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Nutrient-rich foods to improve diet quality in the first 1000 days of life in Malawi and Zambia: Formulation, processing and sensory evaluation

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Nutrient-rich foods to improve diet quality in the first 1000 days of life in Malawi and Zambia: Formulation, processing and sensory evaluation

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List of abbreviations

DGLVs	dark green leafy vegetables
DHA	docosahexaenoic acid
DHS	Demographic and Health Surveys
EPA	eicosapentaenoic acid
FAO	Food and Agriculture Organization of the United Nations
FGDs	focus group discussions
FISH	CGIAR Research Program on Fish Agri-Food Systems
ICF	Inner City Fund
IFAD	International Fund for Agricultural Development
IYCF	infant and young child feeding
MoH	Ministry of Health
RDA	recommended dietary allowance
SPRODETA	Small Producers' Development & Transporters Association
SUN	Scaling Up Nutrition
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WRO	World Relief Organization

Definitions and terms

1000 days: The period of time from the onset of pregnancy to a child's second birthday, which is considered the window of opportunity to positively impact the child's growth, development and cognition.

Acute malnutrition: Also known as wasting, acute malnutrition is characterized by a rapid deterioration in nutritional status over a short period of time. In children, it is measured using the weight-for-height nutritional index or mid-upper arm circumference. There are two different levels of severity of acute malnutrition: moderate acute malnutrition and severe acute malnutrition.

Anemia: Characterized by reduction in hemoglobin levels or red blood cells, which impairs the ability to supply oxygen to the body's tissues, anemia is caused by inadequate intake and/or poor absorption of iron, folate, vitamin B12 and other nutrients. It is also caused by infectious diseases such as malaria, hookworm infestation and schistosomiasis, as well as genetic diseases. Women and children are high-risk populations. Clinical signs include fatigue, pallor (paleness), breathlessness and headaches.

Chronic malnutrition: Chronic malnutrition, also known as stunting, is a form of growth failure that develops over a long period of time. Inadequate nutrition over long periods of time (including poor maternal nutrition and poor infant and young child feeding practices) and/or repeated infections can lead to stunting. In children, it is measured using the height-for-age nutritional index.

Complementary feeding: The use of age-appropriate, adequate and safe solid or semisolid food in addition to breastmilk or a breastmilk substitute. The process starts when breastmilk or infant formula alone is no longer sufficient to meet the nutritional requirements of an infant. It is not recommended to provide any solid, semisolid or soft foods to children less than 6 months of age. The target range for complementary feeding is generally considered to be 6–23 months of age.

Exclusive breastfeeding: An infant receives only breastmilk and no other liquids or solids, not even water, with the exception of oral rehydration salts or drops or syrups consisting of vitamins, mineral supplements or medicine. The United Nations Children's Fund (UNICEF) recommends exclusive breastfeeding for infants aged 0–6 months of age.

Food fortification: The addition of micronutrients to a food during or after processing to amounts greater than were present in the original food product. This is also known as enrichment.

Food and nutrition security: Food and nutrition security exists when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life, as defined by the 2012 Committee on World Food Security.

Food security: Food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life, as defined by the 1996 World Food Summit.

Infant and young child feeding: Term used to describe the feeding of infants (less than 12 months old) and young children (12–23 months old). Infant and young child feeding programs focus on the protection, promotion and support of exclusive breastfeeding for the first 6 months of life, on timely introduction of complementary feeding from 6 months of age, and continued breastfeeding for 2 years or beyond.

Malnutrition: People are malnourished if their diet does not provide sufficient nutrients for growth and maintenance or if they are unable to fully use the food they eat due to illness (undernutrition). They are also malnourished if they consume too much energy in relation to energy expenditure (overnutrition).

Micronutrients: Essential vitamins and minerals required by the body in miniscule amounts throughout the life cycle.

Minimum acceptable diet: Proportion of children aged 6–23 months who receive a minimum acceptable diet (apart from breastmilk). It is a composite indicator that is calculated from two fractions: (1) the proportion of breastfed children 6–23 months of age who had at least the minimum dietary diversity and the minimum meal frequency during the previous day, and (2) the proportion of non-breastfed children 6–23 months of age who received at least two milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day.

Minimum dietary diversity: Proportion of children aged 6–23 months who receive foods from four or more food groups.

Minimum meal frequency: Proportion of breastfed and non-breastfed children aged 6–23 months, who receive solid, semisolid or soft foods (and milk feeds for non-breastfed children) the minimum recommended number of times or more (noted as "feeding frequency" in this report).

Nutritional status: The growth or micronutrient status of an individual.

Obesity: A person with a body mass index (BMI) of 30 or more is considered obese.

Overweight: A person with a body mass index (BMI) of 25 or more is considered overweight.

Supplementation (micronutrient): Provision of micronutrients via a tablet, capsule, syrup or powder.

Executive summary

Malawi and Zambia, neighboring countries located in Southeastern Africa, both have populations of about 17–18 million people; however population density is drastically different (11 people per square kilometer in Zambia compared to 192 people per square kilometer in Malawi).[1] Malawi's Human Development ranking is 0.485 as of 2018, putting it in the low human development category, with a position of 172 out of 189 countries and territories, while Zambia is categorized as medium human development at 143 out of 189 countries (HDI 0.591).[2] Although development has brought benefits to urban areas, poverty in rural areas remains widespread.

While many rural households depend on subsistence agriculture, low dietary diversity and seasonal hunger impact food security and nutritional status for the population—seen in high rates of chronic malnutrition in children under 5 (stunting). Food insecurity and malnutrition remain at critical levels in both countries, with persistently high stunting rates—nearly double that of the global average (35% in Zambia, 37% in Malawi and 21% globally). Although rates of malnutrition have improved in Zambia over the last 5 years (reduction in under-5 child stunting from 40% to 35%) (DHS, 2015; Zambia Statistics Agency, MOH Zambia and ICF 2019), rural-urban disparities in child nutrition outcomes remain persistent in both countries. Realizing the need to improve food and nutrition security in each country, the governments of Zambia and Malawi joined the Scaling Up Nutrition (SUN) movement in 2010 and 2011 to improve organization of cross-sectoral nutrition interventions. Each country designated a coordination group to develop and operationalize nutrition strategies—the Department of Nutrition within the Malawi Ministry of Health and Population, and the National Food and Nutrition Commission of Zambia, each prioritizing nutrition interventions in the first 1000 days.

Diets in Zambia and Malawi are dominated by cereals such as maize and cassava, cooked into a hard porridge called *nshima* and accompanied by seasonal plant-source foods. Although diets are predominantly plant-based in rural areas, fish is an important part of the diet in both Malawi and Zambia, accounting for approximately 40% of animal protein consumed (FAO 2019). Not only is fish an important source of animal protein in the diet, but it also contains essential vitamins, minerals and fatty acids, and when consumed with plant-source foods it can increase the bioavailability of nutrients from these foods as well. Fish consumption during the first 1000 days—from conception to the child's second birthday—is especially important, as fish contain essential fatty acids and micronutrients which are important for cognitive and physical growth.

This report focuses on nutrition strategies implemented in Zambia and Malawi with the aim to improve consumption of nutrient-rich foods during the first 1000 days, as part of a project entitled Strengthening Capacity of Local Actors in Nutrition-sensitive Agri-food Value Chains in Zambia and Malawi. The project, funded by the International Fund for Agricultural Development (IFAD) and implemented by McGill University, WorldFish, Bioversity International and local partners in each country focused on improved production and processing of fish, dark green leafy vegetables (DGLVs), and beans to improve availability, access and consumption of nutrient-rich foods for young children. The report begins with a literature review describing the food and nutrition security situation in each country, including traditional complementary feeding methods (the introduction of foods for children at 6 months of age, following exclusive breastfeeding), followed by methodology and study design. Through participatory design, sensory evaluations and acceptability trials, market diagnostics and analysis of opportunities to scale-up, results of the development of age-appropriate nutrient-rich products are presented and discussed in this report.

Key findings

- Nutrient-rich fish, DGLVs and bean powders were highly acceptable in target areas of Malawi and Zambia, when combined with local recipes prepared for infants and young children (6-23 months) as well as adults, offering an opportunity to improve the nutrient content of local recipes through the use of locally available nutrient-rich foods.
- Access to small-scale infrastructure tested in this study should be upscaled in order to increase consumption of fish and bean powders for infants and young children. Production of bean and fish powders at the household level was time-consuming for women and traditional processing techniques may result in sub-optimal food quality.
- Although improved processing methods are necessary for upscaling production and supply of nutrient-rich powders, demand for these products may be stimulated by awareness raising of the nutritional importance and versatility of products such as fish powder to be added to foods for infants and young children as well as the whole family.

Dried fish for sale along the Kasama-Luwingu Road in northern Zambia.

Background

In the project Strengthening Capacity of Local Actors in Nutrition-Sensitive Agri-Food Value Chains in Zambia and Malawi, a component to improve production and processing methods of diverse, nutrient-rich foods, particularly fish, DGLVs and beans was implemented. Specific emphasis was placed on improving nutrition in the first 1000 days of life, particularly among poor women and children, by increasing availability, accessibility and consumption of nutrient-rich fish products (WorldFish 2017). The project, led by McGill University and funded by IFAD, aimed to work with communities to identify locally available and accessible species of fish, DGLVs and beans, and to utilize and explore local processing methods to create nutrient-rich powders for increased consumption of essential nutrients by infants, young children and other family members. Activities were designed with the communities to enhance nutrition by incorporating nutrient-rich powders in their own local recipes, improve complementary feeding practices for children, and give insights on the feasibility of scaling up the production of nutrient-rich agri-food products produced within local communities. This report reviews the importance of aquaculture, agriculture and dietary diversity; the role that essential nutrients from fish, DGLVs and beans play in the first 1000 days of life, with focus on complementary feeding; as well as promotion, acceptance and scaling up of diverse complementary foods, processed from local fish, DGLVs and beans in selected areas of Malawi and Zambia.

Women and a man in Ipusukilo ward of Zambia show a solar drying tent.

Introduction and literature review

Role of aquaculture, agriculture and dietary diversity in the first 1000 days of life

The nutritional status of children in the first 1000 days of life, from conception to two years of age, is crucial for optimal growth and development. During this time, the mother's nutrition is very important to ensure her own health, the growth of the fetus, optimal birth outcomes, exclusive breastfeeding of the child from birth up to 6 months of age, and continued breastfeeding with complementary feeding up to the child's second birthday. A child's nutritional status depends on many factors, including food, caregiving practices, water, sanitation and hygiene. Dietary diversity, as an indicator of diet quality, is associated with greater micronutrient adequacies in the diet (Ruel 2014). Minimum Dietary Diversity for Women (MDD-W) is based on consumption of foods from a minimum, of 5 out of the 10 food groups as a proxy for micronutrient adequacy in the diet, whereas for children it is based on consumption of foods from 4 of 7 food groups. Agriculture and aquaculture are accountable for producing sufficient amounts and varieties of foods; however, parallel investments on nutrition education and social behavior change communication to promote optimal dietary diversity of women and children in the first 1000 days of life are essential (Ruel 2014).

Malnutrition in Malawi and Zambia

Sub-optimal mental and physical development of the child can result from poor nutrition during the first 1000 days of life. Diets with a variety of nutritious foods are important for the mother during pregnancy and lactation, as well as diverse, nutritious, age-appropriate foods for the child from 6 months of age. In Malawi, exclusive breastfeeding of children younger than 6 months is practiced by 61% of mothers, a decrease of 11% from the 2010 survey, when 72% of mothers exclusively breastfed (DHS NS 2016). In Zambia, 70% of children younger than 6 months are exclusively breastfed (Zambia Statistics Agency, Ministry of Health, Zambia, and ICF 2020). In the recent Demographic and Health Surveys, 37% of children under 5 years old in Malawi were stunted, 12% were underweight and 3% wasted (NSO 2016a). In Zambia, the rates were 35% stunted, 12% underweight and 4% wasted (Zambia Statistics Agency, Ministry of Health, Zambia, and ICF 2020).

Low dietary diversity may contribute to poor nutritional status and micronutrient deficiencies such as anemia and vitamin A deficiency. Dietary micronutrient deficiencies of iron and vitamin A are common in both countries. The prevalence of anemia in Malawi in women age 15–49 years is 33%, and in children 6–59 months it is 63% (DHS NS 2016). Data for Malawi shows a prevalence of anemia of 45% in pregnant women and 33% in lactating women, compared with 30% of non-pregnant, non-lactating women) (DHS NS 2016). The anemia rate increases in pregnant and lactating women due to increased needs for iron during this time. In Zambia, vitamin A deficiency continues to be a public health issue, with 73% of children 6–59 months receiving vitamin A supplementation and many women receiving a post-partum dose (Zambia Statistics Agency, Ministry of Health, Zambia, and ICF 2020; CSO 2014).

Nutritional requirements of a child 6 months of age or older exceed that which breastmilk alone can provide, therefore complementary feeding must begin at 6 months of age. Most childhood undernourishment occurs during this time (Victora 2010), when the child transitions from only breastmilk to breastmilk complemented with semi-solid foods. The most common foods used in complementary feeding in Malawi and Zambia are made from staple foods such as maize or cassava. In Malawi, protein-rich foods such as legumes and nuts are fed to 18% of children aged 6–23 months; fruits and vegetables are fed to 59%, and fish, meat or poultry are fed to 37% (DHS 2015). In Zambia, only 13% of children aged 6–23 months are fed appropriate diets as recommended by minimum acceptable dietary standards (Zambia Statistics Agency, Ministry of Health, Zambia, and ICF 2020). Whereas in Malawi, only 8% of children meet minimum acceptable dietary standards (DHS NS 2016). The minimum acceptable diet for infants and young children includes indicators for minimum dietary diversity for children (consuming

at least four out of seven food groups), feeding frequency, and consumption of breastmilk.

