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**FACULTY OF NATURAL RESOURCES AND ENVIRONMENTAL SCIENCES**

**DEPARTMENT OF FISHERIES AND WATER RESOURCES MANAGEMENT**

**AN EVALUATION OF THE NUTRITIONAL COMPOSITION OF LOCALLY  
PRODUCED ON- FARM FEEDS OF NILE TILAPIA (*Oreochromis niloticus* Linnaeus,  
1758) IN SELECTED DISTRICTS OF EASTERN UGANDA.**

**BY**

**KIPSIRMOI ELLY**

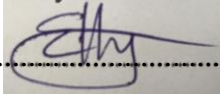
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**TO BE SUBMITTED TO THE FACULTY OF NATURAL RESOURCES AND  
ENVIRONMENTAL SCIENCES IN PARTIAL FULFILMENT OF REQUIREMENTS  
FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN FISHERIES  
AND WATER RESOURCE MANAGEMENT OF BUSITEMA UNIVERSITY**

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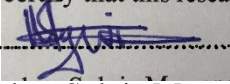
## DECLARATION

I **KIPSIRMOI ELLY** hereby declare that unless otherwise references quoted, the work embodied in this work is entirely a result of my own effort and has never been submitted to any institution of higher learning for the award of a bachelor`s degree

signature..........

date 10<sup>th</sup> October 2025

## **APPROVAL**

This is to certify that this research has been submitted with my approval as a supervisor  
signature..........date 13<sup>th</sup> October 2025

Dr Tebitendwa Sylvie Muwanga

(Supervisor)

## **DEDICATION**

I dedicate this thesis to my parents for their efforts and support during the process, my classmates whom we shared, the farmers respondents during the mini survey and lastly my friends who has collectively helped made it.

## **ACKNOWLEDGEMENT**

I am thankful to the Busitema University library staff who provided me with a good environment and internet that allowed me to write this proposal.

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## **LIST OF ACRONYMS**

**ABW:** Average Body Weight

**DR:** Doctor

**DO:** Dissolved Oxygen

**MAAIF:** Ministry Of Agriculture Animal Industry and Fisheries

**FO:** Fisheries Officer

**AFO:** Assistant Fisheries Officer

**BOD:** Biological Oxygen Demand

**COD:** Chemical Oxygen Demand

**DM:** Dry matter.

**CP:** Crude Protein.

**CF:** Crude Fat.

**EE:** Ether Extract.

## ABSTRACT

In Uganda, aquaculture has emerged as a vital sector for food security, employment, and economic growth, with Nile Tilapia (*Oreochromis niloticus*) emerging as one of the most commonly farmed fish due to its adaptability and high market value. However, the sustainability and productivity of tilapia farming is significantly influenced by the quality and nutritional composition of fish feeds. The present study therefore aimed to evaluate the nutritional composition of the different locally available fish feed ingredients used in the culture of Nile Tilapia in four districts (Kween, Kapchorwa, Bukwo and Sironko) of Eastern Uganda. The specific objectives were to: i) investigate the common locally produced feed ingredients used by fish farmers in Eastern Uganda and ii) assess the nutritional composition of the commonly locally produced on-farm feed ingredients with focus on protein content. The study administered questionnaires to fish farmers to obtain qualitative data such as type of production system, level of farming and commonly used fish feed ingredients while proximate analysis was carried out on commonly used ingredients to determine their crude protein composition. Results revealed that farmers in the studied districts common adopt earthen ponds to culture Nile tilapia on a small-scale, feeding them mainly on cabbage, wondering jew, maize bran and sweet potato leaves. Proximate analysis revealed that all locally used feed ingredients contained crude protein <30% way below the recommended for culture of all ages of Nile Tilapia, which explains the low body weight gain reported by farmers at harvest. It is recommended that the commonly used feed ingredients at present must be supplemented with alternative feeds rich in proteins such as black soldier fly larvae.

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

Global aquaculture hit 185 million tons (live weight equivalent), an increase of 4% from 2020 (FAO 2022) with China being the main contributor. Although the global aquaculture production continues to increase, Africa's contributions remain minimal. To date, global investment in aquaculture has grown in the bid to enhance fish production to meet the demand-supply gap arising from the continual decline in capture fisheries according to world bank report 2013. For example, African countries that made a substantial contribution to the aquaculture production in 2021 included Egypt (67.00%) Nigeria (11.2%), Ghana (5.7%) and Uganda (4.5%). While such an increment is unmistakable, the contribution of African countries to the global aquaculture remains deplorably low at around 2.7%. However, aquaculture in the continent is likely to grow with the recent investments from the private sector and the government like in Uganda. Such investments are aligned to feed manufacturing and cage fish farming. In the past few years, there has been increasing interest in tilapia fish farming in Uganda, with the number of earthen ponds increasing from 14,100 in 2016 (Kaliba et al., 2006) to 26,445 in 2019 (URT, 2019). As a result, demand for good-quality fish diets has also increased.

Despite imported commercial feeds for fish being popular, its monopoly has raised costs, to levels smallholder fish farmers cannot afford. This means small holder farmers opt to use locally available feed ingredients of both plant and animal origin as a nutritional supplement for their farmed fish (Chenyambuga et al., 2014; Kaliba et al., 2006). These ingredients include maize bran, kitchen leftovers, garden byproducts, rice polish, banana leaves, sweet potato leaves, fishmeal and poultry by-products to mention but a few kwikirza et al (2016). The local ingredients used vary in nutritional value from one region to another, depending on climate conditions, geographical zone, soil type and seasonal production (NRC (National Research Council), 2011; Onyango et al., 2019). while most commercial fish farmers in Uganda especially cage fish farmers have adequate resources to either make appropriate feeds or buy already complete formulated feeds, the availability and cost of fishmeal and soybean meal or oilseed cake are major constraints (De silva, 1993), Thompson et al., 2005). Amidst use of locally formulated feeds, there are some farmers who continue to make their own feed

without knowing the nutrient composition of the ingredients used. This research proposes to fill this knowledge gap through a comprehensive study on the types, availability and nutritional quality of local fish feeds ingredients in Eastern Uganda that could be used as alternatives to fishmeal.

