

**DEVELOPMENT OF FEED GRADES USING SWEET POTATO (*ipomoea batata* [L.]
LAM) LEAF MEAL AND TUBER PEELS**

BY

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DEPARTMENT OF ANIMAL SCIENCE

FACULTY OF AGRICULTURE,

UNIVERSITY OF BENIN

BENIN CITY, NIGERIA

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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE,
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**IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A
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MAY, 2024

CERTIFICATION

This is to certify that this research work was carried out by Osahenrumwen Faith OSAIGBOVO of the Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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DEDICATION

This Project work is dedicated to God Almighty for his love, sustenance, care, provision, good health and guidance during the course of this research work, and also to my wonderful parents and sister for their unwavering support, advice, love and encouragement.

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ABSTRACT

This study was conducted to examine the development of feed grades (25%, 50%, 70%) using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels. The experimental work was carried out in the main laboratory Unit of the Faculty of Agriculture, University of Benin, Ugbowo, Benin City, Edo State. The feed grades of sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels include 100% Leaf Meal, 100% Tuber peels, 25% Leaf Meal + 75% Tuber peels, 50% Leaf Meal + 50% Tuber peels and 75% Leaf Meal + 25% Tuber peels. Data collected include proximate and mineral composition and were subjected to statistical analysis using Analysis of Variance ANOVA of GenStat Statistical package and means were separated using Duncan Multiple Range Test of the same GenStat package. Based on the findings in this study, it is evident that the proximate composition of sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels varies significantly across different grades. The highest dry matter content (89.95%) was observed in the 100 tuber peels grade, the 100% Leaf Meal grade showed the highest (14.96%) crude protein content. Moreover, the 100% Leaf Meal grade also indicate the highest (4.737%) ether extract content, which could contribute to energy density in feed formulations while 100% Leaf Meal grade contained the highest (14.450%) crude fiber content, the ash content was higher (13.163) in leaf meal grades compared to tuber peels, indicating differences in mineral composition. Based on the findings of this study, it is recommended to incorporate sweet potato leaf meal and tuber peels in feed formulations, tailored to meet specific dietary requirements. The findings showed that 100 Leaf Meal grade consistently gave the highest proximate and mineral element, 100% Leaf Meal grade is therefore recommended as diet for animal production.

CHAPTER ONE

1.0 INTRODUCTION

The sweet potato, scientifically known as *Ipomoea batata*, L. has a rich and diverse history that traces back thousands of years. Originating in the Americas, particularly in Central and South America, this versatile tuberous root holds a significant place in agricultural and culinary traditions worldwide (El-Sheikha and Ray, 2017). Its cultivation dates back to prehistoric times, with evidence of its consumption found in archaeological sites across the Americas, suggesting its importance in ancient diets (El-Sheikha and Ray, 2017).

Sweet potatoes (*Ipomoea batata* L.), from *Convolvulaceae* family, have great genetic diversity offering many different sensory aspects including a broad range of colors (pulp and peel), taste and texture for the consumers. This tuberous crop like sweet potato is cultivated for the nutritional value of its starchy roots and also because it adapts to several cultivation conditions without special needs or elevated manage costs when compared with potato (*Solanum tuberosum*), for example. Although the sweet potato cultivation is spread worldwide (Carballo *et al.*, 2018 and Niu *et al.*, 2019), Latin America, Asia and Africa account for around 85% of the global production (FAOSTAT, 2020). World production of sweet potatoes is reported to be 105 million metric tons/year (Vithu *et al.*, 2019).

Originated from Latin America, its cultivation is made in more than 100 countries, some African countries are also important producers, mainly Uganda and Nigeria that harvest around 3% of the global production (Sugri *et al.*, 2017). Sweet potato roots are used mainly as direct food for millions of people, with some amount being processed by the food industry or used for animal feeding (De Albuquerque *et al.*, 2019 and Selvakumaran *et al.*, 2019). Traditionally, the

consumption of Sweet potatoes occurs as cooked roots but its use as ingredient in food formulations, ready-to-eat products and beverages is growing up. The direct use of Sweet potatoes as food is still the most abundant, and only a limited percentage of the roots is utilized for animal nutrition and for industrial applications (Lee and Kim, 2020). Boiling, steaming, roasting and frying are the most frequent ways to cook sweet potatoes for human consumption and each of those thermal treatments can benefit their sensory quality (Hou *et al.*, 2020).

