrient deficiencies are connected to low dietary intakes of vitamin A, iron and iodine (Allen *et al.* 2006). However, other more neglected micronutrient deficiencies are due to non-availability of selenium, zinc and calcium in the diet which significantly affect the health of individuals (Capon and Smith 1982). Less attention has been paid to this aspect over the years. It has been reported that zinc deficiency contributes to death of 800,000 children globally per year, while rickets caused by calcium deficiency (as opposed to vitamin-D deficiency) has been a problem that is now gaining more attention than before (Hagan *et al.* 2010).

Fish products are considered as a good source of many of the micronutrients of significance. The levels of most of the minerals are found in high amounts in fish bones. However, apart from eating small sized fish species whole (with the bones inclusive), consumption of fish bones of larger fish is rarely practiced. An increased use of seafood, including bones, could contribute significantly to reducing the level of micronutrients and protein malnutrition (Toppe 2014). Many vulnerable groups cannot afford to buy seafood products; and especially in areas where seafood is not available. A solution to the economic and logistic challenges in increasing fish consumption among the poor will be essential in order to make seafood accessible and affordable in micronutrient deficient areas.

Small pelagic fish are among the most affordable and healthy fish. Two meals a week of most carps will do the same, and no fish oil is needed in their feed in order to become a good source of beneficial omega-3 oils (Toppe 2014).

Consuming one hundred grams of small pelagic fish such as sardines or anchovies once a week will more than cover the needs of omega-3s for a person. duct should be processed from low cost high quality fish products. Improved utilisation of existing fishery resources should also play a more important role in meeting the increasing demand of valuable nutrients from the aquatic environment. Reducing post-harvest losses, estimated at more than 10% in volume and up to 30% in value, could release millions of tonnes of healthful fish products for consumption (Toppe 2014).

By-products as a result of processing represent in many cases more than 50% of the fish being processed. These by-products are in many cases low cost products, but with a high nutritional value (Toppe 2014).

High quality fish products from underutilized small pelagic fishes and edible fish processing by products that can easily be stored and transported should be considered as supplement to diets in such areas.

The product should have a potential of being easily introduced into local diets and acceptable by the indigenous population. The option of vacuum packaging can be a solution for storing dried processed fish products for use during emergency situations.

The project aims at developing low cost nutrient dense fish products, utilizing low value fish and edible fish by products, using small and medium scale processing and preservation methods that would stabilize the nutritional value and ensure food safety. Although these by-products have a low economic value, they could have a high nutritive value and can be used to develop products that will add value to existing local diets and to the National School Feeding Initiatives. An added advantage will be the reduction of waste of fish processing Industries.

**Statements of Objectives**:

The objectives of this project are as follows:

- To produce fish powder from dried edible byproducts from processing factories.
- To produce fish powder from dried underutilized fish eg. Burrito.
- To use the fish powder produced from dried fish processing by products and undervalued fish for physical, chemical, microbiological, sensory and shelf life analysis.
- To incorporate the fish powder into local snacks for school pupils under the School Feeding Program.

## 2. MATERIALS AND METHODS

### 2.1.1Burrito Fish *(Brachydeuterus auritus)*

Fresh burrito fish *(Brachydeuterus auritus)* (Figure 1) was purchased from the Tema Fish Market and iced. The fish was subsequently frozen and held at between -15 and -17 ºC until thawed. The fish is washed, mechanically dried in an oven at 55 °C for 8 h with a moisture content of about 6.9 %. The dried fish was milled using the Jacobson Hammer mill with a 250µm mesh sieve and packaged into polypropylene pouches (24 cm x 14 cm) with a gauge of 49.24 mil. The powders were stored at -18 ºC until ready for use.

Figure 1: Fresh Burrito (*Brachydeuterus auritus*)

The production of burrito fish powder is presented in a process flow chart of Figure 2

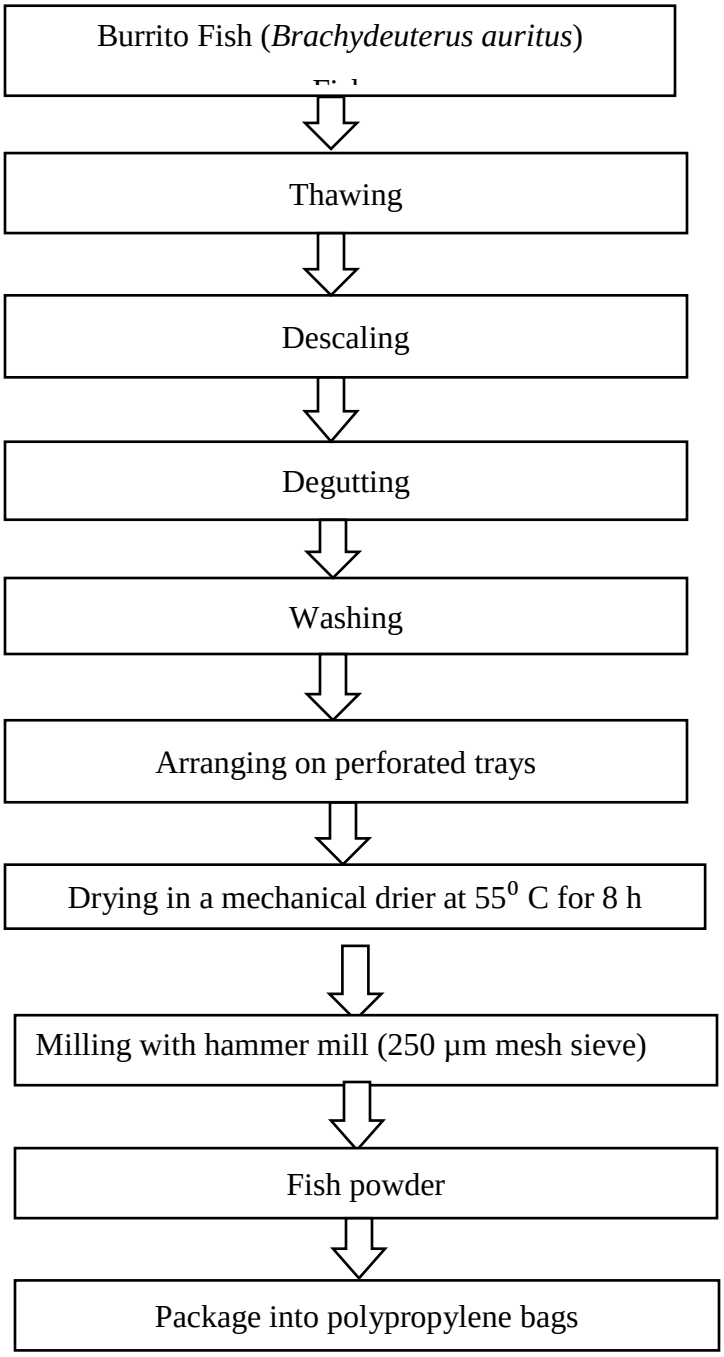


**Figure 2. Production of burrito fish powder is presented in a process flow chart**

### 2.1.2 Fresh Fish By-Products (Trimmings, Gills and Frames)

The fresh fish by-products (Figure 3) were tightly packaged in clear polypropylene bags and frozen as shown below by Cosmo Seafoods Company in Tema, where they were obtained and then transported in an ice-chest to the Food Research Institute.

**Figure 3 Fresh fish by-products (trimmings, gills and frames) packaged in a polypropylene**

The by-products were washed and dried to moisture contents of 4.8 % (fish trimmings), 8.9 % (frames) and 6.8 % (fish gills) as done previously with the burrito in Figure 1. These were milled into powder using a hammer mill with a 250 µm mesh sieve (Jacobson Machinery Works, Minneapolis, USA. Model 160B). The powdered products were packaged into polypropylene bags and stored at -18 ºC until ready for use just like that of the burrito fish.

### 2.2 Physicochemical analysis

All the various powders from burrito and fish edible by products were subjected to the following analyses:

Moisture content was determined by AOAC 925.10 (2000) 17$^{th}$ Ed. Water activity and pH were determined using the Hygrolab water activity meter and bench type pH meter respectively.

Ash was determined by AOAC 923.03 (2000) 17th Ed. Iron, phosphorus and calcium were determined using 2,2-bipyridyl colorimetric, Molybdenum blue colorimetric and Permanganate titration method respectively. Fat was determined by AOAC 923.39C (2000) 17th Ed. Energy was determined by at water factor. Protein was determined by Kjedahl method. Histamine was determined by the method of Hardy and Smith. Heavy metals were determined by AOAC (2005).

**2.3 Microbiological analysis**

The powders were also subjected to the following microbiological analyses:

a. Total aerobes bacteria counts (APC)

Total APC of the samples were determined by using dry rehydratable film media (3M™ Petrifilm™ Aerobic Count Plates, 3M Microbiology, St. Paul, MN) in accordance with the AOAC Official Method (AOAC International 2002a). 3M Petrifilm Plate Reader (3M Microbiology) was used to enumerate the counts and reported in colony- forming units (cfu/g).

b. Coliform and Escherichia coli determination

Total coliform was assayed using dry rehydratable film media (3M™ Petrifilm™ EC/CC Plates, 3M Microbiology) in accordance with the AOAC Official Method (AOAC International 2002b). Red colouration of a colony confirmed the presence of a coliform whiles a blue colouration denoted the presence of E. coli which was confirmed by a biochemical kit (API 20E, BioMerieux, SA, France).

c. Pathogen detection.