## **1.2 Problem statement**

In Uganda inclusive of the Eastern region, aquaculture has emerged as a vital sector for food security, employment, and economic growth. The Nile Tilapia (*Oreochromis niloticus*) is one of the most commonly farmed fish due to its adaptability and high market value. However, the sustainability and productivity of tilapia farming are significantly influenced by the quality and nutritional composition of fish feeds. The variability in the availability, quality, and nutritional value of these feeds across different districts poses a significant challenge for fish farmers. Locally produced fish feeds are often used by farmers as a cost-effective alternative to imported feeds. Yet, there is limited comprehensive data on the nutritional composition of these local feeds and whether they meet the dietary requirements for optimal tilapia growth and health. Despite the availability, there is limited understanding of the existing local feed ingredients basing on their nutritional adequacy, and how they align with international standards practice in fish farming. Evaluating the nutritional content of locally produced feeds is therefore essential to identify deficiencies and establish improvements to align with recommended nutritional standards. Such evaluation can contribute to the development of effective feed formulations that enhance productivity and support the long-term sustainability of aquaculture in Eastern Uganda.

## **1.3 The aim and objectives of research**

### **The aims of the thesis**

The overall aim of the study was to evaluate the nutrient composition of the different locally available fish feed ingredients used in the culture of Nile Tilapia in four districts (Kween, Kapchorwa, Bukwo and Sironko) Please name the districts) of Eastern Uganda.

### **1.3.1 Objectives of the research**

- 1) To investigate the common locally produced feed ingredients used by fish farmers in Eastern Uganda.
- 2) Assess the nutrient composition of the commonly locally produced feed ingredients with focus on crude protein content.

#### **1.4 Research questions**

- 1) What are the common feed ingredients used by fish farmers in Eastern Uganda?
- 2) What is the nutritional composition of the commonly used fish feed ingredients among fish farmers in Eastern Uganda.

#### **1.5 Justification**

Fish farming is a vital component of the agricultural sector in Uganda, contributing to food security and income generation. Understanding local feeds is essential for maximizing production and ensuring that fish farmers can compete in both local and international markets.

With the increasing pressure on aquatic resources, sustainable aquaculture practices are essential. Assessing local feeds can help identify locally available, sustainable high quality feed ingredients, reducing dependence on imported feeds and promoting the use of environmentally friendly practices (Chenyambuga et al., 2014; Kaliba et al., 2006).

The findings from this research can inform policymakers and stakeholders about the current state of fish feeds in the region. This information is crucial for developing targeted interventions, support programs, and training initiatives aimed at enhancing the aquaculture sector.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Overview of Commonly Cultured Fish Nutrition

Fish culture is the artificial breeding, rearing, and harvesting of fish in a controlled environment. Aquaculture in Uganda is a growing sector with significant potential to contribute to food security, employment, and the national economy.

Primarily, the cultured species are the African cat, the Nile tilapia, and the mirror carp, with catfish surpassing the two. However, due to international market demand, Nile tilapia is leading. (kwikiriza et, 2016)

##### 2.1.1 Nutritional Requirements of Nile Tilapia

Proper fish growth depends on diet, however it's important that provide a diet that has all the essential nutrients in the right proportion. The are divided in to macro and micro nutrients.

##### **Macro nutrients**

Protein are body building blocks they are important for the growth and development of muscles, playing reproduction functions.

**Carbohydrates:** these are essential for providing energy required for the fish to swim while looking for food, mates and others

**Lipids:** vital for cell membrane structure and hormonal function

##### **Micronutrient requirement**

Vitamins essential for various metabolic process including growth vision and immunity. (Tabara et, al, 2025)

Vitamin needs of fish

Table 2.1 showing vitamin needs of fish

Vitamin	Purpose
Vit A	Vision, growth, and immune function.
Vit B	Energy metabolism, nerve functions and red blood cell production.
Vit E	Antioxidant, cell protection and immune function
Vit D	Calcium absorption and bone formation
Vit C	Immune functions, tissue repair and collagen synthesis
Vit K	Blood clotting and bone health

Minerals required for bone formation, muscle and maintaining electrolyte balance

Mineral needs

Table 2.2 showing minerals needs of fish

Mineral	Purpose
Calcium	Essential for bone formation, muscle function and nerve transmission.
Phosphorous	Plays a vital role in energy production, bone formation and cell function.
Magnesium	Essential for muscle function, nerve transmission and maintaining electrolyte
Sodium	Crucial for maintaining fluid balance

### 2.1.2 Importance of balanced diets in aquaculture

A balanced diet provides the necessary building blocks for proper growth and development of fish. Reproduction proper nutrition is essential for the production of healthy egg and sperms ensuring successful breeding (Gabriel, Akinrotimi, Bekibele, *et al.*, 2007). Disease resistance nutrients play a vital role in maintaining the immune system of the fish thereby fish becoming resistant.

### **2.1.3 Common feed ingredients used in catfish and tilapia farming**

Feed ingredients are material used to formulate fish feeds. These include soybean ground nuts, sunflower, The cotton seed cake. Several leaf meals have been studied with respect to their suitability as protein sources in fish diets these include leucaena, sesbania sweet potatoes leaves, coco yam leaves, banana leaves, the animal material include blood meal, fish meal and black soldier fly larvae.

## **2.2 Ingredients used by fish farmers in Uganda**

Local feeds constitute to protein contents, fats, carbohydrates, and minerals, local feeds are majorly classified in to animal and plant source. Examples include tadpole meal, maggots, earthworm meal, housefly larvae, among others.(G *et al.*, 2017)

In most parts of Africa, these are available in small quantities, and their production is inconsistent and sporadic in nature(Gabriel, Akinrotimi, Bekibele, *et al.*, 2007).

### **2.2.1 Types of Locally Available Feed Ingredients**

The various local feeds can be categorized according to origin as in below

**Plant-Based Ingredients:** Soybean Meal: A high-protein ingredient often used in fish feeds, providing essential amino acids.

Corn and Corn Gluten Meal: Commonly available grains offering energy and some protein content.

Rice Bran: A byproduct of rice milling, rich in fats and fibre, and an excellent energy source.

Pea Protein: A good alternative protein source, particularly in regions where peas are cultivated.

**2. Animal-based ingredients:** fish meal: made from processing whole fish or fish byproducts, providing high-quality protein and essential fatty acids.