Local foods used in complementary feeding

There is increasing interest in the development of recipes from diverse local foods for complementary feeding to increase consumption of essential micronutrients, as local foods may be more acceptable and affordable for communities as compared to commercial supplements and fortified foods. In a study conducted in Nigeria, complementary foods made from local cereals were more affordable and readily accepted than commercial complementary foods. However, infants eating only cereals and breastmilk were getting inadequate amounts of iron and calcium (Agbon 2009). In Bangladesh, a fish chutney was used as a condiment in the main meal of pregnant and lactating women and a fish powder was incorporated as complementary food for infants (Bogard 2015). In the Democratic Republic of Congo, caterpillars were used to fortify the cereal diet (Bauserman et al. 2013). These studies demonstrated that using locally available, nutrient-rich foods to fortify local dishes could significantly contribute to increasing micronutrient intakes of pregnant and lactating women, infants and children.

Nutritional importance of the three target food groups: Fish, dark green leafy vegetables and beans

Three target food groups—fish, DGLVs and beans—were selected for their potential contributions to improving diet quality in Malawi and Zambia. Many small fish are especially rich in vitamin A and calcium, as they are often consumed whole, including the bones, eyes and viscera. When consumed as part of a meal, fish can improve the bioavailability or absorption of iron and zinc from other foods (ANEP 2013). Essential fatty acids, including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which are only found in fish, were found to be critical for consumption by pregnant and lactating mothers as well as young children, as essential fatty acids are crucial for cognitive development in the first 1000 days of life. Consumption of fish by the mother is a strong determinant of omega-3 fatty acid content of breastmilk, and fish and breastmilk were identified as the most important dietary sources of omega-3 fatty acids for children at complementary feeding age (Michaelsen 2011).

DGLVs are rich in vitamins A, C, E and K, as well as B vitamins such as folate, which promotes heart health, development of the nervous system of a fetus and can help to prevent certain birth defects (Yan 2016), making it an important source of nutrients during pregnancy. Nutrient analyses of eight African leafy vegetables, including pumpkin leaves and cowpea leaves, found that pumpkin leaves could provide 50%–75% of the recommended dietary allowance (RDA) of vitamin A and iron for children, and cowpea leaves could provide more than 75% of the RDA of vitamin A (van Jaarsveld 2014). Increased consumption of DGLVs was proven to be correlated to increased serum retinol levels and improved vitamin A status in young children (Takyi 1999) and lactating women (Khan 2007).

In a study on legume consumption comparing bean consumers to non-bean consumers, bean consumers had higher intakes of dietary fiber, folate, potassium, magnesium, iron and copper (Papanikolaou 2008). Beans also provide a good plant-source protein, and may reduce risk for cardiovascular diseases, diabetes, as well as obesity (Garden-Robinson 2013). The prevalence of overweight and obese women in Malawi—one out of every five women (DHS 2016)—highlights the effect that beans may have in weight management.

Methodology

Study setting

A study team, led by a WorldFish staff member with a technical background and field experience in nutrition and food and nutrition security in developing countries, and WorldFish staff based in Zambia, Malawi and WorldFish headquarters in Penang, Malaysia, planned, developed and conducted the study. Close consultations and engagement with partners and communities in Malawi and Zambia took place throughout.

As detailed in Figures 1 and 2, two areas were selected in each country for project implementation: Kameme and Lufita extension planning areas in Northern Malawi, and Ibale and Ipusukilo wards in Northern Zambia.

Participants were selected, with the help of national partners SPRODETA (Malawi) and Self Help Africa (Zambia), from each community based on present and possible future engagement with nutrient-rich products.

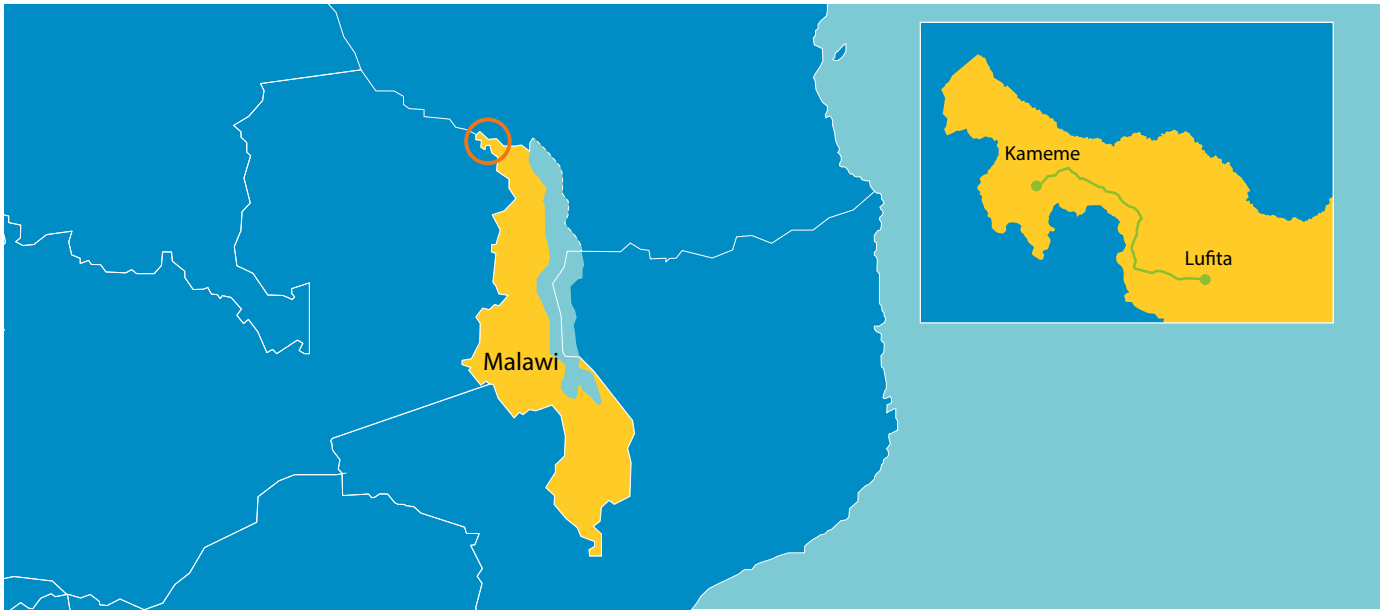


Figure 1. Map of Chitipa District, Malawi showing Kameme and Lufita communities (Malawi).

Figure 2. Map of Luwingu District, Zambia showing Ipusukilo and Ibale communities (Zambia).

Key informant interviews, focus group discussions (FGDs), cooking demonstrations and sensory evaluations were held in Malawi in March 2017 and in Zambia in April 2017 to discuss local agrobiodiversity and seasonal availability of foods. Processing workshops and market visits were conducted in Zambia in June 2017 and in Malawi in September 2017. Information about the setting of each community, including geographic distance and access to the nearest town is presented in Table 1.

Study design

Methodological framework

Figure 3 details the methodological framework for the activities related to the participatory development of nutrient-rich powders from local nutrient-rich agri-food products. Each activity in the methodological framework is numbered in the order in which it was completed—starting with "1. Focus Group Discussions about locally available foods and their seasonal availability." The study was designed to be highly participatory, involving local community members in every step and providing feedback to the community through knowledge sharing and advocacy of research outcomes.

1. Key informant interviews and focus group discussions

Key informant interviews and FGDs were held in Malawi in March 2017 and in Zambia in April 2017 to discuss local agrobiodiversity and seasonal availability of selected nutrient-rich foods. Key informants included district-level government officials from the Ministry of Health, Ministry of Agriculture and Department of Fisheries, as well as volunteers from community-level health posts.

The first FGD was held in Kameme Navitengo Extension Planning Area on March 9, 2017. This community is located approximately 40 km from Chitipa town, and is accessible by unpaved road, which made it difficult to access the community during the rainy season. Twenty participants, 20–42 years old, participated in the cooking demonstration and sensory evaluation, and five infants took part in the acceptance evaluation.

The second FGD was held in Lufita Extension Planning Area Section I on March 13, 2017. This community is located approximately 10 km from Chitipa town, and is accessible by using the Chitipa-Karonga road, the first tarmac road linking these towns which was completed in 2013. Twenty-six participants, 19–42 years old participated in the cooking demonstration and sensory evaluation and six infants took part in the acceptance evaluation.

FGDs in Luwingu District, Northern Province of Zambia began in April 2017. The first FGD was held in Ipusukilo Nsanje on April 21, 2017. This community is located approximately 20 km from Luwingu town and is accessible by unpaved road. Twenty-four participants, 21–50 years old participated in the FGD. Eight children aged between 6 months and 23 months as well as seven other children older than 23 months of age (data not reported), participated in the cooking demonstration and sensory evaluation.

	Malawi		Zambia	
Community	**Kameme**	**Lufita/Chinunkha**	**Ipusukilo**	**Ibale**
Dates of FGDs, Cooking Demonstrations and Sensory Evaluations	March 9–10, 2017	March 13–14, 2017	April 21–22, 2017	April 26–27, 2017
Dates of Processing workshops and Market Visits	September 18, 2017	September 19, 2017	June 21, 2017	June 20, 2017
Access to Community	60 km from Chitipa town, unpaved road	10 km from Chitipa town, paved road	20 km from Luwingu town, unpaved road	80 km from Luwingu town, unpaved road

Table 1. Details on project setting and dates for focus groups discussions, cooking demonstrations and sensory evaluations.

The second FGD in Zambia was held in Ibale on April 26, 2017. This community is located approximately 80 km from Luwingu town and is accessible by using unpaved road and footpaths. Twenty-four participants 15–42 years old participated in the FGD. Fifteen children, of which four (data not reported) were older than the target age range of 6–23 months, participated in the cooking demonstration and sensory evaluation of foods.

2. Cooking demonstrations and sensory evaluations

FGDs, cooking demonstrations and sensory evaluations were designed to take place over 2 days in each community. On the first day, participants participated in FGDs on topics such as seasonal availability of local foods, important foods for different family members and reasons for importance, common dishes and preparation methods, and ingredients that are highly accessible to many households, with a focus on the three target food groups. Participatory cooking demonstrations were held on the second day, starting with the formulation of the three nutrient-rich powders, one from each food group, then incorporating these powders into the three selected dishes, and finally, completion of the sensory evaluation of each dish by adults as well as children (if present).

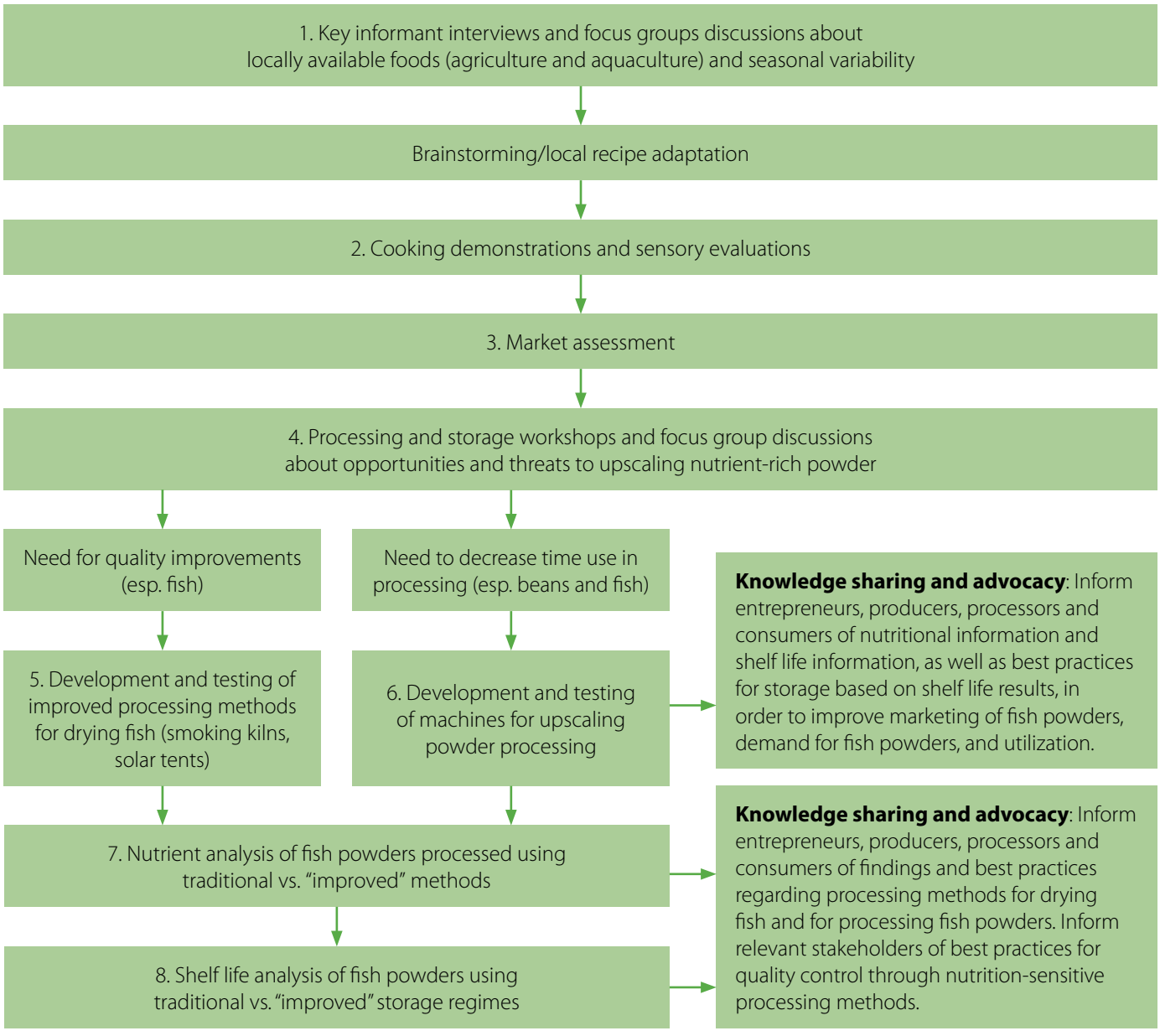


Figure 3. Methodological framework for participatory development of nutrient-rich powders.