For detection of Bacillus cereus, 0.1 mL of a sample homogenate was spread over a plate of mannitol-egg yolk-polymyxin (Oxoid, Basingstoke, England) agar and incubated at $30^0$C for 24 h. Suspect colonies were submitted for biochemical identification as described in the Bacteriological Analytical Manual (Rhodehamel and Harmon 1998).

In order to detect *Staphylococcus aureus*, a 25 g portion of sample was enriched in tryptic soy broth (DIFCO Laboratories, Detroit, MI) containing 10% NaCl and plated on manitol salt agar

(DIFCO Laboratories) containing an egg yolk supplement. Identification of yellow opaque colonies was selected and *S. aureus* confirmed using a biochemical kit (APISTAPH, BioMerieux).

For detection of *Salmonella spp.*, a 25 g portion of sample was enriched in selenite F broth (Oxoid) and streaked on Salmonella shigella agar (Oxoid). Typical colonies was purified and biochemical analysis carried out using a biochemical kit (API 20E, BioMerieux) according to the AOAC Official Method (AOAC International 2002c).

For isolation of *Listeria monocytogenes*, a 25 g portion of sample was added to 225 mL of Listeria enrichment broth (Oxoid) and plated on Listeria 482 M.-S. CHUNG, C.-M. KIM and S.-D. HA selective agar (Oxoid) containing a Listeria supplement (SR140, Oxoid). Typical colonies were purified and biochemical analysis performed using a biochemical kit (API Listeria, BioMerieux).

In order to detect *Vibrio spp*., a 25 g portion of sample was enriched in alkaline peptone (DIFCO Laboratories) broth containing 2% NaCl and plated on thiosulfate citrate bile salt sucrose (Oxoid) agar. Presumptive positive *Vibrio spp*. colonies was confirmed using a biochemical kit (API 20E, BioMerieux).

**2.4 Fortification of Carbohydrate Foods**

The powdered products were used in the fortification of carbohydrate base foods which are of low nutrient value. Different percentages of the powders (5, 8.8, 12.5, and 16.3) were used in the preparations to determine the acceptable levels of inclusion in the products through a sensory evaluation. The preparation of these foods are described below.

**2.4.1 Fortified Baked Corn Dough (Aboloo) Preparation**

Aboloo or baked corn dough is a corn dough product sweetened with sugar and baked. The dough mass was molded into near regular dome-shaped mounds usually 6-10 cm in diameter and baked at 177 °C for 15 min. For 5 % aboloo, the quantities of ingredients were as follows:

| Ingredients | Quantity (g) |
|---|---|
| Corn Flour | 235 |
| Sweet Potato Flour | 50 |
| Baking powder | ¼ tsp |
| Sugar | 1 ½ |
| Fish Flour | varied |

### 2.4.2 Fortified Agbelikaklo Preparation

Fried cassava balls or agbelikaklo, is also a food crop snack. Its basic constituent is grated uncooked cassava. After squeezing out the liquid through a cheese cloth or sack, salt was added to taste. Ground onions may be added as spice and the dough was molded into small round balls about 2-3 cm in diameter that were deep fried for 8 min until golden brown. For 5 % agbelikaklo, the quantities of ingredients were as follows:

| Ingredients | Quantity(g) |
|---|---|
| Cassava dough | 285 |
| Blended Onion | 60 g |
| Fish Flour | varied |
| Salt | ½ tsp |
| Frying time | 8 min |

### 2.4.3 Fortified Yakeyake Preparation

Yakeyake is steamed grated cassava mass. Cassava roots were washed, peeled, grated, and squeezed through a cheese cloth. The grated cassava was sieved to remove the course component, mixed with the appropriate quantity of the fish powder and salt to taste. For 5 % yakeyake the quantities of ingredients were as follows:

| Ingredients | Quantity(g) |
|---|---|
| Cassava dough | 285 |
| Fish Flour | varied |
| Salt | ½ tsp |
| Cooking time | 5 min |

### 2.4.4 Fortified yam mpotompoto

Yam mpotompoto is a cooked yam dish which is cooked until the yam disintegrates. Yam was washed, peeled and diced into water. Washed tomatoes, pepper, onion were added. Salt was added to taste as well as fish powder and brought to boil. The tomatoes, pepper and onion were removed and ground and then returned to the pot. Palm oil was added and stirred. The heat was lowered and cooked until the yam was completely mashed, possible a wooden spoon must be used to mash the yam and was served hot. For 5 % Mpotompoto the quantities of ingredients were as follows:

| Ingredients | Quantity (g) |
|---|---|
| Yam | 300 |
| Onion | 50 |
| Pepper | 2.8 |
| Tomatoes | 63 |
| Palm oil | 30 ml |
| Salt | 2.8 |
| Water | 600 ml |
| Fish powder | varied |

### 2.5 Sensory Evaluation

Acceptability test was used to assess the consumer acceptance of a food when incorporated with different percentages of fish powder. Burrito, tuna frames, trimmings and fish gills powder were used in the percentages of 5, 8.8, 12.5, and 16.3. The selected dishes in which these fish powder were incorporated were the Yakeyake, aboloo and mpotompoto.

The sensory characteristics investigated were appearance, colour, taste, aroma, texture, mouthfeel and overall acceptability. The panelist were requested to give numerical values to each sensory characteristic assessed using the nine point hedonic scale, with 9 meaning like extremely and 1 meaning dislike extremely. The mean scores for the sensory characteristics of the dishes and the overall acceptance were found.

### 2.6 School Feeding Acceptability Test

Permission was sought from the Institutional Review Board for the Council for Scientific and Industrial Research as per attached letter (Appendix A). Eventually approval was given to the project team (Appendix B). Based upon this approval permission was also sought from the Regional Director of Education, Greater Accra. With her approval the, La Enobal Cluster of Schools was notified about the project's intention to conduct the studies over at the school through the La Dade-Kotopon Municipal Director (Appendix C). Subsequently consent forms to participants and their guardians or parents were sent out and a 100 % approval was returned (Appendix D).

#### 2.6.1 Preparation of Fish powder based products for Schools

Following results from the in-house sensory evaluation, three well accepted products were further developed for the school acceptability testing. These were yakayake, abolo and mpotompoto. Table 1 shows the percentage levels of fish powders inclusion in the three food preparations.

**Table 1: Percentage levels of Fish powders inclusion in three food products**

| Food Item | Burito | Trimmings | Frames | Gills |
|---|---|---|---|---|
| Yakayake | 8.8 | 8.8 | 8.8 | 12.5 |
| Abolo | 5.0 | 5.0 | 5.0 | 5.0 |
| Mpotompoto | 12.5 | 12.5 | 8.8 | 12.5 |

### 2.6.2 Acceptability test conduction at School

A total of one hundred school children between the ages of 11 and 12 years who with their consent and their parents participated in this study. A copy of such two signed consent forms are presented in Appendix E. The children were asked to access the following attributes of the products. These were appearance, colour, taste, aroma, texture, mouthfeel and overall acceptability. The panelist were requested to give numerical values to each sensory characteristic assessed using the 5 point hedonic scale, with 5 meaning like extremely and 1 meaning dislike extremely. The mean scores for the sensory characteristics of the dishes and the overall acceptance were found.

### 2.6.3 Shelf life studies and packaging

A two month storage period of the powdered products were carried out at FRI at different storage conditions. Approximately, 50 and 100 g of the products were placed in the packaging pouches and sealed (Appendix I) under the following conditions

1. Non-vacuum packaged into polyethylene pouch (24 cm x 14 cm) with a gauge of 49.25 ml.
2. Vacuum packaged into polyethylene pouch (24 cm x 14 cm) with a gauge of 49.25 ml.

The products were stored under the following conditions.

a. Shelf storage at normal temperature of (27±2 ºC) and relative humidity of 75%.

b. Refrigeration storage at a temperature of (5 ±2 ºC)

b. Freezing storage at a temperature of (-18 ±2 ºC)

#### 2.6.3.1 Chemical analyses

Changes in chemical properties of the powders during storage were monitored by measuring the FFA and reported as mg KOH/100 g following the AOAC (1990) method 939.05,

#### 2.6.3.2 Sensory Evaluation

Samples of the stored powders were periodically removed from their respective pouches and served to 16 panellists. The panellists were asked to assess the appearance particularly colour and odour of the powders. The characteristics were given a 5-point hedonic scale as 5-white, 1-brown for colour and 5-neutral, 1-mushy/rancid for odour (Appendix H)

### 2.6.4 Evaluation of Results

A computer programme was used for statistical calculations (MINITAB 10.2 Inc. State College, PA. USA Inc). For most of the data, the difference of means between pairs was determined by ANOVA. The level of significance was set at $P<0.05$.