Blood Meal: A high-protein byproduct derived from slaughterhouses; it's rich in nitrogen. (Kwikiriza *et al.*, 2016; G *et al.*, 2017)

### **2.2.2 Sources of these ingredients (agricultural by-products, wild plants)**

When formulating feed for tilapia, sourcing the right ingredients is crucial for nutritional adequacy and cost-effectiveness. Here are the different sources of tilapia fish feed ingredients:

#### **1. Agricultural byproducts:**

**Soybean Mills:** Sourced from local oilseed crushing plants, soybean meals serve as a high-protein ingredient.

**Corn and wheat byproducts:** Local grain mills provide corn gluten meal, bran, and other byproducts that are energy-dense.

**Kitchen wastes:** This is being used at the household level of aquaculture especially in backyard fish farming, where remnants from household wastes are used to feed the fish. These are used indiscriminately, without any standard. Examples of feed in this category are cassava and yam peels. Faturoti and Akinbote (1986) recorded 20% substitution with high level of economic performance when cassava peel was fed to tilapia. Oresegun and Alegbeley (2001) recommended the addition of 0.2% methionine with 20% inclusion of cassava peel. Also, kitchen remnants like bread, cooked rice, and yam are commonly used in the culture of fish.

**Fishery byproducts:** fish processing plants: fish meal and fish oil can be obtained from processing plants, which use fish and fish waste not suitable for human consumption. These are used as fish ingredients.

**Local fisheries:** Small-scale fishers may sell bycatch or surplus fish, providing a fresh source for feed.

**Livestock feed fills:** These include blood meal and feather meal, which are high in protein and can be sourced from local slaughterhouses or dairy farms e.g. the blood meal.

**Aquaculture practices:** Some farms cultivate microalgae like spirulina as a protein source, offering a sustainable alternative.

**Duckweed and water hyacinth:** These plants can be harvested from local ponds or cultivated in small systems for fish feed.

**Food processing industries:** Waste products from beer and spirits production, such as spent grain and yeast, can provide a good source of nutrients.

**Vegetable processing plants:** Leftovers from vegetable processing, including peels and stems, can be added to feed formulations.

### 2.3 Traditional vs. commercial feed formulations

Difference between local made fish feeds and commercial fish feeds can be summarized in the table below. (Gabriel, Akinrotimi, Onunkwo, *et al.*, 2007; Theodora S. Hyuha, 2011; I.S., J.I and K, 2017; Omasaki *et al.*, 2017; Pius Mmanda, 2020)

Table 2.3 shows Traditional vs commercial

Local feeds	Commercial feeds
These are feeds made by farmers at their farmers in local way	Refers to feeds produced by fish-by-fish feed industrial for sell.
This are produced in small scale for only farm	These feeds are produced in very high scale
These feeds lack some nutrients in them	It contains all the essential feeds nutrients
The technology used in making the local feeds are low	High technology is paramount in making these feeds
The cost of production is low	There is high cost of production

#### 2.3.1 Nutritional Composition Analysis of Local Feed Ingredients

This provides a foundational understanding of the nutrient composition of various ingredients commonly available for tilapia feed in Uganda. Farmers should utilize this data, considering local ingredient availability and nutritional requirements, to formulate balanced diets for optimal tilapia growth and production. Regular analysis and adjustments may be needed based on seasonal variations in ingredient quality(Kwikiriza *et al.*, 2016; G *et al.*, 2017)

Table 2.4 showing nutritional analysis of local feed formulation

<b>Product</b>	<b>Dm</b>	<b>Cp</b>	<b>Ee</b>	<b>Cf</b>	<b>Nfe</b>	<b>Ash</b>
<b>Fish meal</b>	879±0.6	551±1.7	187±1.5	13±0.6	68±1.0	182±1.5
<b>Maize bran</b>	894±3.0	118±4.6	107±2.7	55±0.7	349±3.5	29±1.3
<b>Rice bran</b>	923±4.2	70±3.8	41±1.6	309±2.4	349±3.5	229±2.2
<b>Wheat bran</b>	882±1.6	171±6.2	58±2.3	127±2.3	582±6.9	60±2.6
<b>Banana leaves</b>	899±1.0	170±1.8	127±1.4	241±01.8	337±1.3	124±3.6
<b>Cotton seed cake</b>	892±2.0	388±7.2	107±1.0	249±4.5	192±2.6	63±4.6
<b>Cassava leaves</b>	919±3.6	308±4.8	86±4.1	156±4.0	368±2.1	82±5.2
<b>Sunflower cake</b>	929±0.4	259±0.1	54±0.8	368±0.2	266±0.8	51±0.1
<b>Sweet potato</b>	892±1.6	353±3.6	43±3.7	105±3.6	388±1.1	104±3.6
<b>Arabica coffee husk</b>	893±1.9	47±1.8	36±0.6	383±2.6	418±3.6	115±2.8
<b>Brewery bye product</b>	919±1.9	264±0.3	291±0.1	158 ±0.6	221±0.5	66±0.4

**DM= Dry matter, CP=Crude protein, CF=Crude fat, Ea.= Ether extract.**

### 2.3.2 Protein content

Nile tilapia requires the same ten essential amino acids as other finfishes. Protein requirements for optimum growth are dependent on dietary protein quality/source, fish size or age and the energy contents of the diets and have been reported to vary from as high as 45-50 percent for first feeding larvae, 35-40 percent for fry and fingerlings (0.02-10 g), 30-35 percent for juveniles (10.0-25.0 g) to 28-30 percent for on-growing (>25.0 g). The best protein digestibility occurs at 25 °C (Gabriel, Akinrotimi, Bekibele, *et al.*, 2007; Namulawa and Monchie, 2016; Pius Mmanda, 2020) and the optimum dietary protein to energy ratio was estimated in the region of 110 to 120 mg per kcal digestible energy respectively for fry and fingerling. Tilapia

broodfish require about 40-45 percent protein for optimum reproduction, spawning efficiency and for larval growth and survival.(G *et al.*, 2017)

### **2.3.3 Lipid (fat) content**

The lipid nutrition of farmed tilapia has been reviewed by. The minimum requirement of dietary lipids in tilapia diets is 5 percent but improved growth and protein utilization efficiency has been reported for diets with 10-15 percent lipids. Both n-3 and n-6 polyunsaturated fatty acids (PUFA) have been shown to be essential for maximal growth of tilapia. For Nile tilapia the quantitative requirement for n-6 PUFA is around 0.5-1.0 percent. Unlike marine fish species, tilapia appear not to have a requirement for n-3 highly unsaturated fatty acids (Gümüş and İkiz, 2009)

### **2.3.4 Carbohydrate levels**

The exact carbohydrate requirements of tilapia species are not known. Carbohydrate utilization by tilapia is affected by a number of factors, including carbohydrate source, other dietary ingredients, fish species and size and feeding frequency(Gümüş and İkiz, 2009). Complex carbohydrates such as starches are better utilized than disaccharides and monosaccharides by tilapias.