3. Market assessment

WorldFish staff visited local markets to explore the current production, marketing, transportation and storage of key foods and products to investigate and understand the value chain for these products. Interviews were also conducted with key informants, including producers, vendors, consumers and government officials to gain further insights into the market forces and factors affecting availability of nutrient-rich foods to consumers.

4. Processing and storage workshops

Based on initial positive reactions from the sensory evaluation and acceptability trials of nutrient-rich powders, processing and storage workshops were held in June 2017 in Zambia and September 2017 in Malawi. The aim of these workshops was to introduce nutrient-rich powder processing to a greater number of community members and explore the opportunities and limitations to scaling up nutrient-rich powder processing in communities through (a) hands-on processing of the nutrient-rich powders, (b) tasting of local recipes with nutrient- rich powders, and (c) discussions about the strengths, weaknesses, opportunities and threats (SWOT) to scaling up nutrient-rich powder production and use within the community.

a. Processing nutrient-rich powders

At the beginning of each workshop, participants were informed of the objectives of the workshop and later were asked to bring forward the materials that they will use in the processing of powders and cooking demonstrations. For each workshop, varieties of small fish, DGLVs and beans were identified using data collected from previous FGDs, cooking demonstrations and key informant interviews which informed the seasonal availability of these foods and preferred varieties in each community, as well as best practices for producing powders. Some of the materials that participants brought included mortars, pestles, sieves, bowls (in which the powders were kept), *imbowla* (charcoal stove for cooking as well as for further drying of the fish and beans by roasting), charcoal, and cooking utensils such as pots, plates and spoons. In addition, participants brought beans and dried vegetables. For beans, approximately 2 kg per site were sourced locally and soaked overnight and dried for 2 days in advance before the actual day of the workshop. Beans were pre-soaked to improve the nutrient-sensitive processing methods, as soaking beans helps to remove anti-nutritional factors and makes for easy pounding. Dried small fish varieties of *masukulunji* and *usipa* (approximately 3 kg of each species) were bought at Karonga market by the study team en route to Chitipa. The images below show some of the materials that participants brought for use during the processing workshops at Kameme, Lufita and Chinunkha in Malawi.

Plate 1. Materials brought to processing workshops by participants.

Plate 2. Mortars, pestles, sieves, bowl, *imbowla*, pots, plates.

In each workshop, participants were asked to break into three groups to start pounding the dried small fish, DGLVs and beans into powders. Facilitators asked the groups to rotate so that all groups acquired hands-on experience in processing the three types of powders. The participants were asked if they would be willing to taste the powders cooked into dishes. Participants were also informed that they would be asked to provide feedback after having tasted the dishes. Photos below show some of the participants processing the foods into powders.

Plate 3. Dried vegetables.

Plate 4. Dried small fish species *usipa*.

Plate 5. Dried beans, brought by participants.

Plate 6. Pounding of dried small fish into powder.

Plate 7. Dried small fish species, *masukulunji*.

Plate 8. Powdered fish.

Plate 9. Dark green leafy vegetable powder.

Plate 10. Bean powder.

Plate 11. Dark green vegetable powders added to rice after fish powder has been added.

Plate 12. Cooking coarsely ground beans.

b. Cooking and Tasting

Participants cooked rice and coarsely ground beans (which could not be sieved) in separate pots. These served as the base for different nutrient-rich powders of fish, DGLVs and beans to be added for the participants to taste and provide feedback. Pictures below show some of the foods being cooked for the participants to taste.

The cooked foods (with different powders added) were served on plates for participants to taste as shown in the Plates 13 and 14.

Plate 13. Serving of dishes on plates.

Plate 14. Tasting a cooked dish with nutrient-rich powders.

c. Discussion about processing each nutrient-rich powder

Having gained hands-on experience in processing each powder, as well as tasting the powders in dishes that were provided for lunch, the group then convened for a discussion. To facilitate discussion, facilitators guided participants through a participatory SWOT analysis in order to understand the use of nutrient-rich powders in the communities. The SWOT was conducted to evaluate the (S) strengths of each product, (W) weaknesses of each product, (O) opportunities for each of the powders to be widely consumed, produced or sold in their communities or markets, and (T) threats present in the community to the use of the powders. Later, the participants voted on the powders which participants would be willing to purchase, if available at the market, and they also checked if there were business opportunities in producing these powders at the local level and what would be needed to start such kind of businesses.

5. Development and testing of improved processing methods

Observations of current practices in the communities, market assessments, FGDs and key informant interviews revealed the need for enhanced processing methods to improve food safety and nutrient retention when drying or smoking fish before processing into fish powder. The study team and partners developed prototypes of solar drying tents and smoking kilns for "improved" methods for drying and smoking fish, based on literature review and past successful research projects.

6. Development and testing of machines for scaling up processing of nutrient-rich powders

Through market visits and discussions during processing workshops, the need for machinery to scale up and improve the quality of nutrient-rich powders was identified. Potential machines were identified that could be tested for scaling up nutrient-rich powder production. Upon return to Lilongwe and Lusaka, members of the study team contacted local machinery vendors to inquire about testing.

Data collection techniques

1. Key informant interviews and focus group discussions

Key informant interviews were conducted to speak with stakeholders about agriculture, aquaculture, health and nutrition. Interviews were conducted with stakeholders working in nutrition, health and fisheries, including health care facilities, extension officers and government representatives at local, district, regional, and national levels, in addition to traditional authorities in target areas.

FGDs were selected as a data collection method to provide insight from a large number of people in the community with diverse perspectives on nutrition and child feeding in the first 1000 days. Participants were selected for FGDs to represent gender (women and men), pregnant and lactating women, and caretakers of children under 2 years of age (mothers, fathers or grandparents).

2. Cooking demonstrations and sensory evaluations

For the cooking demonstrations and sensory evaluations, participants were asked to bring their children under the age of 2 years to participate. All participation was voluntary, and any person who did not consent to participate was excluded.

2.1 Selection of ingredients for nutrient-rich powders

Local fish, DGLVs and beans were identified through FGDs based on the degree of availability, season in which they are available, cost and acceptability in the community. Each community identified one food ingredient that could be used in each of the target food groups. More detail about the foods identified is included in the page 19.

2.2 Formulation of recipes incorporating nutrient-rich powders

The first day of FGDs ended with participatory development of recipes to incorporate nutrient-rich powders based on dishes that are commonly cooked in the community.

Country	Community	Number of women	Number of men	Number of children
Malawi	Kameme Navitengo	14	6	5
Malawi	Lufita Section I	21	5	6
Zambia	Ipusukilo	19	5	8
Zambia	Ibale	20	4	11
	Total	**74**	**20**	**30**

Table 2. Composition of each FGD/cooking demonstration disaggregated by gender and age.

2.3 Sensory evaluation/taste trials

Three nutrient-rich powders were created at the beginning of the cooking demonstration, then these were incorporated into the three recipes, based on local dishes, developed by participants. Participants were asked to taste each dish created with nutrient-rich powders. Following the tasting, sensory evaluations of the dishes were conducted; each adult participant was asked questions using a five-point scale, ranging from (1) do not like very much, (2) do not like, (3) neutral, (4) like, and (5) like very much, for five categories: taste, odor, texture, appearance and overall impression.

Mothers and caretakers were asked if they were willing to feed the foods to their children, and to complete an acceptability evaluation on their impression of the child's acceptability based on the following:

- Intake: yes or no
- Duration of feeding: if the child ate one bite (1), ate for less than one minute (2), ate for greater than 2 minutes (3), or finished the portion (4)
- Facial expression: happy (1), neutral (2), or dislike (3)
- The mother's judgment of her child's acceptance, based on a five-point scale, the same as for the adult sensory evaluation.

A sensory evaluation form filled out by each participant is shown in Annex 5.

The study team instructed the participants to make sure they understood the evaluation forms and filled them out correctly, or assisted with filling the form out. The participants were requested not to consult with each other during the sensory evaluation, and to feel free to give their opinion and feedback.

3. Market assessment

In order to explore the current production, marketing, transportation and storage of key foods and powdered products, members of the study team visited local and town markets and interviewed key informants and merchants about production, purchase and sale of fish, DGLVs, beans, and any foods that were sold in powdered form (e.g. groundnut powder).

4. Processing and storage workshops

Local fish, DGLVs and beans were purchased in dried form for the processing workshops. Beans were soaked overnight, then sun-dried for two days before processing into bean powder. Details on the workshop activities are given in the page 21 is the results from the processing workshops, page 12 is the study design.

Between 18 and 36 participants attended each processing workshop as shown in Table 3.

In Malawi, workshops were also attended by field extension officers, five from Kameme and three from Chinunkha. To strengthen collaboration at the district level, district stakeholders implementing similar projects in Chitipa District were invited to participate in these workshops. The two workshops were attended by two representatives from Chitipa District council, the Chitipa District Health Office nutrition officer, and a field officer from the World Relief Organization. These district stakeholders played a pivotal role during the two workshops. In addition to acting as translators, they assisted in giving information and answering questions on nutrition education, promotion of nutritious products, and child feeding.

5. Development and testing of improved processing methods

The study team conducted workshops for participatory evaluation of traditional fish processing techniques to identify locally suitable innovations to overcome food quality and safety issues in fish processing. A SWOT analysis was used only in Zambia as fresh fish is sourced and processed within the study area and by target households. The knowledge gained in Zambia led to the development of an improved smoking kiln and a small solar drier.

To test the efficiency of the innovations, fish samples (fresh and processed (traditionally and improved technologies)) were collected for nutrient composition analysis. In Malawi, fish traded and consumed within the study area is sourced from Karonga (a town on the northern shores of Lake Malawi), where fish is caught and processed.

Solutions for improving fish processing for fish traded between Karonga and Chitipa were also explored by the Malawi research team.

6. Development and testing of machines for scaling up processing of nutrient-rich powders

Upon return to Lusaka and Lilongwe, study team members identified local vendors of agricultural and culinary machinery that could be tested for producing nutrient-rich powders. In Lusaka, SARO Agro Industrial Ltd. was identified as a key vendor for agricultural machinery and study team members were allowed to test various machines at no cost. Machines for grinding dried small fish were tested; the amount of fish powder, processing waste and the time taken for grinding dried small fish into powder were recorded. These parameters were also recorded during processing using the traditional processing methods (mortar and pestle).

Country	Community	Number of women	Number of men	Number of children
Malawi	Kameme	32	7	2
Malawi	Lufita/Chinunkha	26	6	7
Zambia	Ipusukilo	19	5	8
Zambia	Ibale	20	4	11

Table 3. Composition of each processing/storage workshop.

Photo credit: Chosa Mwenitete/WorldFish

Amatuku ready to be pounded into powder.

Results

Malawi

1. Key informant interviews and focus group discussions

1.1 Production and consumption of target food groups in Chitipa District

Fish

Chitipa District is bordered by Zambia to the west, Tanzania to the north, Karonga District and Lake Malawi to the east, and Rumphi District to the south, making it a crossroad for fish coming from all of these locations. The main sources of fish in Chitipa District are from Lake Malawi and from Lake Tanganyika, Tanzania. Local sources of fish include small rivers and fish farming. According to the Chitipa District Department of Fisheries, there are 490 ponds, totaling 67,401 ha in Chitipa District, with 112 of these ponds in the Lufita extension planning area and 5 fish ponds in the Kameme extension planning area. Fish are commonly purchased in Chitipa, although the supply fluctuates throughout the year due to fishing restrictions in Lake Malawi, use of traditional fishing practices, and imports from Tanzania. Fish harvesting is the highest during the calm weathers between August and November whereas in between November and March, Lake Malawi restricts the types of gear used, making it harder to catch the commonly consumed small fish species. The northern side of Lake Malawi does not have any commercial fishing, thus resulting in a fluctuation of fish supply and reliance on fish imports from Tanzania at certain times of year.

Kameme Navitengo and Lufita Section I each reported one local source where fish are occasionally caught; each are small rivers within walking distance of the communities. From the FGDs, it was reported that most fish are purchased, and the most common are dried small fish. Kameme Navitengo community is located approximately 12 km from the Isongole Market on the Tanzania-Malawi border, where dried small fish is readily available. It was reported that the community does not know how to store fresh fish, as it is not available. Dried small fish is stored in containers or wrapped in paper or banana leaves and hung in the house to keep it away from pests. In Lufita Section I, it was also reported that dried small fish is the easiest form of fish to obtain from the market. Lufita is closer to the Chitipa-Karonga road, making Lake Malawi the main source of fish to Lufita, whereas Kameme gets fish traded from Lake Malawi and Lake Tanganyika as it is closer to the border with Tanzania. Fresh fish is more easily accessible closer to Lake Malawi or if caught from the rivers, but most fish consumed in Kameme Navitengo and Lufita Section I is dried small fish. Fish was reported to be frequently consumed, with "frequently" defined as once every couple of weeks.