## 3. Results and Discussions

### 3.1 Physicochemical Studies

The following are the results of the physicochemical analysis of the dried powders as shown on Tables 2 and heavy metals content of the powders (Table 3)

**Table 2 Proximate and Chemical results of dried powder prepared from edible fish processing by products and burrito**

| Parameter | Fish Trimming | Tuna Frames | Fish gills | Burrito |
|---|---|---|---|---|
| Moisture (g/100g) | 4.8 | 8.4 | 6.8 | 9.8 |
| Water Activity ($a_w$) | 0.6 | 0.65 | 0.62 | 0.6 |
| Ash (g/100g) | 3.4 | 44.11 | 42.99 | 14.0 |
| Fat (g/100g) | 5.7 | 11.3 | 4.5 | 11.1 |
| Protein (g/100g) | 80.71 | 28.66 | 38.29 | 70.4 |
| Carbohydrate (including fibre) (g/100g) | 5.39 | 7.53 | 7.42 | 1.0 |
| Energy (Kcal/100g) | 395.7 | 242.5 | 223.3 | 381.5 |
| Phosphorus mg/100g | 600.9 | 1010.2 | 1071,8 | 93.71 |
| Calcium (mg/100g) | 1066.5 | 13184.3 | 15469.3 | 2586.63 |

Tuna trimmings contained 80.71 g/100 g protein; burrito 70.40 g/100 g protein (Table 2). Lead (Pb) was not detected in Tuna trimmings whilst insignificant ($P > 0.05$) levels of 0.44, 0.33 and 0.21 mg/100 g were detected in Tuna frames, gills and burrito respectively (Table 3).

All fish products contained high levels of iron, eg, burrito contained 16.58 mg/100 g; tuna frames and gills 16.82 and 19.54 mg/100 g respectively (Table 3). Zinc levels also ranged from 0.41 mg/100 g in tuna trimmings to 1.88 mg/100 g in tuna gills (Table 3). RDI for children 9 to13yrs per day for Zn, is 8 mg, Mn is1.9. The RDI for Cu, is 700mcg and Fe, is 8 mg (Allen *et al*., 2006).

**Table 3 Heavy metals content of dried powder prepared from edible fish processing by products and burrito**

| Parameter | Fish Trimming | Tuna Frames | Fish gills | Burrito |
|---|---|---|---|---|
| Lead (mg/100g) | Not Detected | 0.04 | 0.04 | Not Detected |
| Copper | 0.06 | 0.25 | 0.14 | 0.08 |
| Iron (mg/100g) | 16.58 | 16.82 | 19.54 | 18.9 |
| Zinc (mg/100g) | 0.41 | 0.59 | 1.88 | 0.67 |
| Manganese (mg/100g) | 0.11 | 0.76 | 1.03 | 1.56 |
| Arsenic (mg/kg) | 1.00 | <1.00 | 1.00 | <1.00 |
| Mercury (mg/kg) | <1.00 | <1.00 | 1.00 | <1.00 |
| Cadmium (mg/kg) | <1.00 | <1.00 | <1.00 | <1.00 |

The concentrations of lead, copper, iron, zinc, manganese, arsenic cadmium and mercury are presented in Table 3. The results of the analysis indicate that the concentration of cadmium, arsenic and mercury varied from <1.00 to 1mg/100 mg. Lead was found at only 0.04 in the tuna frames and gills. All these results were below the 0.5 mg/ 100 mg limit recommended by the FAO/ WHO (1972) and adopted by many countries (CIFA, 1992). Because of the known toxicity, of mercury, lead and cadmium, The Joint Food and Agriculture Organization/World Health Organization (FAO/WHO) Expert Committee on Food Additives suggested a provisional tolerable intake of 400±500 mg cadmium per week for man; 0.3 mg per week for mercury and, lead, a weekly intake of 3 mg (FAO/ WHO, 1972). The maximum concentration of lead which is permitted in prepared foods specially intended for babies or young children is 200 mg /kg (FAO/WHO, 1972).

### 3.2 Microbiological analyses of dried powders of burrito and edible fish by products from fish processing plant

The microbiological analyses of the dried powders of burrito and edible fish by products from fish processing plant is shown on Table 4.

## Table 4 Microbiological analyses of dried burrito and edible fish by products from fish processing plant

| Sample Description | pH | Aerobic Plate Count at 30°C/72h cfu/g NMKL 86 2013 | Coliform Count cfu/g NMKL 44 2004 | *E. coli* Count cfu/g NMKL 125 2005 | *Enterococcus* Count NMKL 68 2011 | *Enterobacteriaceae* Count cfu/g NMKL 144 2005 | Mould & Yeast Count cfu/g ISO 21527-1: 2008 | | *Cl. Perfringens* Count cfu/g ISO 7937 2004 | *Vibrio*/25g ISO TS 21872-1 2007 | *B. cereus* Count cfu/g NMKL 66 2010 | *Staph. aureus* Count cfu/ml NMKL 66 2006 | *Salmonella* spp./25g NMKL 71 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Yeasts | Moulds | | | | | |
| Fish Frames | 6.27 | $2.7 \times 10^5$ | <10 | <10 | <10 | <10 | 90 | <10 | <10 | Not Detected | <10 | <10 | Not Detected |
| Fish Gills | 6.79 | $1.8 \times 10^6$ | <10 | <10 | <10 | <10 | 220 | <10 | <10 | Not Detected | <10 | <10 | Not Detected |
| Fish Trimmings | 5.82 | $3.3 \times 10^6$ | <10 | <10 | <10 | <10 | 380 | <10 | <10 | Not Detected | <10 | <10 | Not Detected |
| Burrito Fish | 6.51 | $3.7 \times 10^3$ | 180 | <10 | <10 | <10 | <10 | <10 | <10 | Not Detected | <10 | <10 | Not Detected |

Note: 1. NMKL - Nordic Committee on Food Analysis Method
2. ISO - International Standards Organization Method
3. CFU - Colony Forming Unit

### 3.3. Physicochemical properties of fish powder-fortified snacks

Figures 4 (fortified aboloo), 5 (fortified agbelikaklo), 6 (fortified yakeyake), and 7 (hot fortified mpotompoto) are the products from the fish powders.

**Figure 4 Fortified aboloo**

**Figure 5 Fortified agbelikaklo**

**Figure 6 Fortified yakeyake**

**Figure 7 Hot fortified mpotompoto**

Physicochemical properties of the food products are shown in Tables 5, 6 and 7. The protein contents of mpotompoto fortified with 12.5 % burrito, 8.8 % tuna frames, 12.5 % tuna gills and 12.5 % tuna trimmings were 7.59 %, 3.75 % 6.12 % and 8.5 % respectively. Ash contents also ranged from 1.12 % for 12.5 % trimmings to 5.54 % for 8.8 % tuna frames. The control (non-fortified) contained 1.17 %. Energy contents ranged from 104.09 % for 8.8 % inclusion of tuna frames to 149.04 % for 12.5 % inclusion of tuna gills. The control had energy content of 86.45 %. Most inclusions for abolo and yakayake also showed high values of nutrients.

**Table 5 Proximate results of Mpotompoto with various levels fish powders inclusion based on the sensory evaluation**

| Parameter | Control | 12.5% Burrito | 8.8% Frames | 12.5% Gills | 12.5% Trimmings |
|---|---|---|---|---|---|
| Moisture g/100 g | 81.51±1.39 | *69.22±0.99 | *73.33±1.09 | *67.45±1.29 | *70.95±1.32 |
| Ash g/100 g | 1.17±0.07 | *2.34±0.04 | *5.84±0.06 | *4.67±0.23 | 1.12±0.09 |
| Fat g/100 g | 3.45±0.03 | *6.4±0.12 | *4.15±0.61 | *7.5±0.28 | *6.02±0.03 |
| Protein g/100 g | 1.1±0.02 | *7.49±0.22 | *3.75±0.32 | *6.12±0.73 | *8.50±0.82 |
| Carbohydrate g/100 g | 12.78±0.98 | *14.56±0.96 | 12.94±0.97 | *14.27±1.07 | 13.41±0.32 |
| Energy Kcal/100 g | 86.45±1.26 | *146.28±1.97 | *104.09±1.92 | *149.04±1.39 | *141.82±1.29 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly ($P<0.05$) higher than the control.**

**Table 6 Results of Aboloo with inclusion of the various fish powders based on the sensory evaluation**

| Parameter | Control | 5% Burrito | 5% Frames | 5% Gills | 5% Trimmings |
|---|---|---|---|---|---|
| Moisture g/100g | 61.99±1.32 | *48.76±1.78 | *44.24±1.2 | *46.44±1.47 | *54.02±1.09 |
| Ash g/100g | 0.76±0.07 | *2.77±0.51 | *4.34±0.4 | *3.21±0.03 | *0.83±0.02 |
| Fat g/100g | 0.35±0.03 | *0.9±0.02 | *0.9±0.02 | *0.85±0.06 | 0.5±0.03 |
| Protein g/100g | 4.27±0.13 | *6.25±0.15 | *6.970±0.55 | *8.60±0.27 | *8.90±0.32 |
| Carbohydrate g/100g | 32.63±1.8 | *41.32±0.92 | *43.56±1.28 | *40.91±0.95 | *35.76±1.07 |
| Energy Kcal/100g | 150.75±1.99 | *198.38±2.05 | *210.22±1.39 | *205.67±2.07 | *183.14±1.44 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the control.**