Hybrid tilapia showed the carbohydrate (44 percent) digestibility in the following progression: starch>maltose>sucrose>lactose>glucose. Carbohydrate utilization by tilapia species have been reviewed. Nile tilapia is capable of utilizing high levels of various carbohydrates of between 30 to 70 percent of the diet.

It has also been demonstrated that larger hybrids utilize carbohydrates better than local fish. reported that the inclusion of soluble non-starch polysaccharides (NSP) in the form of cellulose in the diet of Nile tilapia increased the organic loading of the culture system, while insoluble NSP (guar gum) placed less organic load on the system by increasing nutrient digestibility and improving feces recovery.

### **2.3.5 Fiber content**

Fiber refers to plant material such as cellulose, hemicellulose, lignin, pantoums and other complex carbohydrates. These are indigestible and they do not play an important role in nutrition. Fiber adds bulk to a feed but increases the amount of faecal material produced. The goal in commercial aquaculture is to limit the diets Fiber content and use highly digestible feeds(Kwikiriza *et al.*, 2016)

### **2.3.6 Moisture content**

Accurate determination of the moisture (water) content in individual feed ingredients and mixed feeds is critical throughout the feed industry. Most analytical methods used to determine apparent water content of feedstuffs are empirical, estimating water by evaporation and loss of weight on drying (oven drying methods). These methods differ greatly in effectiveness, resulting in bias. Bias associated with measuring the water content of feedstuffs is a concern not only because of the lack of confidence in the moisture value itself, but also because moisture determinations affect accurate quantification and expression of other nutrient values. Methods for determining moisture in feeds have frequently been borrowed from the cereal, forage, or other applications without validating the extension of the method. Methods such as Karl Fischer titration measure water by direct comparison to a calibration standard for water and can be used as reference methods for the evaluation of empirical methods (Gümüş and İkiz, 2009; Barba *et al.*, 2012a)

### **2.3.8 Ash content**

The ash content of a sample is a measure of the amount of inorganic non combustible material it contains. The residues after a sample is completely burnt - in contrast to the ash remaining after incomplete combustion - typically consist of oxides of the inorganic elements present in the original sample. Ash is one of the components in the proximate analysis of biological materials, consisting mainly of salty, inorganic constituents. It includes metal salts which are important for processes requiring ions such as Na<sup>+</sup> (sodium), K<sup>+</sup> (potassium), and Ca<sup>2+</sup> (calcium). It also includes trace minerals which are required for unique molecules, (Gümüş and İkiz, 2009; Barba *et al.*, 2012a)

## **2.4. Comparison of Local Feed Ingredients with Commercial Feed**

Fish fed with commercial feeds shows significant higher weight increase, specific growth rate, protein efficiency ratio and low food conversion ratio than fish fed with local feed. Significant ( $P < 0.05$ ) higher mortality was recorded in fish fed with the local feed. The growth performance was a reflection of the proximate composition of the feeds with local feed having low crude protein (10.95%), lipid (3.95%) and ash (4.92%) when compared to commercial feeds which has 42% crude protein, 12% lipid and 9.5% ash with protein being most significant. Carbohydrate (69.90%) and crude fibre (2.88%) were higher in the local feed than in commercial feeds with an imbalance in carbohydrate and lipid ratio. Cost of feeding with local feed to a weight gain of 31.67g was higher, while the cost of feeding with commercial feed is cheaper.

#### **2.4.1 Nutritional adequacy of local feeds**

The scarcity and increase of commercial feed prices mainly due to COVID-19 pandemics, these conditions have increased the need to seek for local feeds which is hopefully at low cost, sustainable and carbon footprint related to its production and transportation.

#### **2.4.2 Growth performance of cultured fish fed on local feeds vs. commercial feeds**

Fish fed with commercial feeds shows significant higher weight increase, specific growth rate, protein efficiency ratio and low food conversion ratio than fish fed with local feed. Significant ( $P < 0.05$ ) higher mortality was recorded in fish fed with the local feed. Mortality was attributed to stress resulting from the poor quality of the feed.

### **2.5 Challenges Associated with Using Local Feed Ingredients**

The inclusion of plant materials in the fish feeds can lead to reduced performance in many cases. This is attributed to a number of factors including poor palatability which is acceptable to the taste, poor digestibility defined as quantification of digestive processes which gives a relative measure of the extent to which ingested feed and its nutrients have been digested and absorbed by the animal, antinutritional factors and high fibre content (Nakavuma *et al.*, 2020). Antinutritional factors are defined as substances which themselves or through metabolic products arising in living systems, interfere with food utilization affecting the health and production of the fish. Cereals are plentiful and economical during harvest seasons but progressively become more expensive until the next harvest cycle (Namulawa and Monchie, 2016).

Additionally, the availability of raw materials fluctuates seasonally, with agricultural inputs being most abundant during harvesting times (Rønnestad *et al.*, 2013)

#### **2.5.1 Variability in nutritional composition**

Different plant varieties and animal breeds exhibit significant variations in their nutritional composition. For example, the protein content of wheat can range from 10–15%, depending on the cultivar. Similarly, different cattle breeds produce milk with varying fat and protein content. (Arosemena, De Peters and Fadel, 1995; Mengistu *et al.*, 2020b)

Soil composition, climate, and agricultural practices significantly affect nutrient levels in crops. For instance, the iron content in rice varies based on soil conditions and fertilization method.

Drought stress can reduce the carbohydrate content in some crops while increasing their protein content (Abd El-Hack *et al.*, 2022)

Food processing alters nutrient composition. Milling of wheat reduces fiber and micronutrient content as bran and germ are removed (Slavin, Jacobs and Marquart, 2000). Heat treatment, such as pasteurization, can degrade vitamins like vitamin C in fruit juices (Barba *et al.*, 2012b)

Storage affects nutrient stability, especially vitamins. "Vitamin C content in fresh vegetables can decrease by up to 50% during refrigerated storage. (Rickman *et al.*, 2011)

### **2.5.2 Seasonal availability of feed ingredients**

The availability of feed ingredients fluctuates throughout the year due to climatic conditions, harvesting schedules, and market dynamics. (Gabriel, Akinrotimi, Onunkwo, *et al.*, 2007) These variations impact the cost, quality, and accessibility of feed for livestock and fish.