Dark green leafy vegetables

DGLVs are consumed very frequently, often as part of the daily meal, however in relatively small quantities. Many varieties are used, with the most common being rape, Chinese cabbage, pumpkin and bean leaves, mustard and amaranth. DGLVs are often boiled with salt and some households cook them with baking soda. Production of DGLVs is highest during the rainy season, and some households in Kameme and Lufita preserve DGLVs by sun-drying or blanching and sun-drying. The most common dried leafy vegetables are pumpkin, sweet potato, cowpea, and bean leaves. The most common source of DGLVs in both communities is from their own production.

Beans

The most easily and readily available beans in Kameme Navitengo are the Buyole, Kwayiti, Mandondo and Boma varieties, and the most common beans in Lufita Section I are Buyole, Mabulangeti, Masusu, and Mwasipengile. Beans are commonly obtained fresh during the rainy season and sun-dried during the dry season. During the FGDs, it was reported that communities in Kameme Navitengo use ash or chemicals to dry and preserve beans and for storing beans in sacks to prevent them from pest attacks. The common source of beans reported was own production in Kameme Navitengo, whereas in Lufita Section it was from the market.

Many varieties of beans were reported in the FGDs, and in interviews with agricultural extension officers in Lufita and Kameme, it was noted that beans are a cash

crop in the Chitipa area, and especially in Kameme. Many people frequently consume bean leaves but not the beans as they are sold for income. People in Kameme Navitengo frequently travel to the Isongole Market on the Tanzania-Malawi border, or to Zambia and Chitipa town to sell beans, depending on the best price offered. Lufita Section I community members often travel to Chitipa town to purchase or sell beans. Beans are consumed in small amounts, as a relish or a small side dish used as a dipping sauce for *nshima*.

1.2 Current initiative to improve health and nutrition in Chitipa District

Key informants were interviewed at local, community and district level clinics about monitoring of nutritional status and growth, as well as nutrition education. Nutrition programs face huge challenges, as there is a lack of personnel and resources. Programs largely focus on growth monitoring and therapeutic feeding for malnourished children. There are no preventative measures for improving nutrition in Kameme or Lufita.

At the national level, a harmonized care group model has been rolled out in many districts across Malawi, although at the time, Chitipa District had only 10% coverage in the south of Chitipa town. Care groups are formed by community members who are interested in agriculture and nutrition, and they are taught nutrition messages to spread within their respective communities. Nutrition education focuses on linking local agriculture production to the six food groups (as per Malawi's food based dietary guidelines)[3] and cooking demonstrations on how to prepare local dishes from all food groups for the whole family.

2. Cooking demonstrations and sensory evaluations

2.1 Selection of food items within target food groups

Kameme Navitengo selected *mutera* (*Oreochromis niloticus*) in the fish group, *isalwa* (leaf of the *Buyole* variety of *Phaseolus vulgaris*) in the vegetable group, and *mwasipengile* (*Phaseleous vulgaris*), a variety commonly called "sugar bean" in the bean group. Lufita Section 1 selected the Lake Malawi sardine, locally known as *usipa* (*Engraulicypris sardella*) in the fish group, pumpkin leaves (*Cucurbita maxima*) in the vegetable group and also *mwasipengile* in the bean group.

Mutera was obtained dried; however, it was still quite oily to the touch due to a high fat content, in comparison with *usipa*. The study team worked with participants to dry the small fish more, using a metal grill positioned approximately six inches above a fire (Plate 15). This was done to further reduce moisture and fat content, as a high fat content can cause rancidity during storage.

Preparation of the *mwasipengile* bean before cooking differed. In Kameme, participants used the raw bean and milled it together with maize. The women said that it was advantageous to mill maize and beans together to fortify the maize meal as well as to reduce time spent on drying and pounding the beans at home. As maize meal is cooked for a long time to make *nshima*, the raw bean meal would also be cooked in this time. In Lufita Section I, the beans were soaked for 12 hours and sun-dried before pounding and cooking.

Recipe selection

The three dishes chosen in each community were the same, although measurements of ingredients differed according to taste: (1) soup made with bean powder, tomato and onion, with addition of fish powder; (2) DGLV, with fish powder and pounded groundnut; and (3) orange juice with DLGV powder. As the recipe development and cooking were led by the participants, the amount of each ingredient used differed in each community, based on local taste and preferences.

Plate 15. Participants dry *mutera* (*Oreochromis niloticus*) to reduce moisture and fat content (Kameme Navitengo, Malawi).

Participants prepared the amounts of each ingredient that they wanted to add to the recipe, and the study team recorded the amounts used. The recipes created by each community are described in Annexes 2–3.

Steamed DGLVs with groundnut powder is a common relish in these communities whereas beans are less commonly eaten. The addition of fish and bean powders to dishes and making juice at home were new concepts in this area. Both communities reported that children like juice, but that it is expensive to buy and that many people do not know how to make juice. The study team inquired about which fruits were available in different seasons and can be utilized to make juice. Participants reported guava and orange during the FGDs and stated that often times, these fruits are highly available but underutilized as they spoil quickly. Mango was also mentioned as highly available in the rainy season. Orange was chosen as an ingredient for making juice, as there was an abundance of oranges at the time of the cooking demonstrations. The study team selected to add DGLV powder to the orange juice in order to increase the bioavailability of iron in the DGLV due to the enhancing effect of ascorbic acid in citrus fruits (Davidsson 2003). A small amount of sugar was added to the juice to reduce bitterness.

2.2 Sensory evaluations

Community 1: Kameme Navitengo

Recipe 1: DGLVs with groundnut and fish powder

Twenty participants tasted and evaluated recipe 1: A local dish containing DGLVs cooked with groundnut powder, with fish powder added. All the respondents ranked taste, odor, texture, appearance and overall impression as 5, "like very much." Five infants were present for tasting and acceptance evaluation by their caretaker. Caretakers noted that the infants ate the food, they were happy and all infants finished their portion. The caretakers' judgment of acceptability was 5, "like very much," for all infants.

Recipe 2: Soup

Twenty participants tasted and evaluated recipe 2: A soup made with bean powder, tomato, onion and fish powder added at the end. All respondents ranked taste, odor, texture, appearance and overall impression as 5, "like very much". Five infants tasted the soup and the evaluation was done by their caretakers. Caretakers noted that the infants ate the soup, seemed happy, and all infants finished their portion. The caretakers' judgment of acceptability by the infants was 5, "like very much".

Recipe 3: Juice

Twenty participants tasted and evaluated recipe 3: A juice made of oranges with DGLV powder added, and a small amount of sugar (1 tablespoon to the juice of 20 oranges). Responses varied among participants, but the majority ranked the juice highly, 4 or 5, across all categories. Approximately one-quarter of the participants were neutral or did not like the juice, noting that they did not like the appearance. Five infants were present for the tasting and acceptance evaluation. Caretakers noted that all infants tried the juice, but no infant finished the portion and their facial expression was neutral. The caretakers' judgment of acceptability varied from neutral to very good.

Community 2: Lufita Section I

Recipe 1: DGLVs with groundnut and fish powder

Twenty-six participants tasted and evaluated recipe 1: DGLVs with groundnut powder and fish powder added. All participants ranked taste, odor, texture, appearance and overall impression as "like very much" (5)." Six infants participated in tasting and acceptance evaluation. Caretakers noted that all infants tried the vegetable relish and finished their portion, and all infants were happy when eating the dish. The caretakers' judgment of acceptability was 5, "like very much."

Recipe 2: Soup

Twenty-six participants tasted and evaluated recipe 2: A soup made with bean powder, tomato, onion and fish powder. The majority of participants ranked taste, odor, texture, appearance and overall impression as 5, "like very much," with two participants ranking texture, appearance and overall impression as 4, "like," and five participants ranking odor as 4, "like." One participant ranked the overall impression as 2, "do not like." Caretakers noted that all infants ate the soup and finished their portion, and all infants were happy when eating the soup. The caretakers' judgment of acceptability was 5, "like very much."

Recipe 3: Juice

Twenty-six participants tasted and evaluated recipe 3: The orange juice with DGLV powder and a small amount of sugar added. Overall, the majority of participants ranked taste, odor, texture, appearance and overall impression 5, "like very much." In the categories of taste, odor, texture and overall impression, there were some who gave the ranking of 4, "like." In the category of appearance, there was more variation in responses, with 31% of participants grading the appearance as 4 or lower. Participants noted that they liked the flavor but the orange juice with DGLV powder mixed in had a strange color. Caretakers noted that all infants tried the juice, but no infant finished the portion and their facial expression was neutral. The caretakers' judgment of acceptability varied from neutral to very good.

3. Market assessment

In order to explore the local storage methods of fish, vegetables and beans powders, five markets were visited: Chitipa District council, Lufita market, Chinunkha market, Kameme market and Karonga District council market. The study team spoke with fish retailers who were selling fish in these markets. No transporters or fishermen were spoken with, as fisheries activities did not take place due to strong winds, locally known as *mwera*. Fish retailers in Lufita and Kameme markets reported that no fish processing activities are done by them - the fish is sourced from traders in processed form. Fish available in markets is purchased from processors in Karonga or Tanzania, who dry small fish and sell it to traders and retailers. It was very clear that people in Chitipa do not store fish at home. Fish is bought from the market and consumed directly. Traders and processors close to landing sites store fish before it is transported or traded to communities farther from water bodies. Fish retailers further indicated that dried small fish from Karonga is stored in cartons or sacks for transportation to Chitipa and usually it only takes 3 to 4 days to sell all fish to consumers. Fish traders at Lufita market also reported that it is easier for them to obtain dried small fish, as compared to their friends in Kameme-Navitengo because of Lufita market's proximity to the Chitipa-Karonga road, hence enabling transportation of fish using public transport such as lorries or minibuses. In all the markets that the research team visited, there were no nutrient-rich powders produced and sold in the market. Traders reported that they only knew of groundnut powder, which is traded in markets.

The photos below show some of the dried small fish species that are sold in most markets in Chitipa.

Plate 16. "Masukulunji" fish.

Plate 17. "Gongo" fish (from Tanzania).

Plate 18. "*Usipa*" dried small fish.

Plate 19. Packaging dried small fish for transportation.

Plate 20. Traditional kiln used to smoke fish in Karonga.

Plate 21. Woman drying small fish on open, raised rack on the shore of Lake Malawi.

4. Processing and storage workshops

Following the FGDs and cooking demonstrations to evaluate the acceptability of the local recipes, additional field trips were conducted to work with additional participants to evaluate the processing, storage and potential to up-scale production and processing of the nutrient-rich products. The SWOT analysis technique was used to evaluate the response, and is presented as follows:

A summary of the results of the SWOT analysis from the two workshops conducted in Kameme and Lufita is presented in Table 4.

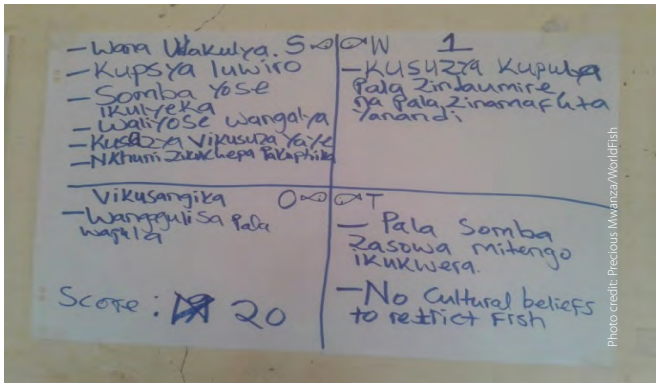


Plate 22. SWOT analysis about fish powder.

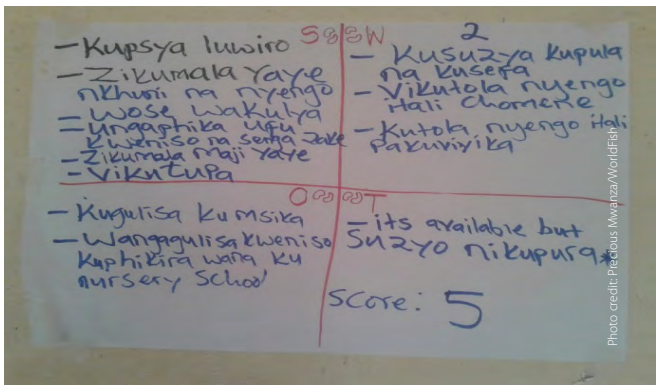


Plate 23. Bean powder.

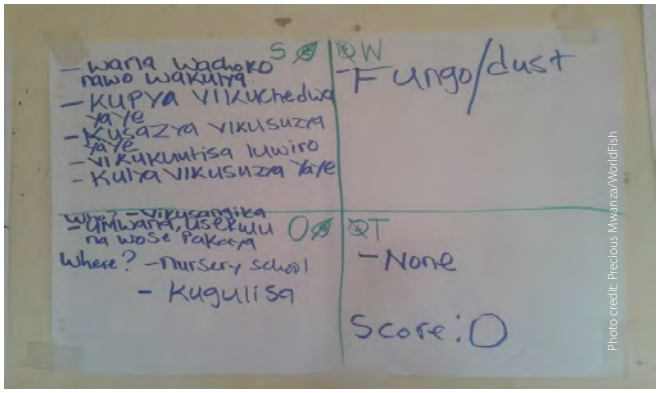


Plate 24. SWOT discussions about DGLVs powder.