There is paucity of information on the utilization graded level of sweet potato leaf and peel in the nutrition of livestock (Solomon *et al.*, 2015) had revealed that sweet potato peels contain adequate amount of calories in form of vitamin B and C as well as useful amount of other micronutrients such as Iron. The carbohydrate of sweet potato peels is highly digestible and soluble. It consists predominantly of starch with 4-7% occurring as sugar. However, the amino acid is observed to be short in tryptophan and total sulphur when compared to the amino acid profile of other crops. It is also moderately high in ascorbic acid, carotene and other vitamins such as thiamine, riboflavin and niacin. Antinutritional factors so far identified includes phytins, oxalates and solamines, however, they can be reduced to the barest minimum in feed by processing (Solomon *et al.*, 2015). Although sweet potato leaves and vines can be cooked and eaten and are very nutritious, they are generally discarded, particularly in North America. (Sun, 2017) examined sweet potato leaves from 40 sweet potato varieties, analyzing, among other things, crude protein, fiber, fat, carbohydrates, gross energy, ash, macro and micro nutrients, total polyphenols, and antioxidant activity. They reported that leaf protein content was 16.69 to 31.08g 100g⁻¹ d.w. (dry weight), crude fiber ranged from 9.15 to 14.26g 100g⁻¹ d.w., and fat from 2.24 to 5.23g 100g⁻¹ d.w. The amounts of the micronutrients Ca, K, P, Mg, Na, Fe, Mn, Zn, and Cu were also judged to be significant and varied considerably from cultivar to cultivar. The most

abundant microelement was K (1625.1mg 100g⁻¹ d.w.) although Fe, Mn, Zn, and Cu were also abundant.

Tuber peels are mostly regarded as waste and consequently posing a threat to the environment. The tuber peel which accounts for about 40 % of the total fruit weight (Gilver and Liliana, 2017) has reportedly been shown to have potential as a promising raw material which could find useful industrial applications especially in the agro-based industries. The peels have been considered for use as organic fertilizers in places like Somalia to enrich soils and enhance better crop production and yield (Okareh *et al.*, 2015). Reports have shown the peels as being good potential substitute for corn starch in the diet of snails and also incorporated with other waste materials in the diet of pigs. Ekhurutomwen and Nwokoro, (2022) reported that plantain, yam and potato peels can successfully be a substitute for maize in the diet of growing pigs in order to reduce cost of feed consumed by the animal. Meanwhile, in the chemical industry, the peels have shown potential for the generation of important chemicals like ethanol and also alkali for the manufacturing of soap. Also in the food industry, flour made from the peels has been reportedly used to enrich wheat flour at various percentages in producing snacks like cookies and sausages, serving as a good source of fibre, antioxidants and potentially benefiting humans in the management and prevention of life style related diseases (Gilver and Liliana, 2017). Several studies have reported the antifungal and antibacterial activities of different parts including the peel of tuber plant for the treatment of a large number of human ailments (Aruwa *et al.*, 2019). Thus, the peel have been suggested for use in pharmaceutical and medical formulations (Alexandre *et al.*, 2019; Aruwa *et al.*, 2019; Barroso *et al.*, 2019; Mohamad Sukri *et al.*, 2019).

1.1 Statement of the problem

The competition between man and livestock for food is high, due to insufficient supply of food items; notwithstanding the economic importance of livestock in the nation as a whole. Several problems have been observed as a barrier to its production. Among these problems are escalating cost of feed ingredient and also some of the unconventional feed stuff which are cheap are not rich enough in vitamins and minerals which are of vital importance to livestock animal.

1.2 Justification of the study

In the world today, conventional feed stuff are highly expensive and scarce. The process has discouraged farmers thereby reducing livestock production. The use of non-conventional feedstuff like potato leaves and tuber peels, can be less expensive and help curb environmental pollution and also enrich the vitamin and mineral source in livestock feed. The potato leaves and tuber peels is rich in minerals like calcium, phosphorous, sodium, magnesium etc. and also rich in vitamins like vitamin A etc. which are essential for livestock production. The use of potato leaves and tuber peels concurrently as animal feed and medicine has not been given much attention. Hence, this study investigates the nutrient compositions and development of feed grades (25%, 50%, 70%) using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels.

1.3 Objectives of the study

The broad objective of this study is the development of feed grades (25%, 50%, 70%) using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels.