### **2.5.3 Processing and preservation challenges**

Lack of Awareness and Knowledge on Fish Feed Management. Many farmers in East Africa have a limited understanding of feed quality, management, and the nutritional requirements of fish. When calculating feed rations, they often fail to feed their fish according to recommended rates and overlook factors like ambient temperature, body mass, and pond biomass.

Feed Formulation Challenges. Properly formulated feeds are crucial for successful aquaculture production, yet many feed manufacturers struggle to provide species-specific nutrients that caters to the different life stages of fish.

In East Africa Uganda, there is a lack of detailed information on the nutritional content of local ingredients. Consequently, most locally formulated feeds depend on international laboratory analyses of high-quality ingredients from literature, lacking sufficient local scientific research to validate their effectiveness in fish production. Feed processing and preservation are essential for maintaining nutritional quality, ensuring safety, and extending shelf life. However, several challenges arise during these processes due to environmental factors, microbial contamination, nutrient losses, and storage conditions. (Munguti *et al.*, 2024)

#### **2.5.4 Potential contamination (toxins, Molds, heavy metals)**

Heavy metals accumulate in fish feeds due to contaminated ingredients, water sources, and industrial pollution. Common heavy metal contaminants in fish feed include lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As), which can bioaccumulate in fish tissues and pose health risks to consumers (Tao *et al.*, 2020). The accumulation of heavy metals in fish feeds varies based on ingredient source and processing methods, requiring strict quality control measures (Saha, Mottalib and Al-Razee, 2021).

Aflatoxins, ochratoxins, and deoxynivalenol (DON) are common mycotoxins found in fish feed ingredients, particularly those derived from grains and oilseeds (Nakavuma *et al.*, 2020). Aflatoxin B1 is particularly toxic to fish, causing liver damage, immunosuppression, and reduced growth. Storage conditions, moisture content, and fungal contamination are major factors influencing mycotoxin levels in fish feeds (Nakavuma *et al.*, 2020).

Agricultural residues from plant-based feed ingredients can introduce harmful chemicals into fish diets. Pesticide residues, such as organophosphates and carbamates, have been detected in fish feeds derived from contaminated crops. Herbicides, including glyphosate and atrazine, may persist in soy-based feed ingredients and affect fish metabolism. Bioaccumulation of pesticide residues in aquaculture species raises concerns over food safety and human health risks (Semalulu, Hecky and Muir, no date).

Microbial contamination in fish feeds can lead to disease outbreaks and feed spoilage. Pathogenic bacteria such as *Salmonella*, *Escherichia coli*, and *Clostridium perfringens* can contaminate fish feeds, posing risks to aquaculture and human health. Fungal contamination of feed ingredients, particularly under high humidity conditions, increases the risk of mycotoxin production and feed deterioration. Proper heat treatment, drying, and storage conditions are essential to minimize microbial contamination in fish feeds. (Oliva-Teles, 2012; Nakavuma *et al.*, 2020; Namulawa *et al.*, 2020)

#### **2.6 Impact of Local Feed Ingredients on Growth Performance and Fish Health**

Using locally available fish ingredients in aquaculture feeds can have significant impacts on fish growth performance, health, and overall sustainability. These effects depend on ingredient quality, nutrient composition, digestibility, and the presence of anti-nutritional factors or contaminants.

Locally sourced fish ingredients, such as fish meal and fish byproducts, provide essential amino acids crucial for fish growth. Fish meal is considered the gold standard protein source in aquafeeds due to its balanced amino acid profile, high digestibility, and palatability. Inclusion of high-quality local fish meal in diets improves feed conversion ratio (FCR), weight gain, and protein efficiency ratio (PER) in cultured fish species (Gabriel, Akinrotimi, Onunkwo, *et al.*, 2007; Gümüş and İköz, 2009; Pius Mmanda, 2020).

In Nile tilapia (*Oreochromis niloticus*), replacing soybean meal with locally sourced fish meal increased growth rates and nutrient retention" (Munguti *et al.*, 2012).

### **2.6.1 Growth rate, feed conversion ratio (FCR), and survival rate**

**Feed conversion rate (FCR)** measures how efficiently fish convert feed into body weight. A lower FCR indicates better feed efficiency, meaning less feed is required to produce a unit of fish weight gain.

$FCR = \text{Total feed consumed over total weight gained}$

**Growth rate:** determines how quickly fish increase in weight over time. It helps farmers assess productivity and profitability.

$SGR\% = \frac{\text{final weight} - \text{initial weight}}{\text{time}} \times 100$

Factors Affecting feed conversion rate (FCR) include: **Feed quality:** High-quality feed improves feed conversion rate (FCR), **Fish species:** Some species convert feed more efficiently than others., **Water quality:** Poor water conditions can lead to poor digestion and higher feed conversion rate (FCR)., **Stocking density:** Overcrowding increases competition for food and raises feed conversion rate (FCR) (Mengistu *et al.*, 2020)

### **2.6.2 Immune response and disease resistance**

The diet of tilapia plays a crucial role in enhancing immune response and disease resistance. Proper nutrition ensures that tilapia develop strong immunity, reducing their vulnerability to pathogens, stress, and environmental fluctuations. Below are key ways in which feed contributes to tilapia immunity and disease resistance. (Oliva-Teles, 2012)

### **2.6.3 Water quality and environmental effects of using local feeds**

Water quality is a critical factor when culturing any aquatic organism. The quality is highly affected by feeds by changing water parameters Ph, dissolved oxygen, alkalinity the amounts

of ammonia and nitrates. This can further lead to increased anoxic condition leading to mortalities of fish.

Low quality feeds are an impediment to sustainable fish farming in Uganda. Low quality feeds affect fish growth, pollute the aquatic ecosystem, escalate conflicts among competing water resource users, and affect enterprise sustainability (Burkholder *et al.*, 2007)

## **2.7 Sustainability and Future Prospects of Local Feed Ingredients**

Sustainability can be attained by stimulating and providing farmers and advisors with appropriate knowledge and skills in animal feed formulation practices and business ideas that can bring all about continuity, accessibility and availability of the local fish feed to fish local.

There is need for research in tilapia fish production under local conditions and strengthening institutional support for organic livestock development in Uganda. This will include the local material used during production of feeds, how better to improve it, how to treat the antinutritional compounds Water quality control and monitoring.