	Fish powder	DGLV powder	Bean powder
Strengths	1. Children can eat (hence an opportunity for children to eat the fish instead of just eating broth) 2. Whole small fish is eaten since bones are crushed into the powder, therefore less waste and more nutrients for infants and old people 3. Easier to pound and cook than beans 4. Easy to mix with any food 5. Has some oil	1. Easy to pound into powder 2. Easy/fast to cook 3. Easy to mix with other ingredients 4. Easy to eat and chew (hence, can be easily fed to children) 5. Easily and locally available	1. Easy to cook 2. Uses little firewood 3. Less time taken to cook 4. Everyone can eat, including infants and elderly people 5. Little water is used 6. Good smell 7. Easy to chew Serves two purposes: bean powder can be added to porridge; the remainder, which could not pass through the sieve, can also be cooked and eaten
Weaknesses	1. When not fully dried, more difficult to pound than vegetables 2. If the fish is very fatty, it is difficult to pound and sieve 3. More difficult to pound sun-dried fish than smoked 4. Not a sweet taste, hence need to add bananas for sweetness 5. Taste of smoked fish better than sun-dried	1. Powder dust easily blown off by wind 2. Irritating smell 3. A bit bitter 4. Color not very appetizing	1. Difficult to pound and sieve if not pre-soaked 2. Time consuming to pound, compared to fish and vegetables 3. Low availability of bean seeds for planting, so not much access to beans Requires continuous stirring when cooking, hence labor-demanding
Opportunities	1. Fish can be locally sourced from the neighboring district of Karonga, if required in large amounts 2. Can be sold in the market 3. Easy to use in school feeding program and health centers 4. Can easily be given to pregnant and lactating women 5. Can easily be stored 6. No negative cultural beliefs	1. Everyone can eat, also children 2. Can be used in school feeding programs that World Food Programme and World Relief are promoting in Chitipa District 3. Can incorporate in foods for infants and old people 4. Can use all leaves, even those of poor quality and are normally thrown away	1. Can easily be sold in markets 2. Can be fed to young children in nursery schools 3. Can easily be grounded into powder using a mills, if available 4. Can be incorporated in many recipes
Threats	1. Fish not locally available during other times of the year, hence are expensive during period of scarcity 2. Smell sometimes not appetizing, if not fully dried	No threat	1. If maize mills used, can cause conflicts because others would not want their maize flour to be mixed with bean flour 2. If not pre-soaked, difficult to pound using mortar and pestle

Table 4. Participants' feedback on strengths, weaknesses, opportunities and threats of each of the powder.

After the SWOT analysis was done, participants were asked to vote for which of the three nutrient-rich powders they liked most and that if available in the market, which powder they would be willing to buy. The results are presented in Table 5.

Most of the participants (35 participants from both Chinunkha and Kameme) reported that they would be very willing to purchase fish powder, if available in the market. Participants reported that fishing and fish farming are not common in the area, thus they mostly rely on the market for sourcing fish. If fish powder was made available, then this would give them an opportunity for their children to eat nutritious fish. On the contrary, participants reported that they would not be very willing to buy vegetable powders, if available in the market because vegetables are locally found and, therefore, easy for them to make the powders at home. On the other hand, 26 participants (from both Chinunkha and Kameme) reported that they would be willing to purchase bean powders if found in the market because it was difficult to pound beans if not pre-soaked.

4.1 Assessment of local storage methods of fish, DGLVs and bean powders

At the end of each workshop, participants were asked how they locally store the powders of fish, DGLVs, beans and groundnut. The results are presented in Table 6.

Powder	Number of participants who will purchase powder		Reasons
	Chinunkha	Kameme	
Fish	15	20	Fish is sourced from the market, and can be expensive due to seasonal fluctuations in availability. If available, it is usually expensive. Therefore, if fish powder is available in the markets, then this would give an opportunity for children to eat nutritious fish.
DGLV	1	0	Vegetables are locally found in the area, hence it is very easy for participants to make their own powder, at home, and not have to buy from the market. The only challenge is the color, which is not very appetizing.
Bean	11	5	It is difficult to pound beans if not pre-soaked. Some participants, especially in Kameme, reported that beans are locally available, and the powder can be made at home.
TOTAL	**27**	**25**	

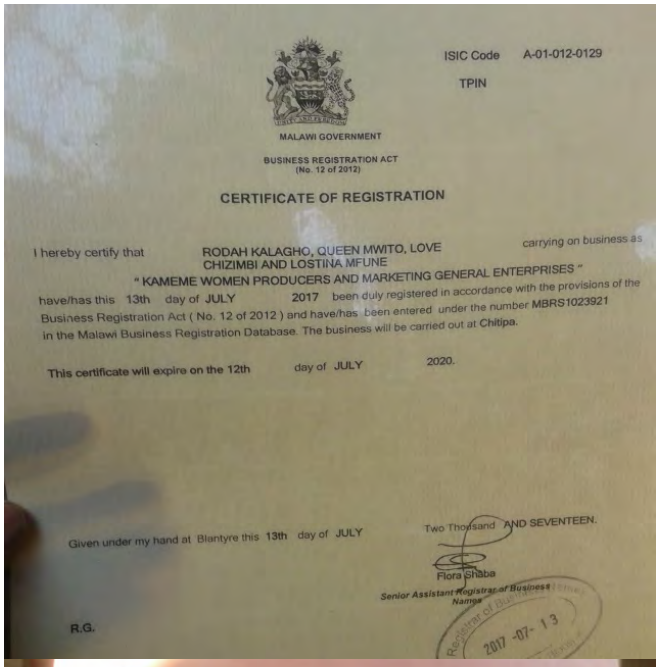
Table 5. Participants' willingness to purchase the powders if available in the market.

Type of powder	Means of storage	Reasons
Fish powder	**None**	**Have never pounded fish into powder**
DGLV powder	None Dried vegetables are kept in "baskets" made from leaves, and these baskets are tied under to the kitchen ceiling so the vegetable leaves are completely dried by smoke.	For prolonged shelf life of dried vegetable leaves.
Beans powder	None Mixed products of (groundnut, soybean and maize) in plastic buckets that are covered and hidden under beds. Sometimes, actellic (Pirimiphos-methyl, an insecticide) or ash is added to beans, kept in sacks.	Have never pounded beans into powder. The mixed flour is used to make porridge for young children.
Groundnut powder	Plastic bottles Small tins	

Table 6. Storage methods used at the household level.

4.2 Identification of already existing women's groups in Kameme and Lufita

As the study team conducted community workshops, existing and established women's groups that could be interested to work with the value chains of fish, DGLVs and beans were identified. Fruitful discussions were held with members of the Kameme Women Producers and Marketing General Enterprises, a group registered with the Government of Malawi, and has a well-established constitution. Several members of the group showed keen interest to promote fish value chain activities, including processing and trading of fish powder.



ISIC Code A-01-012-0129

TPIN

MALAWI GOVERNMENT

BUSINESS REGISTRATION ACT
(No. 12 of 2012)

CERTIFICATE OF REGISTRATION

I hereby certify that RODAH KALAGHO, QUEEN MWITO, LOVE CHIZIMBI AND LOSTINA MFUNE carrying on business as " KAMEME WOMEN PRODUCERS AND MARKETING GENERAL ENTERPRISES "

have/has this 13th day of JULY 2017 been duly registered in accordance with the provisions of the Business Registration Act (No. 12 of 2012) and have/has been entered under the number MBRS1023921 in the Malawi Business Registration Database. The business will be carried out at Chitipa.

This certificate will expire on the 12th day of JULY 2020.

Given under my hand at Blantyre this 13th day of JULY Two Thousand AND SEVENTEEN.

Flora Chaba

Senior Assistant Registrar of Business Names

R.G.

2017 -07- 13

Certificate of Participation

This certificate is awarded to

KAMEME LEGUME COOPERATIVE

In recognition for participating in

2017 CHITIPA DISTRICT AGRICULTURE FAIR

Signature (DAECC) Date Signature (DC) Date

Photo credit: Melly Ahern/WorldFish

Plate 25. Registration certificates of the Kameme Women Producers and Marketing General Enterprises.

5. Development and testing of improved processing methods

As participants from Kameme and Lufita are not engaged in fish processing, the study team explored the possibility of setting up a prototype solar drier at Karonga, one of the main fish landing and processing sites in Northern Malawi. From Karonga, dried small fish, mainly *usipa*, is sold to markets in Chitipa District where households can buy it for further drying and making it into fish powder.

In collaboration with a local fish processing cooperative (Gumi), solar driers can help improve the quality and food safety of dried small fish that is traded regionally.

Initially, three fish landing sites—Mandala, Gumi and Ngala in Karonga District—were earmarked to establish the solar tent fish dryers and smoking kilns to improve fish processing methods. Meetings with Karonga District stakeholders as well as consultations with local leaders were carried out and from the three sites, Mandala and Gumi beaches were selected as potential sites for construction of the solar tent fish dryer. Gumi was selected for construction work to start because the community members were organized, and they had already formed and registered a vibrant and functional fish processing cooperative. The site of an individual fish processor at Mandala was also selected for construction of the solar tent fish dryer, with work to start after the completion of the dryer in Gumi. Both the cooperative and the individual processor agreed to adopt the technology and own the facility as they had land for expansion. Discussions between the cooperative members and study team were conducted to agree on procurement of construction material as well as setting up a revolving fund facility. The study team visited hardware shops in Karonga to assess the availability and costs of materials. Concrete for construction was accessed nearby, free of charge. Plates 27 and 28 show a prototype solar drier and fish drying in the solar drier.

Actual construction of the structure at Gumi began as soon as gathering and procurement of construction materials was completed. The structure was expected to be functional in April 2018.

Plate 26. Prototype solar drier to be constructed.

Plate 27. Drying of fish in the solar drier.

6. Development and testing of machines for scaling up processing of nutrient-rich powders

The study team visited Songani Market (near Zomba) to check on simple processing machines for making powders, bearing in mind the regulations in place for safety of processed foods in Malawi. Several machines used for grinding groundnut and bean were assessed. The traders reported that these machines were sourced from Blantyre, at a cost of MWK 400,000 (USD 550) each. Traders indicated that the machines could grind dried groundnut, beans, soybean and even dried small fish. Testing was conducted with one of the machines to grind dried small fish into fish powder. Based on this initial test, the study team recommended the procurement of a grinding machine for processing fish powder from dried small fish processed in the solar tents as well as dried small fish bought from the market in Chitipa. Plate 28 show one of the grinding machines that was tested.

Zambia

1. Key informant interviews and focus group discussions

Production and consumption of target food groups in Luwingu District

Fish

Key informants noted that fish may be caught in rivers in close proximity to the communities, but fish are not plentiful in rivers near Ibale nor Ipusukilo. Fish are bought from traders

Plate 28. Grinding machine in Songani Market, Zomba, Malawi.

from Banguwelu or Lake Tanganyika and, most commonly, bought dried or roasted. Fresh fish are bought in small quantities, cleaned by removing the intestines and skin, and then placed on a rack with the fire below, for roasting, to enable storage. In Ibale, it was reported that small fish are sun-dried, large fish (such as bream) are smoked and fish such as *imilonge* (catfish) are purchased roasted and then salted at home. For consumption, fish is boiled for a long time until the bones are soft, and the broth after boiling is fed to young children. Dried small fish are commonly prepared with groundnut powder, tomatoes and DGLVs (a dish called *ifisashi*). In Ibale, it was reported that *imilonge* is not fed to infants and young children, as it is believed that the child will not develop teeth. It is also not consumed by pregnant women because it is believed that this specific fish causes a woman to vomit more easily.

Dark green leafy vegetables

DGLVs are consumed frequently, often daily, but in small quantities. Many varieties are used, with the most common being leaves of cassava, cowpea and pumpkin. In Ipusukilo, rape and Chinese cabbage bought from the market are also used. In Ibale, it was reported that rape and Chinese cabbage are expensive. DGLVs are often boiled with salt, and some use baking soda. Many DGLVs are traditionally cooked with groundnut powder. DGLV production is highest during the rainy season; however, dried DGLV are commonly consumed. Drying of vegetables is done at home in direct sunlight, and dried vegetables are not purchased. Cassava leaves are consumed year- round- when harvested, they are consumed fresh, and are dried for other times of year.

Beans

Beans are most commonly obtained dried, as the period of availability of fresh beans is short in Ipusukilo and Ibale. In Ipusukilo, beans from own production were more readily available, as compared to Ibale. Fresh beans are dried in the sun and chemicals. For example, Actellic (pirimiphos-mehyl, an insecticide) is added to speed up the drying. If chemicals are not available, ash is added. The beans are often stored dried, with the husks. In the FGDs, it was reported that people prefer to eat dried beans rather than fresh because of the flavor. It was reported in the key informant interviews and FGDs that beans are boiled for 5–6 hours using firewood. Beans are always cooked with salt, and oil, tomato and onion are added, if available.

Kabulangeti, white beans and Lusaka beans were the three bean varieties reported. Interviews with village heads and agriculture extension officers revealed that beans are not commonly grown in Ibale and Ipusukilo—especially in Ibale, due to the long distance from Luwingu and poor access to bean seeds.

Current initiatives to improve health and nutrition in Luwingu District

Key informants from the district-level Department of Health and Department of Agriculture were interviewed about current nutrition monitoring or growth monitoring systems, as well as nutrition education. Current nutrition improvement efforts face huge challenges due to a lack of personnel and resources. Programs largely focus on growth monitoring and therapeutic foods for those who are malnourished, and less focus is given to preventative mechanisms such as nutrition-sensitive agriculture. With the help of Self Help Africa, the Department of Agriculture and Department of Health have been involved with cooking demonstrations and IYCF consultations in Luwingu District. These programs have very low coverage, however, as they are only carried out in three health centers.