**Table 7 Proximate results of Yakayake with various levels fish powders inclusion based on the sensory evaluation***

| Parameter | Control | 8.8% Burrito | 8.8% Frames | 12.5% Gills | 8.8% Trimmings |
|---|---|---|---|---|---|
| Moisture g/100 g | 51.44±1.02 | *67.305±1.04 | *49.62±1.57 | *48.915±1.93 | *48.19±1.08 |
| Ash g/100 g | 1.41±0.02 | 1.29±0.02 | *5.97±1.02 | *2.07±0.04 | *1.78±0.03 |
| Fat g/100 g | 0.025±.001 | 0.15±.001 | *0.3±0.02 | *0.6±0.01 | *0.4±0.05 |
| Protein g/100 g | 0.69±0.02 | *7.05±0.05 | *3.13±0.03 | *8.79±0.92 | *7.30±1.09 |
| Carbohydrate g/100 g | 46.45±1.1 | *24.21±0.17 | *40.99±1.71 | *39.63±1.03 | *42.34±1.18 |
| Energy Kcal/100 g | 188.75±1.3 | *126.37±1.52 | *179.16±1.67 | *199.08±2.01 | *202.14±2.22 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the control**

### 3.4 Sensory Evaluation

The results of the sensory evaluations are presented on Tables 8, 9 and 10

### 3.4.1 Appearance

The appearance of the food products fortified with the various fishes were liked extremely except the appearance of the food products made from trimmings that were liked slightly according to the hedonic scale used. With the exception of the higher concentrations of Gills the appearance of the reference samples was not significantly ($P<0.05$) different from all the other samples (Tables 8, 9, and 10).

### 3.4.2 Colour

The colour of all the samples was liked very much except the colour of food products fortified with trimmings (Tables 8, 9 and 10) and was significantly ($P<0.05$) different from the reference sample (Tables 8 and 9).

### 3.4.3 Aroma

The aromas of all the samples were liked and were not significantly ($P<0.05$) different from each other.

### 3.4.4 Taste

On the whole, the taste of the fishes in the food products were acceptable to the panelist as is evident by the fact that the taste was not rated below 5 except the taste of food products with Trimmings. The taste for the samples with trimmings was not accepted because of the bitterness. On the other hand the taste of mpotompoto was rated high (above 7) on the hedonic scale. Meaning panelists liked the taste of the fishes in the mpotompoto even with the high concentrations. According to the analysis of variance, there was no significant ($P<0.05$) difference in panelists liking of the taste the samples but there was difference between the samples with trimmings samples and the reference samples.

### 3.4.5 Mouthfeel

Consequently panelists liked the mouthfeel for all the samples but did not like the mouthfeel for the high concentrations of the fishes in the food products. The ratings for these samples were below 5 on the hedonic scale.

### 3.4.6 Overall Acceptability

All the products were acceptable as they were rated above 6 (like slightly) and they were not significantly ($P<0.05$) different from the reference samples except food products with trimmings which were not acceptable because of the bitterness.

**Table 8 Mean score and standard deviations for sensory characteristics and overall acceptability yakeyake fortified with fish powder**

| | Quality Assessed[2] | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sample** | **Appearance** | **Colour** | **Taste** | **Aroma** | **Texture** | **Mouthfeel** | **Overall Acceptability** |
| 5% Tuna Frames | 6.73±1.67bc[1] | 6.73±1.39bc | 6.00±1.57bcd | 6.33±1.54bcd | 6.60±1.4bcd | 6.47±1.41bcd | 6.53±1.46bcd |
| 8.8% Tuna Frames | 6.80±1.42bc | 6.87±1.4bcd | 6.20±1.15bcd | 6.13±1.41bcd | 6.73±1.10cd | 6.33±1.50bcd | 6.27±1.16abcd |
| 12.5% Tuna frames | 6.33±1.39abc | 6.60±1.35bc | 5.93±1.53abc | 5.60±1.59abc | 6.20±1.82abc | 5.73±1.83ab | 5.93±1.71abc |
| 16.3% Tuna Frames | 6.40±1.72bc | 6.27±1.58bc | 5.27±1.71ab | 5.27±1.58ab | 6.27±1.58abcd | 5.53±1.81abc | 5.67±1.78abc |
| 5% Trimmings | 5.60±1.59abc | 5.67±1.72abc | 6.27±1.58bcd | 6.07±1.16bc | 6.53±1.41bcd | 5.93±1.39abc | 5.93±1.49abc |
| 12.5% Trimmings | 4.47±2.17a | 4.67±2.16a | 5.07±1.59ab | 4.8±1.74a | 5.67±1.23abc | 4.87±1.81a | 5.27±1.53abc |
| 16.3% Timmings | 4.00±2.20a | 4.06±2.12a | 4.73±1.71a | 4.53±1.81a | 5.33±1.68abbc | 4.60±1.96a | 4.73±1.44a |
| 8.8% Trimmings | 5.33±1.84ab | 5.46±1.88abc | 6.07±1.33bcd | 5.87±1.18abc | 6.47±1.51bcd | 5.73±1.58bcd | 6.07±1.49bcd |
| Control | 7.93±1.03cd | 8.07±1.03d | 7.60±1.18e | 7.27±1.28cd | 7.47±1.19e | 7.47±0.92e | 7.73±0.96e |
| 12.5% Gills | 6.07±1.67abc | 6.07±1.75bc | 5.87±1.60abc | 5.80±1.61abc | 6.33±1.23bbc | 6.33±1.23bc | 6.00±1.41abc |
| 8.8% Gills | 5.87±1.68abc | 6.47±1.68bc | 6.00±1.46bcd | 5.86±1.66abc | 6.47±1.41bbc | 5.80±1.78bc | 6.07±1.67bc |
| 16.3% Gills | 5.53±2.03ab | 5.13±1.96ab | 5.20±1.86ab | 5.07±1.83abc | 6.07±1.39 | 5.00±1.77 | 5.40±1.76 |
| 5% Gills | 7.13±1.19bc | 7.13±0.99d | 6.67±0.98bcd | 6.67±1.11bcd | 6.93±1.16 | 6.73±1.22 | 6.87±0.92 |
| 5% Burito | 8.07±0.88d | 7.87±0.83cd | 7.67±1.11e | 7.40±1.45cde | 7.67±1.05 | 7.67±1.05 | 7.47±1.64 |
| 12.5% Burito | 6.20±1.90abc | 5.87±1.73abc | 5.87±1.96abc | 5.87±1.46abc | 6.40±1.45 | 5.53±1.81 | 5.67±1.40 |
| 8.8% Burito | 7.27±1.22bc | 7.13±0.99cd | 6.60±1.35bcd | 6.13±1.88abc | 6.53±1.92 | 6.33±1.50 | 6.27±1.98 |
| 16.3% Burito | 5.47±2.17a | 5.27±2.12abc | 4.87±1.81a | 5.13±1.85ab | 5.80±2.18 | 5.20±1.90 | 5.13±1.97 |

[1] Mean in the same column followed by different alphabets are significantly different at 5% level of probability; [2] sensory attributes were evaluated on a 9-point hedonic scale as follows: 1- dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely

**Table 9 Mean score and standard deviations for sensory characteristics and overall acceptability of aboloo fortified with fish powder**

| | Quality Assessed[2] | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sample** | **Appearance** | **Colour** | **Taste** | **Aroma** | **Texture** | **Mouthfeel** | **Overall acceptability** |
| Control | 7.63±0.89e[1] | 7.56±0.81e | 7.63±0.81e | 7.56±0.96e | 7.19±1.05e | 7.44±0.89e | 7.38±0.96e |
| 8.8% Trimmings | 4.75±1.88abc | 4.50±1.86 abc | 4.88±1.63 abc | 4.94±1.57 abc | 4.88±1.78abc | 4.88±1.78abc | 5.06±1.65abcd |
| 16.3% Timmings | 3.88±1.86a | 3.56±1.96a | 4.67±1.54abc | 4.50±1.51abc | 4.00±1.67bc | 4.53±1.68abc | 4.06±1.48a |
| 8.8% Gills | 6.19±1.33bcde | 6.00±.1.26 bcde | 6.19±1.60 bcde | 5.81±1.42 bcde | 5.94±1.44 bcde | 5.67±1.39 bcde | 5.88±1.20bcde |
| 5% Trimmings | 5.69±1.45bcde | 5.50±1.63 abcde | 5.94±1.53 abcde | 5.75±1.39 abcde | 6.06±1.44 bcde | 6.06±1.18 bcde | 6.13±1.20cde |
| 5% Gills | 6.63±1.15cde | 6.69±1.08de | 6.81±1.38de | 6.50±1.21cde | 6.63±1.54cde | 6.63±1.36cde | 6.63±1.31de |
| 12.5% Trimmings | 4.25±1.95abc | 4.06±1.91ab | 4.56±1.59abc | 4.69±1.49abc | 4.13±2.13ab | 4.63±1.71abc | 4.38±1.63abc |
| 5% Burito | 7.47±0.99de | 7.40±1.06de | 6.87±1.30de | 6.53±1.81de | 6.80±1.52de | 6.67±1.91de | 6.87±1.60e |
| 16.3% Burito | 5.07±2.02bcd | 5.20±2.08abcd | 4.40±1.76abc | 4.40±1.76abc | 5.20±1.78abcd | 4.07±1.98a | 4.33±1.76ab |
| 8.8% Burito | 6.80±1.08de | 6.87±1.46de | 5.87±1.88de | 5.47±1.85de | 6.33±1.84de | 5.27±2.28de | 5.60±1.92abcde |
| 12.5% Burito | 5.67±2.26bcde | 5.73±2.21bcde | 5.40±2.06abcd | 4.73±2.09ab | 6.00±1.81bcd | 4.87±1.99abc | 5.00±2.07abcd |