The specific objectives are:

1. Development of feed grades using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels.
2. Determine the proximate compositions of the feed grades developed using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN OF SWEET POTATO

Sweet potato was first domesticated in Americas more than 5000 years ago. The centre of origin and domestication of sweet potato is thought to be either in Central America or South America. Based on the number of related species and analysis of their morphological variation, the geographical centre of origin of sweet potato and its wild relatives has been thought to be between the Yucatan Peninsula in Mexico and the Orinoco River in Venezuela (El-Sheikha and Ray, 2017). Recent reports using molecular markers to assess diversity have found the highest diversity in Central America, supporting the hypothesis that Central America is the primary centre of diversity and most likely the center of origin of sweet potato (Hu *et al.*, 2016). The spread of sweet potato into Africa, North America, Europe, India, China, Japan and the Philippines by Spanish, Portuguese, and British trade, exploration and colonization (El-Sheikha and Ray, 2017).



Figure 2.1 : Nigerian Sweet Potato as seen in Garki Market, Abuja, Nigeria (Blossom Ozurumba, 2017)

2.2 SWEET POTATO PRODUCTION AND CONSUMPTION

Sweet potato has wide production geography, from 40° north to 32° south latitude of the globe, and it is cultivated in 114 countries (Johnson *et al.*, 2015). The world total production of sweet potatoes was 106.60 million metric tons (MMT) in 2014 (Johnson *et al.* 2015). Since the mid-1990s, global production has ranged from a low of 101.28 MMT in 2007 to a high of 147.17 MMT in 1999 (Johnson *et al.* 2015). In 2017, about three-fourth of the global production was from Asia and Pacific Islands, followed by Africa with about 21%, while the Americas (North, Central, and South) account for about 3.6%. In 2018, China was the leading producer of sweet potatoes, with 71.54 MMT or about 67% of the global production, followed by Nigeria (3.78 MMT), Tanzania (3.5 MMT), Ethiopia (2.7 MMT), and Mozambique (2.4 MMT). The United States was the tenth largest producer, with 1.34 MMT production (FAO, 2018). Only two countries in Europe, Portugal and Spain, grow sweetpotatoes, with 22,591 and 13,550 metric tons produced in 2017. In comparison to other major staple food crops, sweet potatoes have good adaptability to marginal growing conditions, short production cycle, and high yield potential (FAO 2017). The average world yield of sweet potatoes is about 14 tons per hectare. Under subsistence conditions in many areas of the tropics, the average sweet potato yield is about 6 metric tons/hectare, far below the 20–26 metric tons/hectare obtained in China, Japan, and the United States, where improved varieties, fertilizer applications, and cultural managements have been introduced. The average annual per capita consumption of sweet potatoes is estimated at 18 kg in Asia, 9 kg in Africa, 5 kg in Latin America. Between 2000 and 2020, sweet potato consumption in the United States increased nearly 80%, from 1.9 kg to 3.4 kg per capita (FAO 2021).

2.3 FOOD AND ECONOMIC IMPORTANCE

The sweet potato is rich source of starch, which is resembles to corn starch granules in shape rather than tuber starch granules. The important constituent of fresh tubers are carbohydrates (27%), protein (1.5-2%), fat (0.2%), sugar (3-6%), appreciable amount of vitamin A,B,C and some minerals viz., potassium, phosphorus and Ca (Hou *et al.*, 2020). It is the cheapest source of calories. The main use of sweet potato is for human consumption. It is usually eaten as after boiling, baking and frying and may be candied with syrup or used as 'puree'. Besides food for human, the tender tops and leaves are used as vegetable in Africa Indonesia and the Philippines. The vines served as good source of fodder for livestock (Hou *et al.*, 2020). Sweet potato is also used in several industrial processes to make alcohol, starch, liquid glucose, citric acid, mono sodium glutamate and ethanol and products such as noodles, candy, desserts and flour. Sweet potato yields high amount of energy per unit area per unit time and is expected to bridge the food shortage and malnutrition. The deeper colour of the flesh indicates higher content of carotene. Among root vegetables sweet potatoes offer the lowest glycolic index rating. That's because the sweet potato digests slowly, causing a gradual rise blood sugar, so feel satisfied longer (Hou *et al.*, 2020).