2. Cooking demonstrations and sensory evaluations

2.1 Species selection within target food groups

In Ipusukilo, the small fish species *amatuku* (*Tilapia sparrmanii*), the DGLV bean leaves (*Phaseolus vulgaris*) and the *Kabulangeti* variety of the common bean (*Phaseolus vulgaris*) were selected. In Ibale, the fish species *impende* (*Tilapia rendalli*), the same DGLV, bean leaves, and the Lusaka variety of the common bean were selected.

T. sparrmanii and T. rendalli were obtained dried; however, they were still oily to the touch. The fish were further dried by roasting in a hot pan in order to reduce the moisture and fat content.

It is important to note a difference in the preparation of the beans in the communities. In Ibale, the community was willing to try to use pre-soaked beans for producing the powder, whereas in Ipusukilo, pre-soaking was not accepted. Roasting of both types of beans was done to further reduce the moisture content.

Recipe selection

Three recipes were prepared in each community. In Ipusukilo, the participants created a dish with fresh cassava leaves and fish powder, and a soup with bean powder and DGLV powder. In Ibale, the participants created a porridge with fish powder, bean powder and mealie meal, and a dish with DGLV powder and groundnut powder. Steamed cassava leaves and leafy vegetables cooked with groundnut powder are two common dishes in these communities; however, the addition of fish powder and DGLV powder to recipes is a new concept in this area.

Both communities chose to produce a juice from oranges. When requested to add a powder to the juice, both communities added the bean powder. In Ibale, the participants chose to boil the orange juice with the bean powder in an attempt to dissolve the powder. The participants ensured that the taste of the recipes would be acceptable to their community. Thus, the amount of each ingredient used in the recipes differed. The amount of each ingredient to be used in the recipes was prepared by the participants and the study team recorded the amounts used in the preparation. The recipes developed are described in the Annex 4–5.

2.2 Sensory evaluations

Community 3: Ipusukilo Nsanje

Recipe 1: Dish with fresh cassava leaves and fish powder

Twenty-four participants tasted and evaluated recipe 1: A dish made with fresh cassava leaves, tomato and onion, with fish powder added. The majority of respondents ranked taste, odor, texture, appearance and overall impression as 5, "like very much." Eight children age 6–23 months participated in the tasting and acceptance evaluation. All caretakers noted that the infants ate the dish, and all children seemed happy. The caretakers' judgment of acceptability was 5, "like very much." The duration of feeding time for eating the portion was two minutes or less than one minute, and the caretakers noted that the portion served was too small, and children wanted more. The caretakers noted that the fish was bitter, due to being slightly burnt, and that smoking the fish could improve the flavor.

Recipe 2: Soup with DGLV powder and bean powder

Twenty-four participants tasted and evaluated recipe 2: A soup made with DGLV powder and bean powder, with tomato and onion added for flavor. The majority of respondents ranked taste, odor, appearance and overall impression as 5, "like very much." However, the appearance category scored lower, with 5 respondents scoring appearance 2 to 4, "do not like to like." It was noted that the DGLV powder changed the color of the soup to a dark green, which was not pleasing to some respondents. Eight infants participated in the tasting and acceptance evaluation. Caretakers noted that all infants tried the soup, and all infants were happy. All caretakers rated acceptability as 5, "like very much." Respondents noted that the soup was their favorite of the three dishes, although they would like to experiment with decreasing the amount of DGLV powder and adding spices to improve the color and appearance.

Recipe 3: Orange juice with bean powder

Twenty-four participants tasted and evaluated recipe 3: A juice which they had interest in learning how to make and incorporating bean powder. All respondents ranked odor and overall impression as 5, "like very much." The majority of participants ranked taste, texture and appearance as 5, "like very much." Eight children age 6–23 months were present for tasting and acceptance evaluation by their caretaker. Caretakers noted that the infants ate the food, six children were happy and two were neutral toward the food, but all caretakers judged the recipe as 5, "like very much" for their children. Several respondents noted that the orange juice could be improved with a small amount of sugar.

Community 4: Ibale

Recipe 1: Porridge with fish powder and bean powder

Twenty-four participants tasted and evaluated recipe 1: A porridge made with fish powder, bean powder, maize flour, tomato and onion. This recipe

received varying feedback, with only the appearance category scoring high—13 of the 24 participants scored the appearance 5, "like very much."

Eleven infants took part in the tasting and acceptance evaluation. Caretakers noted that all but one infant tried the porridge and most ate for more than 2 minutes or finished the portion. All but one infant was happy when eating the porridge. The majority (8 of 11) of the caretakers scored acceptability 5, "like very much."

Recipe 2: Soup with DGLV powder and groundnut powder

Twenty-four participants tasted and evaluated recipe 2: A soup with DGLV powder and groundnut powder. The majority of respondents ranked taste, odor, texture, appearance and overall impression as 5, "like very much," with one or two participants ranking odor and overall impression as 3, "neutral," or 4, "like," respectively.

Eleven infants participated in the tasting and acceptance evaluation. Caretakers noted that all infants tried the soup, the majority finished the portion and all infants were happy when eating the soup. The caretakers' judgment of acceptability was 5, "like very much."

Recipe 3: Orange juice with bean powder

Twenty-six participants tasted and evaluated recipe 3: Orange juice with bean powder. Overall, the majority of participants ranked taste, odor, texture, appearance and overall impression as 5, "like very much." In all categories, there were one or two responses lower than 5. Eleven infants participated in the tasting and acceptance evaluation. Caretakers noted that all but one infant tried the juice, most finished the portion and all but one was happy. The caretakers' judgement of acceptability varied from 3, "neutral," to 5, "like very much." Participants provided feedback that the orange juice could be improved with a small amount of sugar and that pregnant women particularly enjoyed the juice because they often crave citrus fruits.

3. Market assessment

The study team visited the Luwingu main market to get an overview of available products and whether nutrient-rich powders are already produced and sold in markets. Two powders, *pupwe* powder and bean powder, which are produced and sold, are shown in Plates 29 and 30 and dried bean leaves in Plate 31.

Pupwe, a wild DGLV, is commonly pounded and sold as a spice. Groundnut powder is typically added to porridge for children and to common vegetable dishes. Dried bean leaves are commonly used but are not pounded.

Plate 29. Dried bean leaves.

Plate 30. *Pupwe* powder.

Plate 31. Groundnut powder.

4. Processing and storage workshops

Dried small fish were purchased from local markets. Dried DGLVs were sourced from the participants in each community. Beans were purchased from the market, soaked overnight to reduce anti-nutrients, and then sun-dried for 2–3 days before the processing workshop.

As the beans were pre-soaked, additional drying was necessary in order to produce a powder. In one community, participants were curious about whether it was better to (1) pound the beans while still slightly moist (for ease of pounding), then roast the beans, or (2) roast the slightly moist beans to reduce the moisture, then pound. Both methods were tried. It was found that it was easier to follow method 2, roasting the beans for 30 minutes before pounding.

The preparation methods of nutrient-rich powders and how the powders are used in common dishes are described in Table 7.

Plate 32. Bean powders produced following two methods for processing. The heaps in front of the bowls show the amounts left after sieving.

	Fish powder	DGLV powder	Bean powder
Starting weight	750 g	100 g	800 g
Species	Amatuku	Pumpkin Leaf	*Phaseolus vulgaris* (common bean, white variety)
Processing method	Dried small fish was purchased, dried further by roasting in a hot pot, over charcoal for 30 minutes. Fish were cooled and pounded. Pounding was done by two women for 30 minutes. After sieving, 550 g of fish powder was obtained.	Leaves were dried in the sun (pre-workshop), then pounded and sieved. Leaves were put in the mortar, pounded with the pestle, sieved, then larger pieces were pounded and sieved again. The whole process took less than 10 minutes.	Beans were soaked overnight and sun-dried for 2 days (pre-workshop). Sun-dried beans were roasted in a hot pot, over charcoal for 30 minutes, to reduce moisture content. After cooling for 5 minutes, two women pounded the beans. Pounding took 2 hours, then sieving was done.
Amount of powder	550 g	Approx. 100 g	500 g 50 g of particles were too large to pass through the sieve
Dish prepared	Fish powder was cooked with chopped vegetables, tomato and onion.	DGLV powder was added to cooked beans.	500 g bean powder was added to 10 kg maize meal for making *nshima*.

Table 7. Processing of nutrient-rich powders.

The traditional method of pounding, using a mortar and pestle, is good for making DGLV powder, as this took little time and energy. For fish and beans, pounding is labor-intensive, and produces significant loss; 26% of the fish was lost in pounding and 37.5% of the beans. The dishes prepared with the powders were selected by the workshop participants.

Plate 33. Fish powder (large bowl) and portion that could not pass through the sieve (small bowl).

A SWOT analysis was conducted to understand the participants' perspectives on using the nutrient-rich powders in their communities. During the discussions, the study team took notes on flip charts, shown in Plates 34, 35 and 36.

The results from FGDs on the SWOT analysis of scaling up production and use of the nutrient-rich powders in the communities are presented in Table 8. The participants reported that they enjoyed the bean powder in *nshima* because of the flavor and smell. They could taste it very slightly but not very much. The taste and flavor of the DGLV powder with cooked beans was reported as very good; they liked the sauce, which became thicker with the addition of the DGLV powder.

Following the SWOT analysis, participants were asked to vote for the nutrient-rich powder that they would be most likely to purchase, if it was available in the market. Each participant was allowed to vote only once. All 18 participants said that they would purchase fish powder and bean powder, if they were available in the market. Table 9 shows the number of votes for each powder and the reasons given.

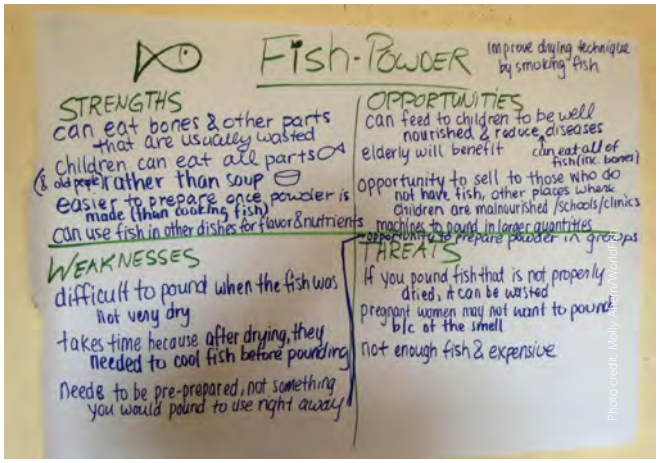


Plate 34. SWOT analysis on fish powder in Ipusukilo.

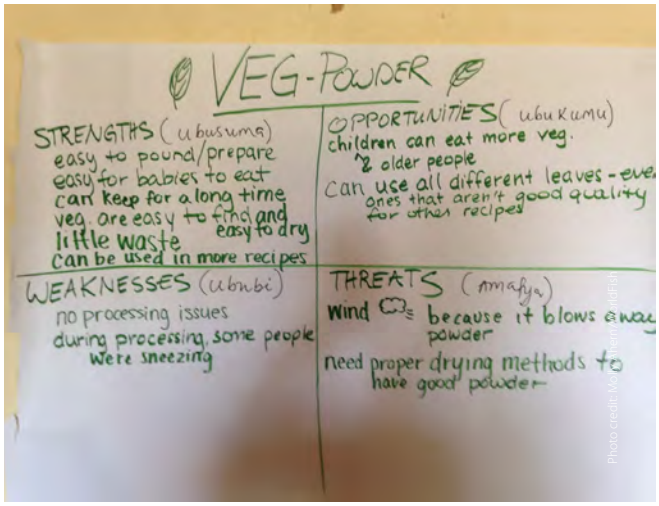


Plate 35. SWOT analysis on DGLV powder in Ipusukilo.

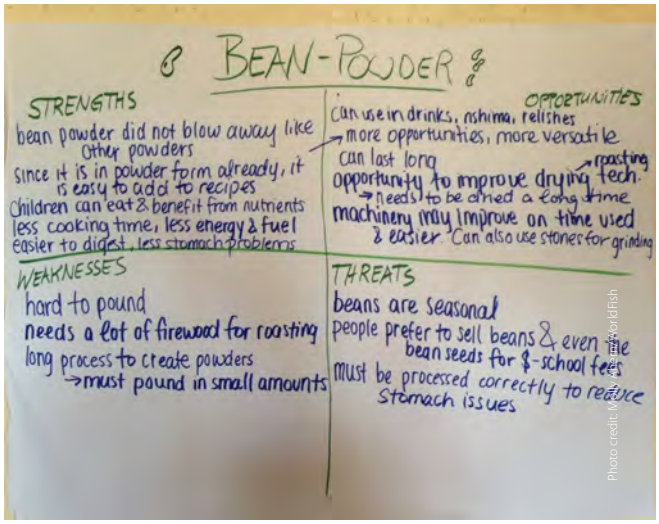


Plate 36. SWOT analysis on bean powder in Ipusukilo.