Need to prohibit the use of non-sustainable and/or adulterated terrestrial feed ingredient sources, including meals derived from endangered and/or protected wild animal species, the use of non deforestation/conversion-free feed ingredients, the use of highly subsidized imported feed ingredient sources, and the use of spoiled, adulterated and/or contaminated feed ingredients (FAO , 2019; Berntssen *et al.* 2010, 2021; Siegel *et al.* 2016; Gonçalves *et al.*, 2018; mowi 2020).

Need to prohibit the use of non-approved terrestrial feed ingredient sources (depending upon the producing/importing country) for perceived religious and/or food safety concerns, including feeds containing terrestrial animal byproduct meals, genetically modified plant feed ingredients, and animal manures (Schofield 2002; Boyd *et al.* ,2020);

Need to reduce the carbon footprint of aquafeeds through the reduced use of imported feed ingredient sources and the increased use and recycling of locally available agricultural and fishery resources derived from sustainably managed and operated agricultural and fishery operations (FAO 1997; Tacon *et al.*2012; Boyd *et al.*2020.)

Need to limit the selection and use of potentially food-grade feed ingredient sources, including fisheries bycatch, small pelagic fish species, and food-grade cereal grains, starches, pulses, and oilseeds (FAO.,2011), Tacon *et al.*, 2012

### **2.7.1 Potential for improvement in feed formulation**

Feed calculator and other new technologies can help to provide the right recipe during feed formulation of local on farm feeds, this technology simplify work

Research and development this can significantly enhance feed formulation through nutritional studies where understanding the digestibility, ingredient innovation feed processing techniques and sustainability practices becomes ideal for the study.

Improvement of local ingredient this can done through research to improve the nutrition content of the plant-based protein ingredients, proper storage procedures and better way to remove antinutritional factor.

Improvement of equipment through upgrading to modern extrusion machines can improve pellet quality, and increase nutrient availability.

### **2.7.2 Role of government and research institutions in enhancing feed quality**

Uganda governments should stimulate domestic feed industries by reducing or removing taxes on imported feed milling machinery and basic feed ingredients.

provide low-interest loans to producers, ensure feed quality and safety through inspections and feed certification, promote the adoption of appropriate feed manufacturing guidelines and standards.

provide the necessary extension services and training on the best feeding and fertilization practices, develop country-specific farm-made feed formulations and promote research on tilapia nutrition and feed management, with emphasis on nonconventional feed ingredients.

On the other hand, commercial feed producers should produce and market necessary feedstuffs to fish farmers, provide high-quality feeds at reasonable prices, make proximate analyses available to clients and provide information on feed availability and efficacy to the public sector.

The Fisheries and Aquaculture Act 2022 provides a framework for the formulation of policies and the transparent and accountable management of the fisheries and aquaculture sectors. This act takes into account fish quality control issues, the diversification of fish products for domestic and international markets, the regulation of imports and exports, and strengthening the infrastructure for domestic, regional, and international trade.

MAAIF is responsible for formulating and implementing policies related to agriculture, including the livestock sector. It oversees the development and enforcement of standards for

animal feed production, ensuring that feeds meet the nutritional requirements necessary for optimal animal health and productivity

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Ugandan government should enact the Animal Feeds Act to regulate the production, storage, importation, exportation, and marketing of animal feeds. This legislation aims to standardize feed quality across the country, ensuring that all feeds meet specified nutritional and safety standards for tilapia fish.

### **2.7.3 Opportunities for small-scale fish farmers in adopting improved feed practices**

Improving feed accessibility for small-scale fish farmers is crucial to the inclusive growth of aquaculture.

Nutritious pond feeds nourish the farmed fish and the pond organisms that help break down fish wastes and produce natural food for the fish. Their ingredient composition makes them less expensive than conventional feeds while maintaining or increasing fish production in a healthy pond environment.

Local, underused and inexpensive agricultural co-products can be effectively used as fish feed ingredients, thereby reducing dependency on ingredients that can be directly consumed by humans.

The Feed Calculator mobile phone application equips small-scale feed millers and farmers to formulate nutritious pond feeds from local ingredients

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

#### **3.1 Study area**

The study was to be conducted at Kween, Kapchorwa, Bukwo, and Sironko, districts in eastern Uganda. The site is characterized by a rainy season from March to May and a dry season during June and receives rains again from July to October site receives an annual rainfall of between 1200 and 1800 mm, and the temperature ranges from 25 to 32 °C. The main economic activities at the study site are agriculture, include crop farming (rice, maize, Irish potato and banana) complemented with fish farming.

#### **3.2 Research strategy**

This study employed a mixed-method approach, combining qualitative and quantitative data collection methods. The research design was partially descriptive mainly Focusing on field survey method. Primary data was collected through structured questionnaire within the five districts in Eastern Uganda. The interview was purposely aim to identify the available and locally used feed ingredients in by fish farmers in Eastern Uganda.

##### **3.2.1 Qualitative data collection**

A kobo collect tool comprising questions concerning the type of fish farm, farming system, local feed ingredients used, source of ingredients. The questionnaire was used to administer to collect data from five respondents in each district of the selected four and later analyzed using micro soft excel.

##### **3.2.2 Quantitative data collection**

To determine the nutritional composition of local fish feeds, we used results from the Mini survey to identify the most used ingredients to collect samples, where five ingredients were sampled of 200g each, preserved and packaged with clear prescription on the package then taken to Kajansi food analytical lab for proximate analysis.

###### **3.2.2.1 Proximate analysis**

Proximate analysis of ingredients provided reference database of the nutritional composition of the locally available ingredients that can be used in fish feeds locally. Proximate nutrient

analysis was to be performed on five locally mobilized ingredients from eastern Uganda. The ingredients are to be analyzed for Moisture, Ash, Crude fat, Crude protein, Gross energy contents and matter basis using standard methods. Moisture content ranges was be obtained.

### **3.2.2.2 Sample preparation**

The individual feed ingredient samples from different regions were pooled, sun-dried for 48 hours, packaged and transported to the laboratory for proximate analysis according to the method described by Sindirações 2005 and Alimentarius 2004. The pooled sample of each feed ingredient was then spread out on a clean plain surface marked into quarters and two opposite quarters was taken and mixed. This process is repeated until the two quarters selected comprised the desired amount of 100–200 g. Prior to analysis, these sub-samples was milled by a JYL-D020 Powerful Multifunctional Blender Food Processor, Joyoung, China and sieved by hand through 1.0 mm circular openings.