[1] Mean in the same column followed by different alphabets are significantly different at 5% level of probability; [2] sensory attributes were evaluated on a 9-point hedonic scale as follows: 1- dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely

**Table 10 Mean score and standard deviations for sensory characteristics and overall acceptability mpotompoto fortified with fish powder**

| **Sample** | **Appearance** | **Colour** | **Taste** | **Aroma** | **Texture** | **Mouthfeel** | **Overall acceptability** |
|---|---|---|---|---|---|---|---|
| 5% Burittoo | 8.00±0.53b[1] | 8.00±0.53b | 6.93±1.33ab | 7.33±0.90b | 7.60±0.83b | 7.47±1.13b | 7.67±0.72b |
| 16.3% Burito | 6.60±0.74ab | 6.47±1.13ab | 5.86±0.95a | 6.31±1.28ab | 6.07±1.28a | 6.27±0.96ab | 6.27±0.88ab |
| 8.8% Burito | 7.47±0.83ab | 7.73±0.59b | 7.47±1.25b | 7.47±1.19b | 7.60±0.91b | 7.53±0.99b | 7.47±0.99b |
| 12.5% Burito | 6.33±1.18a | 6.27±1.22ab | 6.40±1.55ab | 6.80±1.01ab | 6.80±1.37ab | 6.80±1.15b | 6.73±1.03ab |

[1] Mean in the same column followed by different alphabets are significantly different at 5% level of probability; [2] sensory attributes were evaluated on a 9-point hedonic scale as follows: 1- dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely

### 3.5 Acceptability of products during school feeding trials

Pictorial depictions of the feeding trials are shown in Appendix H

Results of the acceptability of the three products for the school feeding trial are presented below

#### 3.5.1 Aboloo

The sensory profile (Figure 8) indicates that aboloo fortified with the powder of fish frames was rated highly compared to the abolo fortified with other fishes. Panelists liked the taste of all the aboloo samples except the aboloo fortified with trimmings.

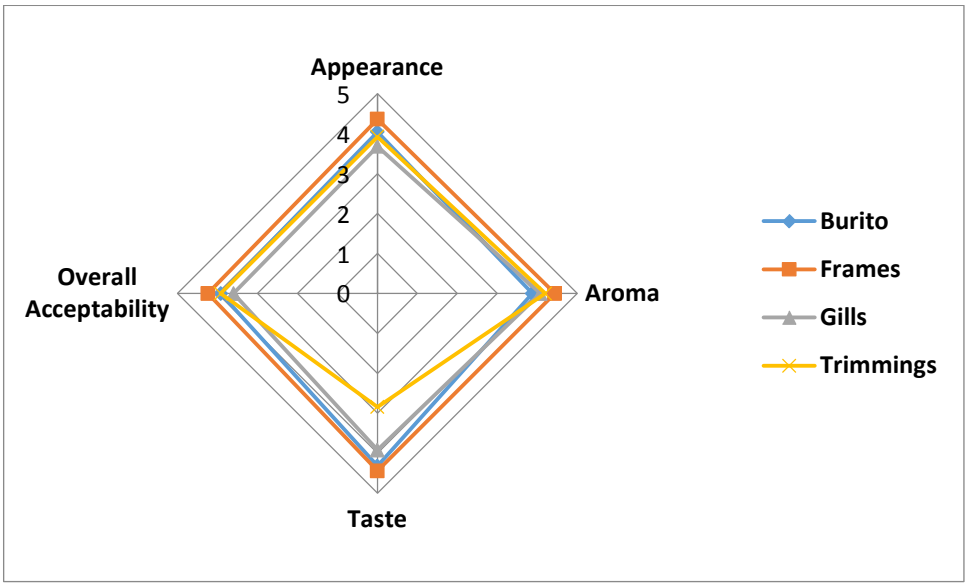


**Figure 8 Sensory profile of Aboloo fortified with different varieties of fish powder**

### 3.5.2 Yakeyake

Yakeyake fortified with the various fishes rated lower in terms of appearance, aroma, and taste. However, trimmings in yakeyake was rated high (4) in terms of overall acceptability (Figure 9)

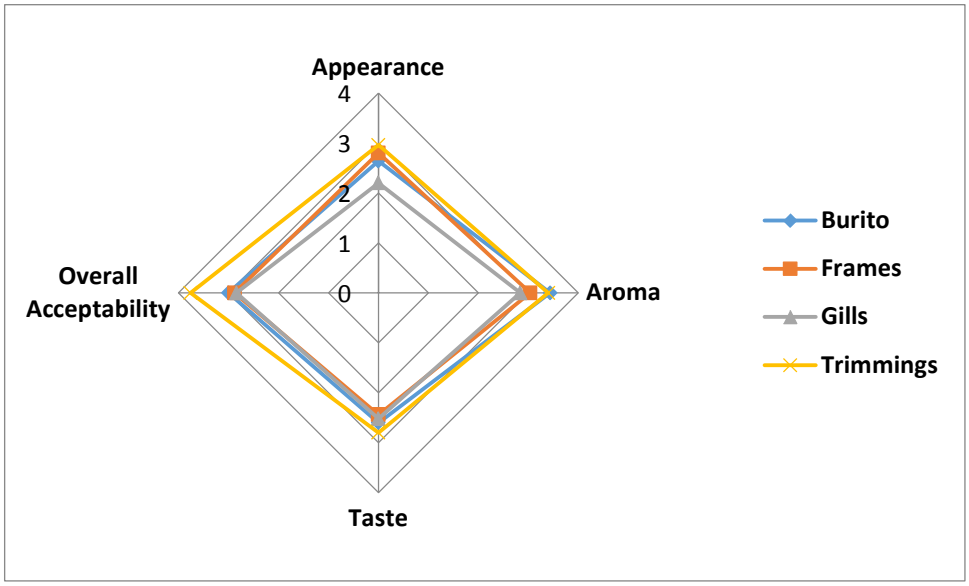


**Figure 9 Sensory profile of Yakeyake fortified with different varieties of fish powder**

### 3.5.3 Mpotompoto

The profile in Figure 10 shows that mpotompoto fortified with the various fishes was rated highest in all attributes. A general trend of a somewhat even rating was observed for all the varieties of fishes used.

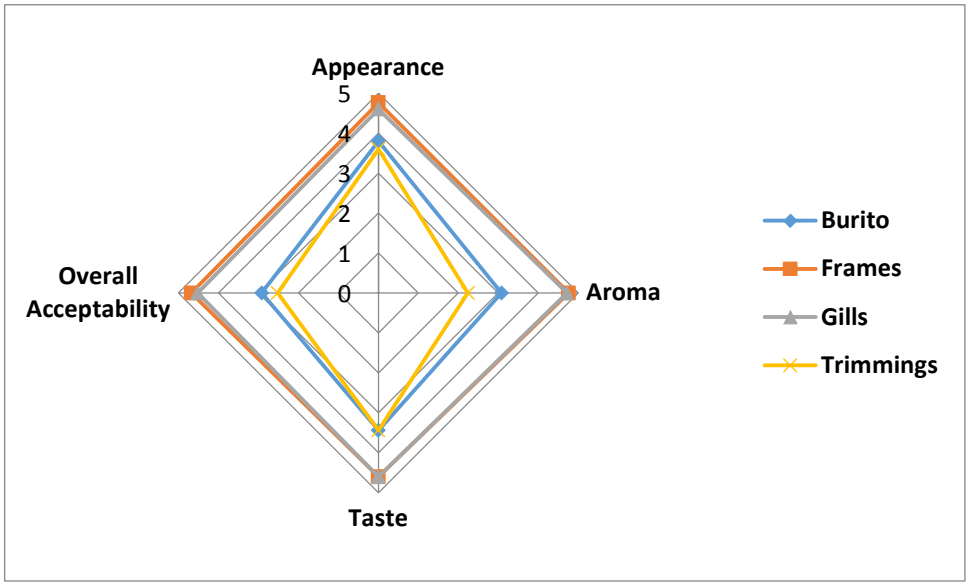


**Figure 10 Sensory profile of Mpotompoto fortified with different varieties of fish powder**

### 3.6 Shelf life studies and packaging

Tables 11 to 12 show the free fatty acid values monitored over the storage period of two months. Though there were instances that powders stored under normal ambient temperature **(**27±2 ºC and RH of 75%) in non-vacuumed packages (with the exception of tuna frames) had significant ($P<0.05$) increase of free fatty acid after two months of storage, these were not observed in the sensory profiles of the powders (Tables 13 to 16) as regards to the parameters monitored during the period. However a longer storage period could have revealed a lot more possibly with the powders stored in non-vacuumed packages at the ambient temperature. A critical observation of the values of the odour and colour of samples stored at refrigeration temperature of 5 ±2 ºC and freezer temperatures (-18 ±2 ºC) in most of the vacuumed packages consistently remained unchanged from the values at the start of the shelf life and packaging studies (at month zero).