	Fish powder	DGLV powder	Bean powder
Strengths	1. Can eat all parts, including bones; less waste and more nutrients for young children and old people 2. Easier to pound than beans 3. Powder decreases cooking time, compared to cooking whole fish 4. Can have fish in more dishes; young children only eat fish broth, now they can eat fish in many dishes	1. Easy to pound; pumpkin leaves were harder to pound than other leaves such as bean leaves, due to stems 2. Easy to feed to young children and old people	1. Versatile—can be added to *nshima*, drinks and other dishes for adults and porridge and other dishes for young children 2. Easy to add to dishes 3. Does not blow away during pounding 4. Little cooking time, fuel and energy used 5. Easy to digest; less stomach issues
Weaknesses	Sun-dried fish is not as good as smoked fish; smoked fish is preferred for taste and is easier to pound	1. Low availability of bean seeds so little access to bean leaves 2. During processing, some people were sneezing	1. Low availability of bean seeds for planting 2. Very difficult and time-consuming to pound, using mortar and pestle; can only pound small amounts
Opportunities	1. Can feed fish to young children and old people so that they get essential nutrients 2. Prolong storage period and have fish when fish supply is low 3. Sell fish powder to areas where there is no fish (due to increased shelf life) 4. Sell to programs: e.g. school meals, malnourished children, hospitals	1. Incorporate in dishes for young children and old people 2. All leaves can be used, also those which are not of good quality and normally wasted	1. Use mill to grind beans, when taking maize for grinding (if the mill allows) 2. Can added to many dishes—baked foods, *nshima*, porridges, relishes 3. Drying/roasting methods can be improved 4. Using a machine for grinding/milling
Threats	1. There are times when there is no fish available for processing into powder; but this is an opportunity for fish processing when fish are highly available so that availability is prolonged 2. Not enough fish/fish is expensive 3. Pregnant women may not want to pound fish because of the smell	1. Bean leaves are difficult to find due to low access to bean seeds; at the same time, bean leaves are the easiest to pound. 2. Proper drying methods needed to obtain good powder 3. Wind blows the powder away; an enclosed area is needed to work in	1. Not realistic to pound beans on a regular basis. If there was a machine to produce bean powder or if sold in the market, people would be more likely to use it 2. Beans are seasonal 3. People prefer to sell beans and bean seeds for money to pay for school fees 4. Must use proper processing methods to decrease digestibility issues

Table 8. SWOT analysis of nutrient-rich powders by participants from Ibale and Ipusukilo, Zambia.

Powder	Number of participants who would purchase (n=18)	Reason
Fish	9	People can grow vegetables and beans and make their own powder, but fish is hard to find to make powder. One woman reported that children lack the nutritional benefits that fish offers, so people would purchase fish powder to meet that need.
DGLV	0	Most people grow vegetables at home and therefore are highly available. It is easy to pound to a powder, so it is easy to do at home. The color makes it less versatile—would not add to *nshima* or porridge because of the appearance.
Bean	9	It is versatile—can be mixed in a porridge for young children and in *nshima* for the family. Difficult to pound, so people would prefer to buy, if available.

Table 9. Participants' vote for which of the three nutrient-rich powders they would be most likely to purchase, if available in the market.

After the FGDs, participants were given leftover powders to use at home. Plate 37 shows the packages made from locally available paper.

Plate 37. Small packages of powder for taking home.

5. Development and testing of improved processing methods

The results of the processing workshops showed that smoking of fish, done mainly by women processors, was a more preferred method than sun-drying. The key challenge faced in sun-drying of fish was infestation by flies and other insects that are attracted by the scent of fish. Thus, food safety and poor hygiene of sun-dried fish when done in open places were identified as major issues. Drying in open places, which is common for sun-drying fish, was reported to be related to "fish getting dirty." Dirt was defined as "sand" or "dust" as well as "microbes" from surrounding environments, which were considered as not always "clean." A further issue was that sun-drying is dependent on suitable weather. Sun-drying can take up several days, and rain can ruin the process. When the fish is gathered in the evening and before the sun comes out the following day, insects or microorganisms may get in contact with the fish and grow or multiply. Smoking of fish is considered to be the preferred processing method for preservation as well as adding market value to fish. Compared to sun-dried fish, smoked fish is considered to be tastier, resulting in higher demand and better marketing opportunities for processors. On the other hand, smoking is described as challenging due to many factors: low availability of wire, fish being burnt, breakage of fish during processing (during turning) and retailing (in transport), time-consuming to collect firewood; and preparing reed mats—which last for a short time—for smoking when wire is not available. In case of smoking indoors, there is a risk of the house catching fire. In addition, there are grave health problems faced by the processor, through smoke and burn injuries.

Suggestions from the participants on how to overcome hurdles in fish processing were collected. For the sun-drying of fish, the following were given:

- Cover the fish with nets when drying.
- Use sheets (iron, plastic or sacks) to cover fish from rain when there is no time to get the fish indoors.
- Use insecticides to kill insects and microorganisms.
- Split large fish for quicker sun-drying.
- Apply salt for quick sun-drying and better taste.
- Keep dried small fish in closed containers to protect it from any bacterial or insect infestation when stored overnight, during sun-drying.
- Eat dried small fish at home as market demand is low and thus is more affordable.
- When consuming at home, fry instead of boil dried fish and wash it in hot water before cooking.

For smoking of fish, the following suggestions were given:

- Prepare and use a reed mat with a small mesh size, if wire is not available.
- Reduce the fire to avoid fish getting burned.
- Dry the fish longer before smoking to avoid breakage.
- Sprinkle water on fish after smoking and dry out in sun to slow down rotting.
- Fold fish in same shape and size for processing to avoid breakage after processing and in transport.
- Use a cover to distribute smoke more equally and allow fish to be smoked from all sides by using a cover, such as a banana leaf, to reduce or even avoid turning of fish and thus reduce breakage.
- Use a cover to protect fish from flies and other organisms.

Ideas on how to avoid smoking indoors or to use firewood more efficiently were not brought up directly in the discussions. However, after probing whether participants have seen or heard about ovens, such as those commonly used for baking bread, ideas started developing on how to better control fire and the heat released by fire. One participant made a drawing of a simple oven, with the fire pit located in the ground and a mud walls constructed on the ground and around the whole structure. This was the starting point of introducing the idea of a smoking kiln, which was then further conceptualized and built mostly from locally available materials. This was an important feature, so that households could build their own smoking kilns.

Regarding sun-drying of fish at the household level, the suggestions on how to innovate and improve the current technologies led to the introduction of a small solar drier (solar tent) to assist households to in keeping fish "clean," from dust, dirt and pests. Further, a solar tent would allow fish drying when there is rain as well as to dry other foods such as fruit or vegetables.

Overall, both technologies described above are expected to improve the quality of fish, which then will also lead to improvement in the quality and food safety of fish powder.

Plate 38. Smoking kiln.

Plate 39. Prototype of smoking kiln to improve fish smoking, Luwingu.

Plate 40. Small solar tent for drying fish and other foods.

6. Development and testing of machines for scaling up processing of nutrient-rich powders

During market visits in Luwingu, the study team met a woman who produces groundnut powder (Plate 42) and sells it from her market stall in the Luwingu main market. She purchased a machine (Plate 42) from the Copperbelt Province and brought it to Luwingu. Arrangements were with the market operators, so that she had an electrical outlet for operating the machine next to her stall.

The woman in Plate 42 allowed the study team to test her small hammer mill for making bean powder. This was deemed to be an effective way to mill beans into powder, although the owner complained that grinding beans produced a lot of dust.

Plate 41. Milling machine for groundnut, Luwingu main market.

Plate 42. Testing a hammer mill for producing bean powder.

Upon return to Lusaka, the study team contacted SARO Agro Industrial Ltd. (SARO), an agricultural and farming equipment supply company based in Lusaka, Zambia. SARO staff and the study team identified a couple of machines for milling dried small fish into powder.

Plates 43–46 show the process of using two different machines, an oil extraction machine, typically used for crushing oil seeds, and a large hammer mill. Dried small fish were first put into the oil extraction machine to extract oil from the fish. Plate 44 shows the "fish cake"—the product produced in the oil extractor from dried small fish. The fish cake was passed through a large hammer mill with a fine sieve setting, resulting in a fine fish powder, as shown in Plate 45.

The amount of dried small fish needed for using the oil extractor machine and the large hammer mill was larger than expected, and much more than 1 kg. This could present challenges to small processors, as they may not have sufficient quantities of dried small fish to process to fish powder, using these large machines.

Secondly, the oil extractor machine needs electrical power, and must be heated up for several minutes before passing the fish through to extract of oil. Lastly, the cost of the oil extractor machine was deemed too high in relation to its use. The fish species that are most available and preferred for fish powder production are small fish that have a lower fat content thus oil extraction is not necessary.

Based on these findings, the study team returned to SARO for follow-up testing on two separate occasions, to test a small hammer mill (Plate 48) and to process fish powder samples for nutrient analysis. The small hammer mill with a fine sieve setting was deemed appropriate for processing fish powder, and can be connected to various power sources, including electricity, solar power or manual power using a pedal. Fish were weighed before and after grinding, resulting in very small amounts of waste (2.5%).

Plate 43. Oil Extractor.

Plate 44. Dried fish "cake".

Plate 45. Large hammer mill.

Plate 46. Fish powder after oil extraction.

Plate 47. Small hammer mill at SARO Agro.

Plate 48. Putting fish into the small hammer mill for testing.

Discussion and recommendations

Results from organoleptic tasting and sensory evaluations for dishes incorporating nutrient-rich products showed that overall impression and acceptance of nutrient-rich products is generally high in both study areas. Focus group participants enjoyed the opportunity to learn new processing techniques and experiment with addition of nutrient-rich powders to local recipes to improve nutrient content. Involving participants with the recipe development and cooking demonstrations ensured that dishes were culturally acceptable.

By using local dishes with nutrient-rich powders added, traditional dishes were naturally fortified using local underutilized ingredients rather than introducing new dishes that may or may not be accepted by local people. In addition, participants learned how to adapt family dishes for purposes of IYCF, which improves women's time use in food, as it reduces the requirement to prepare separate dishes. FGDs, cooking demonstrations, sensory evaluations and processing workshops revealed the acceptance and demand for nutrient-rich products. Based on these findings, researchers have identified key areas for improvement for each nutrient-rich powder.

Fish powder: Improving quality and safety of fish

Due to the diverse and essential nutrients that fish powder can provide to young children and the elderly, who typically do not consume fish, participants noted that their communities would demand fish powder if it was safely processed for the market. Fish powder was very popular, but participants noted that proper processing methods would need to be used to decrease processing waste and ensure food safety. Participants recognized the nutritional importance of fish for young children and all family members, and enjoyed the dishes prepared with fish powder. Upcoming research will be conducted by WorldFish on the nutrient content and food safety of fish dried using solar tents and smoking kilns, to inform local stakeholders and fish powder entrepreneurs of the best practices for drying small fish to ensure good quality and food safety.

DGLV powder: Home processing and use throughout the year

Out of more than 100 participants in the processing workshops, only one participant voted that they would purchase DGLV powder if it was available for sale in communities, highlighting that DGLV powder can be produced at the household level and that there is demand for bean and fish powder to be processed and sold. Further efforts for DGLV powder are to focus on home processing, such as planning and processing of seasonal DGLVs to ensure access to DGLV powder throughout the year. For example, DGLVs are difficult to dry during the rainy season. Working with communities to plan ahead to dry, powder and store vegetables may stabilize access to important nutrients found in DGLVs. This, in combination with a shelf life analysis of DGLV powder, can inform researchers and community members of important considerations for ensuring year-round access to DGLVs.

Bean powder: Efficient grinding methods of beans

Along with fish powder, bean powder was very popular in the vote for nutrient-rich powders that participants would purchase, if available on the market. Participants highlighted the versatility of bean powder, as it has little effect on the appearance and taste of foods that it is added to, thus offering an easy way to add protein and nutrients to local dishes. One of the biggest limitations in the production of bean powder was the time spent by women in pounding the beans into powder with a traditional mortar and pestle. Participants noted that bean powder could be processed using a mill, such as the hammer mill, which many people use for maize. However, participants also noted that the mill owners and other customers using the mill may not like people using the maize mill for beans, or they may have to compete for time in milling the beans as the mill is always busy with other commodities (maize). Not only would milling of beans decrease the time spent in pounding beans, but it also has demonstrated benefits of decreased waste. The

mortar and pestle method resulted in 37.5% of wastage, while the machine-milled beans resulted in less than 5% waste.

Scaling up production of nutrient-rich powders

Further development of innovative nutrition-sensitive processing techniques is necessary for upscaling processing of fish and bean powders, as these two powders were reported more difficult or time consuming to process at home. From the workshop and proceeding discussions, time and energy use were two of the biggest concerns for bean and fish powder production. The hammer mills that were tested greatly decreased the time spent to process beans into powder, as 1 kg of beans could be processed into powder in a couple of minutes (rather than 2 hours with mortar and pestle). Additional tests with the small hammer mill proved to decrease waste, in that fish powder produced with mortar and pestle resulted in 26% waste and fish powder produced with the small hammer mill resulted in 2.5%. However, the energy source for the hammer mill needs to be considered. The hammer mills tested and used at the Luwingu main market are powered by electricity, which is not available in some of the project areas. Engineers from SARO agreed to work with WorldFish in building a prototype of a small hammer mill that can be powered manually by pumping a pedal with the foot. The prototyped machine will be designed to grind fish or beans into powder, while increasing time efficiency, and decreasing waste and reliance on electricity and other energy sources.

A challenge when attempting to upscale the production of bean and fish powder is the local availability of beans and fish. Focus groups and key informants reported low access to beans (particularly in Ibale) and low access to fresh fish, thus it is recommended that the research project further explore the value chain for these food commodities, particularly availability and access to these in the communities. In order for nutrient-rich powder processing to be up-scaled, there will need to be consistent and sufficient access to these food commodities. Availability of fish and beans may also be increased by addressing issues with postharvest losses, as aforementioned technology for improved drying and smoking of fish has potential to decrease food waste and thus increase the amount of safe fish that can be consumed.