According to Ikeokwu, and Orji (2022) all the plant parts, roots, vines, and young leaves of sweet potatoes are used as food, feeds and traditional medicine around the world. Ikeokwu, and Orji (2022) stated that sweet potatoes in our diet is a good source of carbohydrate for man. Most of the dry matter in sweet potatoes consists of carbohydrate primarily starch and sugars and to a less extent pectins, cellulose and hemicellulose. The average dry matter content of sweet potato is between 13-45 % as reported by FAO (2014). The starch comprises of 60-70 % of the total dry matter, the starch granules are made up of amylose (20 %) and amylopectin. Starch pasting

temperatures are usually in a range of 60-70 °C. Potential Source of nutrients on dry weight basis, sweet potato leaves contain 25-37 % protein, 42-61 % carbohydrate, 2-5 % crude fat, 23-38 % total dietary fibre, 60-200 mg/100 g ascorbic acid, and 60-120 mg/100 g carotene. Sweet potato is an excellence source of Beta carotene, an antioxidant precursor of vitamin A (Ikeokwu and Orji, 2022). Vitamin A deficiency is a serious issue especially in developing nations around the world. The health repercussions of vitamin A deficiencies are grave and can include decreased resistance to infectious diseases, increase in infections, morbidity, dry eye as well as increased mortality for both pregnant and lactating women and their children. Sweet potatoes are extremely important source of Vitamin A because they contain high levels of red-carotene, beta-carotene is transformed into Vitamin A in our livers with every molecule of beta-carotene producing two molecules of Vitamin A. sweet potato is a good source of anthocyanins and total phenolics. Research on nutraceutical properties of purple fleshed sweet potato indicated that the extracted anthocyanin's exhibited strong radical scavenging activity, antimutagenic activity and significantly reduced high blood pressure and liver injury in rats (Van Loo-Bouwman *et al.*, 2014). Other Physiological functions of anthocyanin includes, anti-inflammatory activity, antimicrobial activity, ultra-violent light protection, reduction in memory impairment effects and colorectal cancer (Zhu and Wang, 2014). A study on healthy adult men with borderline hepatitis indicated that purple-fleshed sweet potato beverage intake (400 mg anthocyanins/day) may have a potential capacity for protection of liver against oxidative stress (Zhu and Wang, 2014).



Figure 2.2 : French fries made from sweet potatoes (Wallpaper dog, 2023)



Figure 2.3 : Roasted sweet potatoes (Jo cooks, 2022)



Figure 2.4 : Fried potato chips (Taste of home, 2024)

2.4 NUTRIENT COMPOSITION OF POTATO PEELS AND TUBERS

Sweet potato (*Ipomoea batata* L.) is one of the staple food grown in Africa which play a vital role in combating food shortage and malnutrition among the population. Sanoussi *et al* (2016) asserted that sweet potato is an important food crop of the tropical and subtropical areas which have a nutritional advantage for both rural and urban dwellers of these region by increase in its production and consumption. The physical and chemical components, bioactive substance, concentration of sodium and potassium and antioxidant properties of *Ipomoea batata* were examined by Aminu *et al* (2020). Crude fiber, moisture content were present; phytosteroids, phenols, tannins, flavonoids, protein & amino acids were bioactive substances found in both peels and tuber of the plant. High potassium content and low sodium content were also present in the plant. The extracts showed that it contained an antioxidant properties, the presence of this important substances makes this plant a useful neurocetical therapy for better health management (Aminu *et al.*, 2020).

In comparison with other tubers, Isaac *et al* (2016) revealed that sweet potato contain an average amount of protein and carbohydrate. Also, that it contain some free sugar which give the tuber its sweet taste. In addition, Sanoussi *et al.* (2016) added that sweet potato is a nutritious food, low in fat and protein but rich carbohydrate.

Phytochemicals are bio-active substances (Natural compound) that are present in plants. Phytochemical screening of some plants has revealed the presence of numerous chemicals including alkaloids, tannins, flavonoids, steroids, glycosides, phenolic compounds, saponin, and carbohydrates. Ramanyi (2017) revealed that these chemicals contain active ingredients like metabolites that are mostly used as source of medicine. He further affirmed that secondary metabolites of plants serve as defense mechanism against predation by micro-organisms, insects

and herbivores. In view of this, Shobha *et al* (2015) stated that various medicinal properties have been attributed to natural herbs which constitute the main source of new pharmaceutical and health care products.