**Table 11 Free fatty acid (mg KOH/100 g) changes during 2 month storage of burrito powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | Refrigeration Temperature of (5 ±2 ºC) | | Freezer Temperature of (-18 ±2 ºC) | |
|---|---|---|---|---|---|---|
| | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package |
| 0 | 22.56±1.94 | 22.56±1.94 | 22.56±1.94 | 22.56±1.94 | 22.56±1.94 | 22.56±1.94 |
| 1 | 24.62±1.56 | 23.37±1.04 | 22.89±1.81 | 22.67±0.92 | 22.59±1.74 | 22.57±0.71 |
| 2 | *25.23±0.99 | 23.38±1.13 | 23.09±1.05 | 22.68±1.12 | 22.61±1.39 | 22.59±0.89 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 12 Free fatty acid (mg KOH/100 g) changes during 2 month storage of tuna trimmings powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | Refrigeration Temperature of (5 ±2 ºC) | | Freezer Temperature of (-18 ±2 ºC) | |
|---|---|---|---|---|---|---|
| | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package |
| 0 | 17.06±1.23 | 17.06±1.23 | 17.06±1.23 | 17.06±1.23 | 17.06±1.23 | 17.06±1.23 |
| 1 | 18.34±1.79 | 17.37±1.09 | 17.32±2.79 | 17.11±2.79 | 17.12±1.63 | 17.09±1.29 |
| 2 | *19.44±1.07 | 17.44±2.79 | 17.34±2.79 | 17.17±2.79 | 17.15±1.69 | 17.09±1.89 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 13 Free fatty acid (mg KOH/100 g) changes during 2 month storage of tuna frames powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | Refrigeration Temperature of (5 ±2 ºC) | | Freezer Temperature of (-18 ±2 ºC) | |
|---|---|---|---|---|---|---|
| | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package |
| 0 | 12.01±1.58 | 12.01±1.58 | 12.01±1.58 | 12.01±1.58 | 12.01±1.58 | 12.01±1.58 |
| 1 | 12.11±1.23 | 12.02±1.21 | 12.09±1.23 | 12.01±1.98 | 12.05±1.43 | 12.02±1.548 |
| 2 | 13.09±1.04 | 12.04±0.59 | 12.11±1.63 | 12.02±0.89 | 12.06±1.18 | 12.02±1.68 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 14 Free fatty acid (mg KOH/100 g) changes during 2 month storage of tuna gills powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | Refrigeration Temperature of (5 ±2 ºC) | | Freezer Temperature of (-18 ±2 ºC) | |
|---|---|---|---|---|---|---|
| | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package | Non Vacuum Package | Vacuum Package |
| 0 | 21.34±1.32 | 21.34±1.32 | 21.34±1.32 | 21.34±1.32 | 21.34±1.32 | 21.34±1.32 |
| 1 | 23.09±1.32 | 21.54±1.23 | 21.36±1.18 | 21.35±1.17 | 21.36±1.07 | 21.36±1.53 |
| 2 | *25.21±2.39 | 21.54±1.22 | 21.37±1.53 | 21.35±0.99 | 21.38±1.16 | 21.37±0.79 |

**Values are means of three determination ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 15 Mean sensory scores for colour and odour changes during 2 month storage of burrito powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | | | Refrigeration Temperature of (5 ±2 ºC) | | | | Freezer Temperature of (-18 ±2 ºC) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non Vacuum Package | | Vacuum Package | | Non Package | Vacuum | Vacuum Package | | Non Package | Vacuum | Vacuum Package | |
| | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour |
| 0 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |
| 1 | 3.4±0.1 | 3.3±0.2 | 3.4±0.2 | 3.3±0.3 | 3.4±0.2 | 3.4±0.2 | 3.4±0.1 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |
| 2 | 3.4±0.1 | 3.2±0.6 | 3.4±0.2 | 3.3±0.4 | 3.4±0.1 | 3.4±0.2 | 3.4±0.1 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |

**Values are means of 16 panelists ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 16 Mean sensory scores for colour and odour changes during 2 month storage of tuna trimmings powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | | | Refrigeration Temperature of (5 ±2 ºC) | | | | Freezer Temperature of (-18 ±2 ºC) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non Vacuum Package | | Vacuum Package | | Non Vacuum Package | | Vacuum Package | | Non Vacuum Package | | Vacuum Package | |
| | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour |
| 0 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.3 |
| 1 | 4.4±0.3 | 3.7±0.7 | 4.4±0.1 | 3.7±0.4 | 4.4±0.3 | 3.8±0.1 | 4.4±0.1 | 3.9±0.3 | 4.4±0.1 | 3.9±0.2 | 4.4±0.1 | 3.9±0.3 |
| 2 | 4.2±0.4 | 3.5±0.1 | 4.3±0.2 | 3.6±0.5 | 4.3±0.4 | 3.7±0.2 | 4.4±0.1 | 3.8±0.9 | 4.3±0.8 | 3.9±0.1 | 4.4±0.1 | 3.9±0.3 |

**Values are means of 16 participants ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 17 Mean sensory scores for colour and odour changes during 2 month storage of tuna frames powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | | | Refrigeration Temperature of (5 ±2 ºC) | | | | Freezer Temperature of (-18 ±2 ºC) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non Vacuum Package | | Vacuum Package | | Non Package | Vacuum | Vacuum Package | | Non Package | Vacuum | Vacuum Package | |
| | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour |
| 0 | 3.1±0.6 | 3.3±0.3 | 3.1±0.6 | 3.3±0.3 | 3.1±0.6 | 3.3±0.3 | 3.1±0.6 | 3.3±0.3 | 3.1±0.6 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |
| 1 | 3.1±0.1 | 3.2±0.2 | 3.1±0.2 | 3.3±0.3 | 3.4±0.3 | 3.4±0.2 | 3.4±0.1 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |
| 2 | 3.1±0.1 | 3.2±0.6 | 3.1±0.2 | 3.3±0.4 | 3.4±0.1 | 3.4±0.2 | 3.4±0.1 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 | 3.4±0.2 | 3.4±0.3 |

**Values are means of 16 panelists ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

**Table 18 Mean sensory scores for colour and odour changes during 2 month storage of gills powder which was stored under various conditions**

| Months of Storage | Room Temperature (27±2 ºC) and RH of 75%. | | | | Refrigeration Temperature of (5 ±2 ºC) | | | | Freezer Temperature of (-18 ±2 ºC) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | on Vacuum Package | | Vacuum Package | | Non Package | Vacuum | Vacuum Package | | Non Package | Vacuum | Vacuum Package | |
| | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour | Colour | Odour |
| 0 | 3.5±0.4 | 3.9±0.3 | 3.5±0.4 | 3.9±0.3 | 3.5±0.4 | 3.9±0.3 | 3.5±0.4 | 3.9±0.3 | 3.5±0.4 | 3.9±0.3 | 3.5±0.4 | 3.9±0.3 |
| 1 | 3.4±0.6 | 3.8±0.5 | 3.5±0.3 | 3.9±0.3 | 3.4±0.2 | 3.9±0.2 | 3.4±0.9 | 3.9±0.3 | 3.5±0.2 | 3.8±0.9 | 3.5±0.4 | 3.9±0.3 |
| 2 | 3.4±0.1 | 3.7±0.9 | 3.4±0.9 | 3.8±0.2 | 3.4±0.1 | 3.4±0.2 | 3.4±0.8 | 3.9±0.3 | 3.5±0.2 | 3.8±0.9 | 3.5±0.4 | 3.9±0.3 |

**Values are means of 16 panelists ± standard deviations and those with asterisk are significantly (P<0.05) higher than the initial value (at Month 0 storage time)**

## 4. Conclusion

Fish powder obtained from underutilized fish such as burrito and edible fish processing by products tuna trimmings, gills and frames were found to have 70 to 80.71 g/100 g protein with insignificant (P >0.05) levels of 0.44, 0.33 and 0.21 mg/100 g. All fish products contained high levels of iron, eg, burrito contained 16.58 mg/100 g; tuna frames and gills 16.82 and 19.54 mg/100 g respectively. Zinc levels also ranged from 0.41 mg/100 g in tuna trimmings to 1.88 mg/100 g in tuna gills. These could be rich sources of micronutrients and protein in addressing malnutrition in poor vulnerable groups as they were all microbiologically safe.

The fish powders were used to produce fortified products from locally known snacks as aboloo, agbelikaklo, yakeyake and mpotompoto. Physicochemical properties of the food products fortified with the fish powder showed that their protein contents were increased significant (P <0.05between 3.75 to 8.5 % depending on the powder used. The energy contents of the fortified products ranged from 104.09 to 149.04 %. Most of the fortified products also showed high values of other nutrients.

All the products were acceptable as they were rated above 6 (like slightly) and they were not significantly (P<0.05) different from the reference samples except food products with trimmings which were not acceptable because of the bitterness

During the school feeding trials of the fortified products abolo fortified with the powder of the fish frames was rated highly compared to the abolo fortified with other fishes. The school children liked the taste of all the abolo samples except the abolo fortified with trimmings. However, trimmings in yakeyake was rated high (4) in terms of overall acceptability. Mpotompoto fortified with the various fishes was rated highest in all attributes. A general trend of a somewhat even rating was observed for all the varieties of fishes used. In general fortified products acceptable for the school feeding programe were developed.