Women's groups or cooperatives, such as the Kameme Legume Cooperative, can be integrated into project goals by working with existing groups in the communities to upscale production of nutrient-rich powders. The Kameme Legume Cooperative currently gathers and sells beans from the community but was very interested in the production and processing of bean powders in order to diversify their products. Upon completion of testing the prototype hammer mill and determining best practices, the research team plans to demonstrate the effectiveness of the machine to local stakeholders and interested entrepreneurs, cooperatives and women's groups. In sharing research outcomes and advocating for increased production of nutrient-rich products, researchers aim to motivate local entrepreneurs and stakeholders to derive funds to start up a small business producing nutrient-rich powders locally, improving nutrition in the community as well as enhancing income for those involved.

Increasing consumption of nutrient-rich powders

In addition to scaling up processing, greater advocacy and knowledge sharing of the benefits of nutrient-rich powders are necessary in order to stimulate demand within communities. Data from nutrient composition and shelf life analyses of nutrient-rich powders are necessary to advise communities on the use of these powders to improve the nutritional value of traditional dishes as well as inform on the best practices for processing and storage, for nutrient and food safety. Recommendations will be made, for example, on amounts of nutrient-rich powders to be fed to young children, based on the recommended dietary allowance (RDA) for nutrients. As data became available, knowledge was shared with local stakeholders, consumers and entrepreneurs, with the aim to stimulate demand, production and market for nutrient-rich powders.

Dissemination of innovative techniques for enhancing nutrient content of traditional foods, as well as related nutrition information, is important to impact wider communities. The care group model, used in Malawi, provides an opportunity to engage with local, regional and national

stakeholders to include nutrient-rich powders in the nutrition education and cooking demonstrations. In Zambia, nutrition groups and women groups can also include nutrient-rich powders in nutrition education and cooking demonstrations. These approaches can result in an increase in dietary intake of micronutrients and, thereby, reduced reliance on expensive supplementation and food fortification programs. During key informant interviews in both Malawi and Zambia, it was noted that none of the recipes used during cooking demonstrations held by care groups prior to trainings and workshops held by WorldFish. Care groups and nutrition groups provide a platform for knowledge-sharing within communities as well as within the region, as care groups periodically convene regionally. Through partners across multiple sectors—for example, agricultural extension officers, community elders and health care workers—active members of care groups, nutrition groups and women groups in each community should be identified for receiving training on processing and promotion of nutrient-dense powders for improving diet quality in the first 1,000 days.

Photo: Lewis Hyde/Malawi and WorldFish

Women pounding fish into powder, Ipusukilo ward, Zambia.

Conclusion

As noted by the District Department of Fisheries officer in Chitipa, stakeholders and organizations are mostly engaged in the production of fish with less focus throughout the rest of the value chain, and thus there are no storage or processing centers for preserving fish during times of high production. This highlights an opportunity for improving fish value chains, which may benefit from the processing of fish into fish powder and storage of fish for times of low fish availability. It is recommended that partnerships between interested and motivated community members and existing groups be developed to form processing groups for the production of nutrient-rich powders and, at the same time, with nutrition and care groups to promote the use of nutrient-rich powders in the diets of the young child and family. Processing groups will require training on improved processing technologies to improve nutrient retention and food safety while reducing waste and time burden. At the same time, processing groups may require entrepreneurial training in order to better organize and manage their business activities, such as developing appropriate marketing approaches for nutrient-rich powders in order to increase demand from different consumer groups.

Identifying existing groups within target communities to form processing groups, share knowledge and scale up best practices for processing and storage, as well as promoting, age-appropriate consumption of nutrient-rich, safe foods for young children and family members, has the potential to provide equitable access to nutrient-rich foods and improve livelihoods of small-scale fisherfolk in Malawi and Zambia.

A woman drying small fish in a solar tent dryer at a landing site on Lake Malawi.

Notes

[1] Data from the World Bank Country Profiles for Zambia and Malawi. Accessed on May 1, 2020.

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Annex 1. Types of fish, DGLVs and beans selected as nutrient-rich powders in the communities

	Ingredients selected and preparation methods (if applicable)		
Communities	**Fish powder**	**DGLV powder**	**Bean powder**
Malawi			
Kameme-Navitengo	*Mutera*	*Isalwa* (Leaf of Buyole bean)	*Maspengile*
Lufita Section I	*Usipa*	Pumpkin leaf	*Maspengile*
Zambia			
Ipusukilo	*Amatuku* Method: sun-dried fish were roasted, pounded and sieved	*Cimpapilla* (Bean leaf) Method: sun-dried, then pounded and sieved	*Kabulangeti* Method: dry roasted for 30-40 minutes, then pounded and sieved
Ibale	*Impende (Tilapia rendalli)*	*Cinkamba* (Bean leaf)	Lusaka Method: soaked overnight for 12 hours, dried by roasting, then pounded

Annex 2. Nutrient-rich recipes in cooking demonstrations in Kameme-Navitengo, Malawi

	Recipe 1: DGLV relish	**Recipe 2: Soup**	**Recipe 3: Orange Juice**
Nutrient-rich powder used	**Fish powder**	**Fish powder, bean powder**	**DGLV powder**
Ingredients	Fresh *mugagala* (DGLV) – 800g, chopped Pounded groundnuts – 300g Fish powder – 8tbsp Salt Water – for steaming	Onions – 2 Tomatoes – 4 Fish powder – 15tbsp Bean powder – 500g Water – 2L Sunflower oil – ½ cup Salt	Oranges – 20 DGLV powder – 8tbsp Sugar – to taste
Method	Vegetables are steamed for approximately 5 minutes, then add salt and pounded groundnuts and steam for 5 minutes. Fish powder is added and cooked for another 5-10 minutes	Add oil, onions, tomatoes and salt to pot to cook for 10 minutes. In another pot, bring water to boil. Add in bean powder and cook for 20 minutes, stirring constantly to avoid clumping. Add in fish powder, onions and tomatoes and cook for another 10 minutes	Oranges were cut and juiced. Add in DGLV powder and mix well. Add in sugar to taste

Annex 3. Nutrient-rich recipes made in cooking demonstrations in Lufita Section I, Malawi

	Recipe 1: DGLV relish	**Recipe 2: Soup**	**Recipe 3: Orange Juice**
Nutrient-rich powder used	**Fish powder**	**Fish powder, bean powder**	**DGLV powder**
Ingredients	Rape Pounded groundnuts – 300g Fish powder Salt Water for steaming	Onions – 2 Tomatoes – 6 Fish powder – 15tbsp Bean powder – 500g Water – 2L Oil – ½ cup Salt	Oranges – 20 DGLV powder – 5tbsp Sugar – 3tbsp
Method	In one pot, boil a small amount of water with salt, add rape leaves and steam for 10 minutes. Then, stir in pounded groundnuts and fish powder and cook for another 5-10 minutes	Bring water to a boil, add in salt and bean powder and cook for 20 – 30 minutes. Stir frequently to prevent clumping. In another pot, cook peeled tomatoes and onions with a little oil. Season with salt. Once cooked, add the tomato mixture to the bean soup and stir. Add in fish powder and salt to taste	Oranges were cut and juiced. Add in DGLV powder and mix well. Add in sugar to taste

Annex 4. Nutrient-rich recipes made in cooking demonstrations in Ipusuliku-Nsanje, Zambia

	Recipe 1: DGLV relish	**Recipe 2: Soup**	**Recipe 3: Orange Juice**
Nutrient-rich powder used	**Fish powder**	**DGLV powder, bean powder**	**Bean powder**
Ingredients	Fresh cassava leaves Tomatoes – 4 Onion – 1 Fish powder – 200g Water	Tomatoes – 4 Onion – 1 DGLV powder – 100g Bean powder – 200g Water – 2L	Oranges – 35 Bean powder – 5tbsp
Method	Boil cassava leaves for 30 minutes. Add in fish powder and cook for another 10 minutes. Lastly, add in tomatoes and onion and cook with the lid on for another 10 minutes	Bring 1L of water, added with DGLV powder and bean powder to a boil. Add in the remaining water and boil for 1 hour 30 minutes. In a separate pan, fry tomatoes and onion in oil, then add to soup. Boil soup for another 10 minutes	The oranges were juiced, then added with the bean powder. Stir well and serve (The group did not add sugar but would like to do so when they prepare it at home)

Annex 5. Nutrient-rich recipes made in cooking demonstrations in Ibale, Zambia

	Recipe 1: Porridge	Recipe 2: Soup	Recipe 3: Orange Juice
Nutrient-rich powder used	**Fish powder, bean powder**	**DGLV powder**	**Bean powder**
Ingredients	Mealie meal – 100g Tomatoes – 4 Onions – 2 Fish powder – 100g Bean powder – 100g Water Salt	Tomatoes – 2 Onion – 1 Pounded roasted groundnuts – 150g DGLV powder – 75g Cooking oil Water	Oranges – 20 Bean powder – 30g Water Sugar
Method	Bring 1L of water, added with mealie meal, fish powder and bean powder to a boil. In a separate pan, cook onions and tomatoes in oil for 10 minutes, then add to porridge mixture and cook for 20 – 30 minutes	Bring a small amount of water to boil and add in pounded groundnuts. In a separate bowl, add boiled water to DGLV powder to form a paste. Combine DGLV paste and groundnut paste and cook. In a separate pan, cook chopped tomatoes and onions in oil for 10 minutes, then add to DGLV-groundnut mixture and cook for another 10 minutes	Oranges were juiced and added with bean powder. Add water and bring to a boil. Add in sugar to taste

Annex 6. Sensory evaluation form

Respondent Number: _____ Date: _____

Location: _____ Male/Female/Lactating/Pregnant Woman/Child: _____

Sample Code/ fish-based product	Taste	Odor (Flavor)	Texture	Appearance	Overall Impression
Recipe 1	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 2	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 3	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 4	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: 1. Dislike very much 2. Dislike 3. Neither like nor dislike 4. Like 5. Like very much

ACCEPTABILITY EVALUATION (Expression Bases Sensory) - NEXT SECTION ONLY TO BE FILLED FOR CHILDREN				
	Intake [yes (1), no (2)]	Duration of feeding [one bite (1), < 1 min (2), > 2 min (3), finished portion (4)]	Facial expression [happy (1), neutral (2), dislike (3)]	Caretakers' judgment of child's acceptance [see note 1]
Recipe 1				☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 2				☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 3				☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
Recipe 4				☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Note: 1. Dislike very much 2. Dislike 3. Neither like nor dislike 4. Like 5. Like very much

Acceptability Evaluation (Children, Zambia) n=28														
Intake				**Duration of Feeding**				**Facial Expression**				**Mother's Judgment of Acceptability**		
	Juice	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**
Yes	100%	93%	96%	One Bite	46%	46%	39%	Happy	100%	93%	96%	1 (not acceptable)		7%	
No	0%	7%	4%	<1 min	11%	11%	14%	Neutral			4%	2			
				>2 min	0%	18%	7%	Dislike		7%		3		3.5%	3.5%
				finished portion	43%	25%	39%					4		3.5%	3.5%
												5 (highly acceptable)	100%	86%	93%

Acceptability Evaluation (Children, Malawi) n=12														
Intake				**Duration of Feeding**				**Facial Expression**				**Mother's Judgment of Acceptability**		
	Juice	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**		**Juice**	**Ifisashi**	**Soup**
Yes	100%	100%	100%	One Bite	33%			Happy	42%	100%	42%	1 (not acceptable)			
No				<1 min	17%			Neutral	50%		50%	2			
				>2 min				Dislike	8%		8%	3	25%		
				finished portion	50%	100%	100%					4	8%		
												5 (highly acceptable)	67%	100%	100%

**In cases where "one bite" was noted for the feeding duration, most caretakers noted that the portion size was not large enough.

Table10. Children's acceptability trials.

Sensory Evaluations (Adults, Zambia) n=48															
	Juice					Ifisashi with Fish Powder					Soup				
	Taste	Odor	Texture	Appearance	Overall Impression	Taste	Odor	Texture	Appearance	Overall Impression	Taste	Odor	Texture	Appearance	Overall Impression
1 (low)						19%	17%	15%	8%	13%	0%	0%	0%	0%	2%
2						4%	8%	13%	2%	8%	0%	0%	0%	2%	0%
3					6%	17%	8%	8%	13%	10%	2%	2%	0%	8%	2%
4	6%	2%	6%	2%	0%	4%	6%	8%	4%	8%	8%	0%	2%	2%	2%
5 (high)	94%	98%	94%	98%	94%	56%	60%	56%	73%	60%	90%	98%	98%	88%	94%
Sensory Evaluations (Adults, Malawi) n=46															
	Juice					Ifisashi with Fish Powder					Soup				
	Taste	Odor	Texture	Appearance	Overall Impression	Taste	Odor	Texture	Appearance	Overall Impression	Taste	Odor	Texture	Appearance	Overall Impression
1 (low)															
2	7%	4%	4%	7%	7%	2%				2%					
3	4%	4%	9%	15%	4%										
4	24%	22%	22%	22%	22%		13%	2%	4%	2%					
5 (high)	65%	70%	65%	57%	67%	98%	87%	98%	96%	96%	100%	100%	100%	100%	100%

Table 11. Adults' sensory evaluations.

WorldFish

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world. Headquartered in Penang, Malaysia and with regional offices across Africa, Asia and the Pacific. WorldFish is a member of the CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources.

For more information, please visit www.worldfishcenter.org