Antioxidants are compounds that inhibit oxidation. Oxidation is a chemical reaction that can produce free radicals which causes damage to the cells. Well known antioxidants include enzymes, vitamins C and E, and beta carotene. These are capable of counteracting the damaging effects of oxidation. Oxidative stress is the imbalance between pro oxidants and antioxidants produced in biological system; these have serious effects in the process of aging and development of chronic disease such as arteriosclerosis, cancer and diabetes. Chinyere *et al* (2014) opined that relative oxygen and nitrogen species formed in excess in any biological system destroys cellular components like lipids, protein and DNA or cause a decrease in the capacity of antioxidant defense. Shobha *et al.* (2015) affirmed that antioxidants inhibit the oxidation of molecules and terminates the chain reactions caused by free radicals. Therefore antioxidants are needed to not only reduce the level of oxidative stress common in many chronic diseases but also to serve as adjuvants to other standard therapies in order to provide a synergistic effect in combating diseases.

Ikeokwu and Orji (2022) further added that both tubers and leaves of sweet potato are good sources of antioxidant, fiber, zinc, potassium iron and Vitamin C.

Physiochemical analysis is a method of investigating physic-chemical parameters that makes possible a determination of nature of the interactions between the components of a system through a study of the relations between the system, physical properties and composition. Aminu *et al* (2020) added that characterization of physiochemical properties has attained strong interest in pharmaceutical research area. The author further stated that it is one of the key challenges in

developing a pharmaceutical active ingredient in drugs. According to Lusia *et al* (2015), minerals are naturally occurring chemical elements that the body uses to help perform certain chemical reactions and they are essential for the normal functioning of muscles, heart, nerves and in the maintenance of body fluid composition as well as for building strong bones. Therefore, sodium and potassium play an important role in body regulation. Sodium in the form of sodium chloride is used as flavor in food and also serves as food preservative. This element is required in a small amount in the body to conduct nerve impulses, contract and relax muscles. According to Alinnor and Oze (2011), sodium is an important mineral that assists in the regulation of the body fluid and in the maintenance of electrical potential in the body tissue. Solomon *et al* (2015) further revealed that increase of sodium intake can cause increased blood pressure which in turn can increase the risk for cardiovascular and renal disease. More so, according to Alinnor and Oze (2011) a food source having Na/K ratio of less than 1 has impact on lowering blood pressure. Potassium on the other hand, is required by the body to help balance the level of sodium in the body. Potassium has been found to play an important role in reducing the risk of hypertension which can lead to stroke. Sanoussi *et al* (2016), assert that intake of potassium in the body contributes to the regulation of heart beat, neurotransmission and water balance of the body.

Table 2.1: Proximate analysis of sweet potato peels and tuber

S/N	Parameter	Peels(%)	Tuber (%)
1	Moisture content	66.53	62.05
2	Ash content	5.4	0.6
3	Crude fiber	94.33	87.67
4	Acid insoluble ash value	1.2	0.2
5	Acid soluble ash value	4.2	0.4
6	Water soluble ash value	2.4	0.2
7	Water insoluble ash value	3.0	0.4
8	Protein value	0.1519	0.1544

Sanoussi *et al* (2016)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental location and Duration of Study

The experimental work was carried out in the Main Laboratory Unit of the Faculty of Agriculture, University of Benin, Ugbowo, Benin City, Edo State, Nigeria. Fresh potato tuber and peels were purchased from local market in Benin City, Edo State, Nigeria. Benin City is located between Latitude 6°30' N of the Equator and Longitude 5°40' and 6°E of the Greenwich Meridian in the forest zone, with an average temperature of 27.60C (NAA, 2014). The study lasted for about eight (8) months, which started in September, 2023. The research was conducted in two phases: firstly, calibration was carried out using five (5) trials. The essence of these trials was to get acquainted with the proper production and storage methods of leaf meal and tuber peels. In the second phase, development of feed grades (25%, 50% and 75%) using Sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels, followed by the determination of their chemical compositions such as proximate analysis (dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract) and analysis of some minerals.

3.2 Experimental Materials

Freshly harvested Sweet potato (*Ipomoea batata* L.) leaves, Sweet potato tuber peels, sensitive scale, stainless steel pot, grinding machine, sieve cloth, plastic bowls, spoons, knives, and heat source.