Fish powder could be stored for over long period of time when packaged under vacuum in polyethylene pouches with a gauge of 49.25 ml at a refrigeration temperature of 5 ±2 ºC and freezer temperature (-18 ±2 ºC).

## 5. Acknowledgement

The authors wish to thank the Food and Agriculture Organization (FAO) and the Food Research Institute of the Council for Scientific and Industrial Research (FRI/CSIR) for the financial support towards the work.

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## 7. Appendices

Appendix A. Permission letter sent to Institutional Review Board for the Council for Scientific and Industrial Research

**COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH**

**Sample Submission Letter to CSIR-IRB**

Address

(27-02-2015.)

The Chairperson
Institutional Review Board
Council for Scientific and Industrial Research
Head Office, Opposite Chinese Embassy

Dear Chairperson

**Application for Ethical Approval**

1.1 Protocol Name: Development of low cost nutrient dense fish products based on low value fish and fish by-products , using small and medium scale processing and preservation methods that stabilize the nutritional value and ensure the safety of the product

I wish to submit to you the above-named protocol and essential documents for approval by your committee.

I look forward to receiving any comments that you may have in relation to the above.

Thank you for your co-operation.

Yours sincerely

__Dr Lawrence Abbey_____
(Principal Investigator's Name & Signature)

Enclosed:

1. Initial Submission Form A
2. CVs of PIs and Co-PIs
3. Protocol including number and version, (if applicable)
4. Protocol Amendments including number and version or date, (if applicable)
5. Investigator's Brochure including number and version, (if applicable)
6. Patient Information and Informed Consent Form – English version, including version or date, (if applicable)
7. Advertisement-English and local language (date, if applicable)
8. Insurance Policy (if applicable)
9. Others (Name)

Appendix B. Letter of approval from Institutional Review Board for the Council for Scientific and Industrial Research


COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
HEAD OFFICE

P. O. BOX M. 32
ACCRA
GHANA
WEST - AFRICA

TEL: 233-30-2777651-4 (4 Lines)
FAX: 233-30-2777655
E-MAIL: headoffice@csir.org.gh
WEBSITE: www.csir.org.gh


Our Ref: CSIR/IRB/AL/VOL1 Date: 13th July, 2015

**ETHICAL CLEARANCE**

**RPN 005/CSIR-IRB/2015**

The Institutional Review Board of the Council for Scientific and Industrial Research (CSIR-IRB) has reviewed and given approval for the implementation of your study titled:

***"Development of low cost nutrient dense fish products based on low value fish and fish by-products, using small and medium scale processing and preservation methods that stabilize the nutritional value and ensure the safety of the product"***

**PRINCIPAL INVESTIGATOR** : **Dr. Lawrence Dzarkwei Abbey**

**CO – PI's** : **Mrs. Mary Glover-Amengor**
**Mr. Samuel Manu**

Please note that a final review report must be submitted to the Board at the completion of the study. Your research records may be audited at any time during or after the implementation. Any modification of this research project must be submitted to the IRB for review and approval prior to implementation.

Please report all serious adverse events related to this study to CSIR-IRB within seven days verbally and fourteen days in writing.

This certificate is valid till 26th May, 2016.

**Okyere Boateng**
**(CSIR-IRB, Chairman)**

Cc: Dr. Victor K. Agyeman
(Director General, CSIR)

Appendix C. Letter to seek approval and permission from Regional Director of Education, Greater Accra.


# Food Research Institute

*Bankers: Ghana Commercial Bank*
*Telephone: 233-302-519091-5*
*Fax: 233-302-500331 /233-302-519096*
*E-mail: director@fri.csir.org.gh*
*Website: www.fri.csir.org.gh*

*P. O. Box M20*
*Accra, Ghana*


*ALL COMMUNICATIONS SHOULD BE ADDRESSED TO THE DIRECTOR*

Received
Date: 15-10-15
GREATER ACCRA

*Our Ref:* CSIR/FRI/FAO/RM/VOL.1/4 *Date:* 13-Oct-15

The Regional Director of Education

Ghana Education Service

Accra

Dear Sir/Madam,

**Request to conduct a Consumer Acceptability Study in School**

The CSIR-Food Research Institute is mandated by Government of Ghana to conduct applied research into food resources in the country. We have currently developed fish powders from fish species that are nutritious, but not of much economic value. These have been incorporated into local snacks that could be taken by children to boost their protein and mineral levels. In order to find out if these products will be acceptable to children, we wish to ask permission to conduct a trial in the La Enobal Cluster of Schools. We attached an Ethical Clearance letter from The Institutional Review Board of the Council for Scientific and Industrial Research (CSIR-IRB).

This project is being led by Dr. L. D. Abbey a Senior Research Officer and Quality Manager of the CSIR-Food Research Institute. His contact number is 0244768944.

If the products are acceptable, then we shall train processors to process these fishes for convenient use, thus increasing their income levels as well as making nutritious foods readily and constantly available to the children.

Thank you.

Sincerely yours,

Dr Nanam Tay Dziedzoave

Director

Appendix D. Approval and notification letter to the, La Enobal Cluster of Schools

# GHANA EDUCATION SERVICE

In case of reply the
Number and date of this

Letter should be quoted

REPUBLIC OF GHANA

REGIONAL EDUCATION OFFICE
P. O. BOX M.14

Accra

My Ref:GES/GAR/BCS/V1/02
Your Ref

26TH OCTOBER, 2015.

**THE DIRECTOR**
**FOOD RESEARCH INSTITUTE**
**P.O.BOX M20**
**ACCRA-GHANA**

## PERMISSION TO CONDUCT A CONSUMER ACCEPTABILITY STUDY IN SCHOOL

Based on our discussion with you on the above topic, I wish to inform you that you have been granted permission to go ahead with your research.

You are, however, requested to negotiate with the Municipal Director of Education, La-Dadekotopon and the heads of schools in the implementation of the project in the best interest of Ghana Education Service.

Please endeavour to submit your research report to the Directorate after the exercise.

I count on your co-operation.

Thank you.

**FELICIA BOAKYE-YIADOM (MRS)**
**DIRECTOR OF EDUCATION**
**GREATER ACCRA REGION**

Appendix E. Sample of signed consent letters from parent/guardian and student.

# COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH CSIR-IRB PARENTAL/GUARDIAN CONSENT FORM

**1.1** Title: **DEVELOPMENT OF LOW COST NUTRIENT DENSE FISH PRODUCTS BASED ON LOW VALUE FISH AND FISH BYPRODUCTS USING SMALL AND MEDIUM SCALE PROCESSING AND PRESERVATION METHODS THAT STABILIZE THE NUTRITIONAL VALUE AND ENSURE THE SAFETY OF THE PRODUCT.**

Principal Investigator: Lawrence D. Abbey

Address: CSIR-Food Research Institute P.O. Box M20 Accra

**General Information about Research:**
The research is about the development of low cost nutrient dense fish products, utilizing low value fish and edible fish by products, using small and medium scale processing and preservation methods. This involves the processing of fish and fish by products of low economic value, which would then be included in local diets as a value addition and improving nutrition as well as reducing waste.

The products could also be used in the national school-feeding initiatives as there would be an acceptability study of the products amongst locals and school children. The acceptability studies of the products would be by assessing the appearance, flavor, taste and overall acceptability.

It is estimated that a total period of 3 working days would be used in these studies.

The products will be low cost and easy to store and transport. The technology developed would be transferred to other fish producing / processing areas to create opportunities for small and medium –scale entrepreneurs and a manual covering the processes will be prepared.

**You as a parent/guardian is kindly asked to grant your consent to your ward to participate in this programme**

**Possible Risks and Discomforts**
No possible risks or discomfort are anticipated.

**Possible Benefits**
There would be no direct benefits to the participants but for information purposes. However data generated would be useful to improve the development of products of dense nutrient value from fish to be included in local diets and as a value addition while reducing waste.

**Alternatives to Participation**
Not applicable

**Confidentiality**
Details of participants would not be disclosed to anybody. The information needed is on the products only and the data collected would be published

**Compensation**
There would be no financial compensation, however, some light refreshment by way of soft drinks and cookies would be provided.

**Additional Cost**
Not applicable

**Staying in the Research**
This is not applicable. It is just a cross-sectional study in which data would be collected once only.

**Voluntary Participation and Right to Leave the Research**
The research is voluntary and your ward can withdraw without penalty

**Termination of Participation by the Researcher**
This is not applicable.

**Notification of Significant New Findings**
New significant findings would be shared with participants through interactions with school and community authorities. The results would also be published in a peer –reviewed journal.

**Contacts for Additional Information**
Dr. Lawrence Abbey Mobile 0244768944

**Your rights as a Parent**
This research has been reviewed and approved by the Institutional Review Board and Institutional Animal Care and Use Committee of Council for Scientific and Industrial Research (CSIR-IRB/IACUC). If you have any questions about your rights as a parent/guardian you can contact the IRB/IACUC Office between the hours of 8am-5pm through the landline 0302777651 or email addresses: csirirb_iacuc@csir.org.gh or pselormey@gmail.com. You may also contact the chairman, Mr. Okyere Boateng through mobile number 0204362635 when necessary.