### **Proximate chemical analysis**

Proximate chemical analysis of fish feeds and ingredients was carried out according to AOAC. Dry matter (DM) is determined by drying 2 g of each sample (n = 30) to constant weight in an oven (E 115, WTB binder 7200, Tuttlingen, Germany) at 105°C overnight (12 h). Crude protein (CP) content is quantified by the standard Kjeldahl nitrogen method Pearson (1999), using a 2200 Kjeltex auto distillation unit (Foss, Tecator, Sweden). Lipid content (ether extract, EE) is quantitatively determined using petroleum ether (ST 243 Soxtec™, Hilleroed, Denmark), crude fiber (CF) content is determined using an ANKOM 200 fiber analyzer (ANKOM, New York, USA). Ash content is determined as the residue remaining after incineration of 1 g of sample (n = 30) in a weighed porcelain crucible in a muffle furnace at 550°C for 3 h. The following AOAC (1990) methods is used: DM (930.04; 930.15); ash (930.05; 942.05), CP (954.01); EE (920.39); and CF (962.09). Nitrogen-free extract (NFE) content is calculated by subtracting the sum of crude protein, crude lipid, ash and crude fiber from the corresponding dry matter values.

### **3.3 Data Analysis.**

The apparent digestibility values obtained for dry matter, organic matter (OM), crude protein and energy will be subjected to one-way analysis of variance (ANOVA).

## CHAPTER FOUR

### RESULTS

This chapter summaries the data collected from field both in qualitative where in bar graph and pie charts as to be viewed below

#### 4.1 QUALITATIVE DATA

##### 4.1.1 Type of production system

The results show two type of production systems are used in the studied districts. The results further show fish farmers use ponds (76%) more than tanks (24%) for aquaculture in the selected districted in which research was carried out.

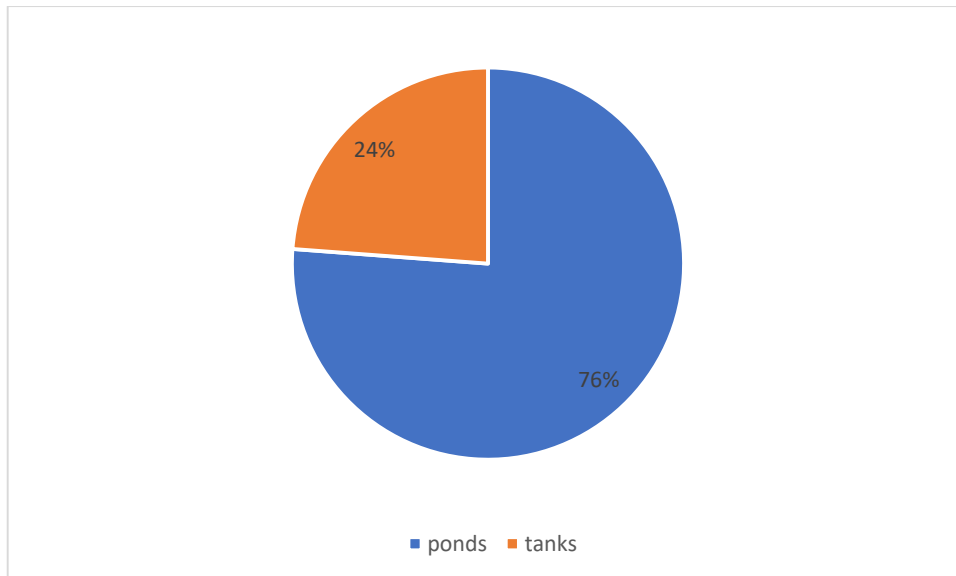


Figure 4.1 shows types of production systems

**4.1.2 Level of fish farming** Results of the study indicate that fish farming in Eastern region is categorised into two: small holder fish farming and medium- scale fish farming (Figure 4.2). According to Figure 4.2, results clearly show that small scale fish farmers (77%) dominate the aquaculture sector in Eastern Uganda.

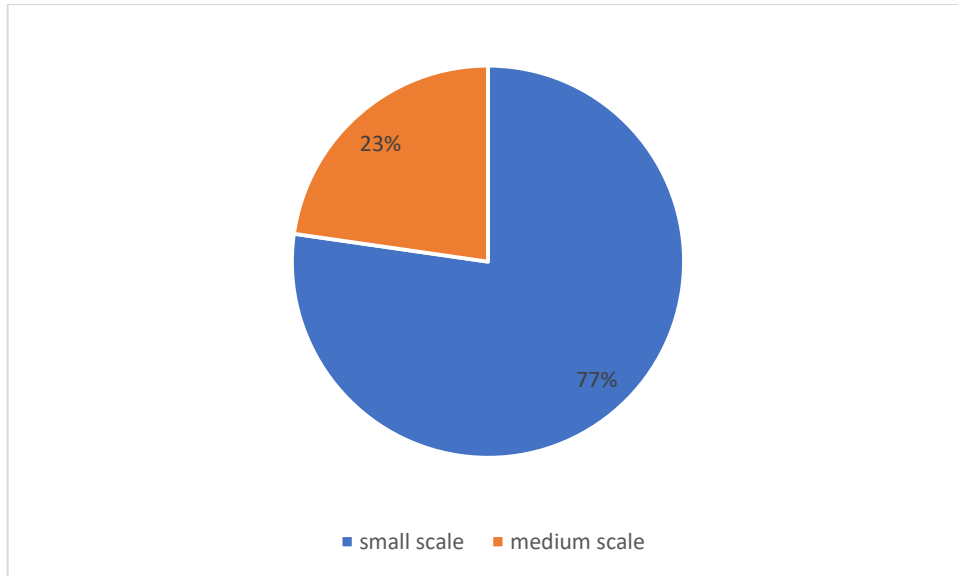


Figure 4.2 Showing level of fish farming

#### 4.1.3 commonly used on-farm feeds

Figure 4.3 shows that culturing *Oreochromis niloticus* in earthen ponds entirely depends on locally produced on-farm feeds dominated by cabbage, maize bran and wondering jew, and to a less extent sweet potatoes.