**PARENTAL/GUARDIAN AGREEMENT**

The above document describing the benefits, risks and procedures for the research titled **"Development of low cost nutrient dense fish products based on low value fish and edible fish by-products, using small and medium scale processing and preservation methods that stabilize the nutritional value and ensure the safety of the product"** has been read over and explained to me in ....GA..... **Language,** and I have perfectly understood the explanation. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to allow my ward to participate.

VERONICA TEMOSON — Name
30/11/15 — Date
Signature or mark of parent /guardian

Raymond K. — Name
30/11/15 — Date
Signature of Witness

Dr. Lawrence Abbey — Name
15/11/15 — Date
Signature of Person taking Consent

# COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
# INSTITUTIONAL REVIEW BOARD (CSIR-IRB)
# CHILD ASSENT FORM

**General Information**

My name is *Dr. Lawrence Abbey* and I am from the *CSIR-Food Research Institute.* I am conducting a research study entitled: Development of low cost nutrient dense fish products, utilizing low value fish and edible fish by products, using small and medium scale processing and preservation methods. I am asking you to take part in this research study. This study would afford me to opportunity to learn more about incorporating fish in local diets that would stabilize the nutritional value and ensure food safety. This will take a total of 3 working days

If you agree to be in this study, you would be asked to *assess* fish based local products

**Possible Benefits**

There would be no direct benefits to the participants but for information purposes. However data generated would be useful to improve the development of products of dense nutrient value from fish to be included local diets and as a value addition while reducing waste.

**Possible Risk**

No possible risks or discomfort are anticipated.

**Compensation**

There would be no financial compensation, however, some light refreshment by way of soft drinks and cookies would be provided

**Alternatives to Participation**

Not applicable to this study.

**Confidentiality**

Details of participants would not be disclosed to anybody. The information needed is on the products only and the data collected would be published

**Voluntary Participation and Right to Leave the Research**

Participation is voluntary and participants can withdraw from the study at will without any penalty.

**Contacts for Additional Information**

*Dr. Lawrence Abbey, CSIR/ Food Research Institute. (0244768944).*

**Your rights as a Participant**

This research has been reviewed and approved by the Institutional Review Board and Institutional Animal Care and Use Committee of Council for Scientific and Industrial Research (CSIR-IRB/IACUC). If you have any questions about your rights as a research participant you can contact the IRB/IACUC Office between the hours of 8am-5pm through the landline 0302777651 or email addresses: csirirb_iacuc@csir.org.gh or pselormey@gmail.com . You may also contact the chairman, Mr. Okyere Boateng through mobile number 0204362635 when necessary.

***NB:** By signing below, it means that you understand and know the issues concerning this research study. If you do not want to participate in this study, please do not sign this assent form. You and your parents will be given a copy of this form after you have signed it.*

**VOLUNTEER AGREEMENT**

The above document describing the benefits, risks and procedures for the research titled "**Development of low cost nutrient dense fish products based on low value fish and fish by-products , using small and medium scale processing and preservation methods that stabilize the nutritional value and ensure the safety of the product"** has been read over and explained to me in ..... **Language** by .....in the presence of .....

**(Name of the person obtaining consent)**

GRACE ODOI... and I MARY N. Okpi. have

**(name of Parent)** **(name of child)**

perfectly understood the explanation. I have been. given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

30th November 2015
Date

Signature or mark of volunteer (Child's)

28/11/15
Date

Signature of Witness (parent's)

15/11/15
Date

Signature of Person Who Obtained Consent

Appendix F. Sensory form for used to assess characteristics of products using the 9 point hedonic scale, with 9 meaning like extremely and 1 meaning dislike extremely

**BALLOT SHEET FOR CONSUMER EVALUATION OF A FISH POWDER BASED SNACK**

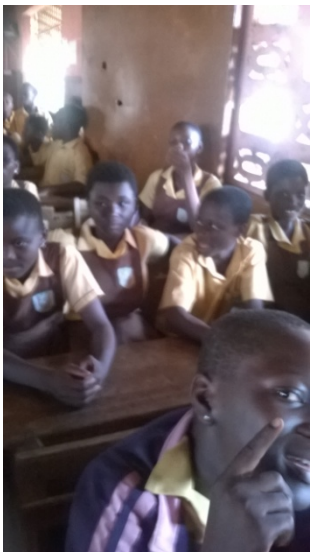
You have been provided with Fish snacks. Please assess these samples and rate under the listed attributes using the scale below. Refresh your palate with the unsalted cracker and rinse your mouth with the water provided before moving to the next sample. Rate the sample provided from left to right. For each sample write the code in the box that most represents your feeling about the attribute you are rating**.**

| SCALE | 9<br>Like extremely | 8<br>Like very much | 7<br>Like moderately | 6<br>Like slightly | 5<br>Neither like nor dislike | 4<br>Dislike slightly | 3<br>Dislike moderately | 2<br>Dislike very much | 1<br>Dislike extremely |
|---|---|---|---|---|---|---|---|---|---|
| Appearance | | | | | | | | | |
| Colour | | | | | | | | | |
| Aroma | | | | | | | | | |
| Taste | | | | | | | | | |
| Texture | | | | | | | | | |
| Mouth feel | | | | | | | | | |
| Overall acceptability | | | | | | | | | |

**Comments:**

Appendix G Pictorial depictions of the feeding trials at La Enobal Cluster of Schools

CSIR-FRI staff briefing participants before the trials



Participants listening with rapt attention and excitement to the briefing before the trials

Yakeyake as one of the fortified snacks being prepared for serving to the participants

Mpotompoto as one of the fortified snacks being prepared for serving to the participants

Fortified Aboloo being placed in plates for serving

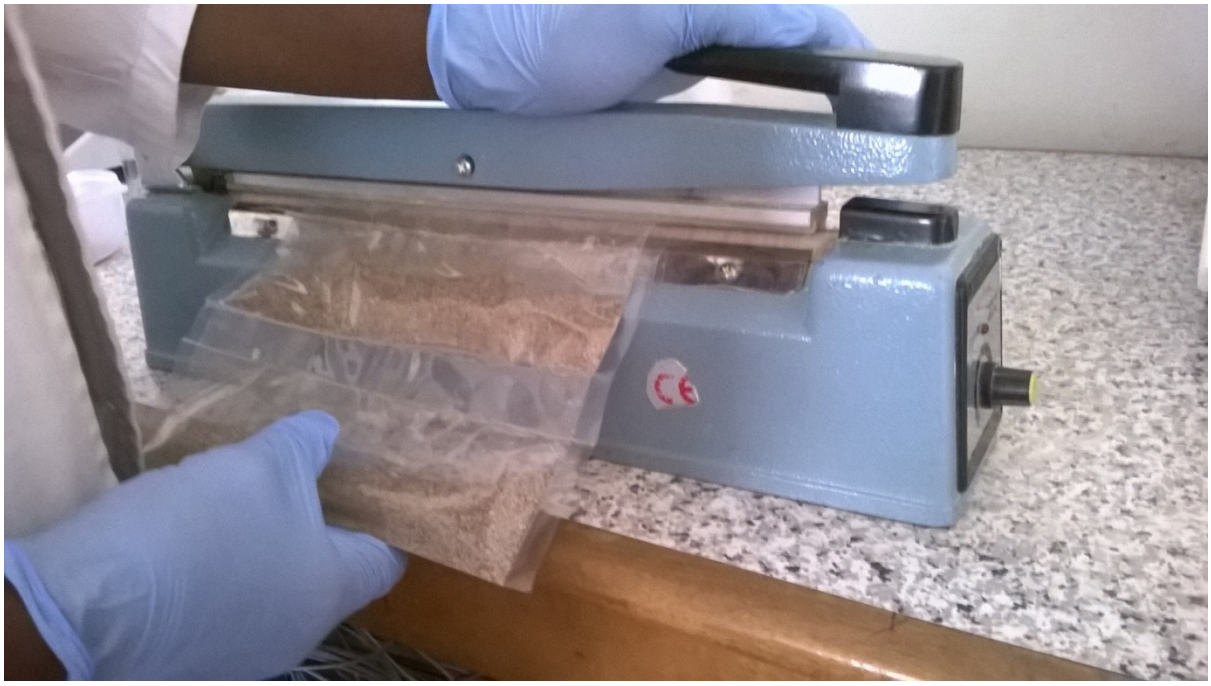
Participants evaluating the fortified products served to them

More participants evaluating the fortified products served to them


Small snack products available for refreshment after the trials

Participants having some refreshments after the trials

Appendix H Products placed in the packaging pouches and sealed



Non-vacuum package samples of the powder being sealed

Vacuum packaging of samples of the powder

Samples of the packaged powders

Appendix I. Sensory form used to assess characteristics of stored powders using the 5 point hedonic scale, scale as 5-white, 1- brown for colour and 5-neutral, 1-mushy/rancid for odour

You have been provided with Fish powders. Please assess these samples and rate under the listed attributes using the scale below.

| SCALE | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|
| Colour | | | | | |
| Odour | | | | | |