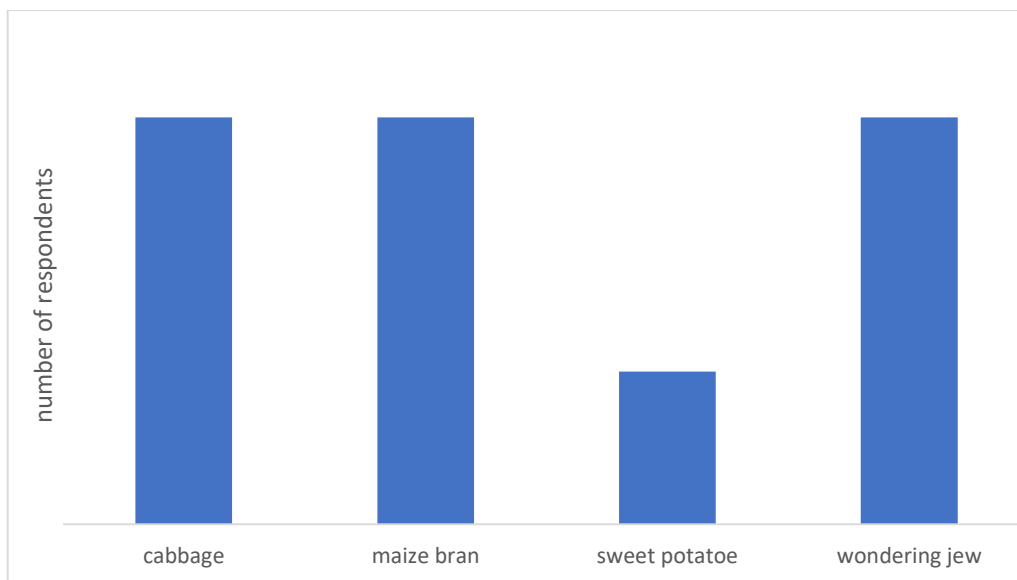


Figure 4.3 shows commonly used feeds

## 4.2 QUANTITATIVE DATA

The 4 selected local feed ingredients used by tilapia farmers that were analysed for crude protein content (Table 4.1). Results indicated that the crude protein content in most local feed ingredients analysed was medium and below the recommended, being dominated by cabbage (15.5%), followed by wondering jew and sweet potatoes (11.1%) while maize bran revealed the least crude protein content (10.0%)

Table 4.5 Shows crude protein composition of the different locally produced ingredients

Feeds	Maize bran	Cabbage	Wondering jew	Sweet potatoes
Protein content mean (%)	9.97	15.505	11.13	11.055
Mean S.D of protein	0.223666	0.2616	0.473761	0.326075

## CHAPTER FIVE

### DISCUSSIONS, CONCLUSION AND RECOMMENDATION

#### 5.1 Introduction

The work presented in this thesis studied aimed to assess the nutritional composition of locally produced on-farm fish feeds used to culture Nile tilapia in selected districts in Eastern Uganda. The specific objectives were to: i) investigate the common locally produced feed ingredients used by fish farmers in Eastern Uganda and ii) assess the nutritional composition of the commonly locally produced feed ingredients with focus on protein content used by fish farmers in Eastern Uganda.

##### 5.1.1 Type of fish production system and level of farming

The result in Figure 4.1 shows that farmers mainly used ponds for aquaculture in the selected districted where research was carried out, and mainly at small scale level (Figure 4.2) These results are in agreement with (Rutaisire (2007) and Kasozi et al. (2017) who stated that in Uganda there is still low adoption to aquaculture, and that most farmers are still small-scale holder fish farmers practicing monoculture.

**5.1.2 Commonly used on-farm fish feeds** Figure 4.3 describes a variety of commonly locally available feed contents was used such as cabbage, sweet-potato leaves which is the least used, f followed by maize brand, wandering jew and the highest in the table was cabbage. These therefore indicates the rate at which locally available feed ingredients can be of benefits to the local fish farmers in fish feed formulation.

Previous studies have shown that feeding is one of main factors required for faster growth and higher yield of cultured *O. Niloticus* (abdel-tawwab et al 2007)

## **5.2 quantitative data**

### **5.2.1 Protein composition.**

Previous studies report that Nile tilapia requires the same ten essential amino acids as other finfishes. Protein requirements for optimum growth are dependent on dietary protein quality/source, fish size or age and the energy contents of the diets and have been reported to vary from as high as 45-50 percent for first feeding larvae, 35-40 percent for fry and fingerlings (0.02-10 g), 30-35 percent for juveniles (10.0-25.0 g) to 28-30 percent for on-growing (>25.0 g) (Please indicate reference). However, all locally used on-farm feeds analysed in the present study (Table 4.1) revealed lower than recommended (< 30%) crude protein composition for all ages of fish. The low protein content in local feeds explains the low weight gain of fish sampled on farms.

## **5.3 Conclusion**

The study concludes that locally produced on-farm feeds in Eastern Uganda show promise but fall short of the nutritional standards required for optimal Nile tilapia growth. While some feeds demonstrate relatively higher protein levels, none meet the required threshold for commercial aquaculture.

Addressing deficiencies in protein and lipid levels, while minimising ash, is crucial for enhancing feed quality.

Improvement of feed formulation and farmer capacity building will be essential for boosting aquaculture productivity in the region.

## **5.4 Recommendation**

To address the challenges faced in the study of feeds to tilapia, the followings are some of the recommendations.

Improve the protein content of local feeds by incorporating higher-quality protein ingredients such as fishmeal, soybean meal, or insect-based proteins.

Balance lipid content to provide adequate energy while avoiding excessive levels that compromise feed quality and storage.

Reduce excessive ash levels by improving ingredient selection and processing practices.

Train farmers and local feed producers in feed formulation, quality control, and storage techniques.

Encourage partnerships between research institutions, government, and the private sector to support feed development and dissemination.

It's very important to equip farmers with skill to culture black soldier fly for magot production which supplement high protein levels to tilapia.

### **5.5 Areas of further research**

Further investigations should focus on the following:

Investigating the digestibility and bioavailability of nutrients in locally produced feeds.

Exploring the use of alternative protein sources such as black soldier fly larvae, earthworms and algae.

Assessing the impact of different feed formulations on tilapia growth performance, survival and feed conversion ratio.

Evaluating the cost-effectiveness of improving.

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## APPENDICES



On a discussion with feed formulators.



Student collecting data from the farm



Sun drying of the formulated fish feeds



Preparing for laboratory analysis.