3.3 Collection and Preparation of Sweet Potato Peels and Leaf Meal

The fresh potato leaves were harvested early in the day before sunrise from the farm. The leaves collected were thoroughly washed to remove impurities and all extraneous materials e.g sand, dirt before sun-drying to remove moisture. The washed leaves were rapidly sundried for about 3-5 days, depending on the sun's intensity. The leaves were also air dried in the evenings in the absence of sunlight. After the leaves were totally drained of moisture, it was weighed and recorded, then dry milled(without water) to achieve a smooth powdery texture. After dry milling, the sample was also weighed for each trial.

Fresh potato tubers were bought from the market. The peels were gotten from the tuber by peeling off using a knife. The peels were chopped into smaller bits, rinsed in water to remove dirt and impurities and was sun dried for 3-5 days with regular turnings to dry of moisture from the peels. Then the tuber peels were taken for grinding to obtain products for drying and reconstitution. The yield was recorded after drying.

The obtained products, leaf meal and tuber peels were reconstituted and combined at varying but known ratios (25:75, 50:50, 75:25).

3.4 Precautions taken during the Production of Leaf Meal and Tuber Peels

1. Fresh potato leaves were obtained from green, healthy plants.
2. Leaves were immediately taken to the laboratory for processing in order to avoid leaf wilting.
3. Matured leaves free of physical injuries were used.
4. The leaves were thoroughly washed to remove dirt and dust which could have altered the result.

5. The washed leaves were sun dried and air dried.
6. Healthy-looking sweet potato was obtained from the market.
7. After each use, all processing equipment were thoroughly washed before re-use to prevent contamination and guarantee result.

3.5 Experimental Treatment

Feed grades shall be developed using sweet potato leaf meal and tuber peels in the following ratio:

Treatment 1: 100% leaf meal and 0% tuber peels.

Treatment 2: 0% leaf meal and 100% tuber peels.

Treatment 3: 25% leaf meal and 75% tuber peels.

Treatment 4: 50% leaf meal and 50% tuber peels.

Treatment 5: 75% leaf meal and 25% tuber peels.

Ground leaf meal and tuber peels were mixed together at different ratios using a known volume of water. After mixing, the mixture was air dried, the resultant dried products were stored in airtight container and properly labeled before taken for chemical analysis.

3.6 Chemical Analysis

Methods of proximate and mineral determination

The Leaf meal and tuber peel resulting combination was analyzed proximately and also some mineral content of the combination was analyzed. Five samples were analyzed at different combination ratios.

MOISTURE CONTENT DETERMINATION

Materials used: Sensitive scale, oven, crucible and Desiccators.

Procedures

A portion of the sample was collected and weighed in two silica dishes that have been previously pre-dried and weighed. Then it was put in the oven at 1000⁰C for 24 hours and then dried to constant weight. The samples were then cooled in a desiccator before weighing again until a constant weight was obtained.

Calculation:

Weight of moisture = weight of sample before drying – weight of sample after drying

% moisture = (weight of moisture)/weight of sample * 100

Dry matter = 100 - % moisture

CRUDE PROTEIN DETERMINATION

A portion of the combined sample was weighed and transferred into clean digestion flasks. Copper catalyst plus sodium sulphate was then added to raise the boiling point. 30ml of concentrated sulphuric acid was added to the digestion flask containing the other mixture, and the sample digested for two hours. The flask was cooled and diluted with water, and was made to 100ml in a volumetric flask. 20ml of 2% boric acid plus indicator was pipetted into a 100ml Erlenmeyer flask. The 100ml flask was then placed under the receiving tube of the distillation unit in a way that the end of the tube is below the level of the H₃BO₃. 10ml aliquot of the sample was then pipetted into the distillation unit and 100ml of 40% NaOH was added. The samples were distilled with standard HCL (0.01N) until the blue colour disappeared. A blank

determination was first carried out, and the Crude Protein value was determined using the following formula:

Calculation:

$$\% \text{ Nitrogen} = \text{Normality of acid} * (14/1000) * \text{volume of acid} * (100/5) * (100/\text{weight of sample})$$

$$\% \text{ Crude protein} = \% \text{ Nitrogen} * 6.25$$

CRUDE FIBRE DETERMINATION

A portion of the combined sample was weighed into a round bottom flask. 100ml of crude fibre reagent that has been boiled was added, and then the beaker placed on the crude fibre apparatus which has been presented to maintain steady boiling. The content was filtered under suction on a piece of close texture linen after refluxing after 1 hour. The residue was rinsed with boiling water until it was free of acid. Also, NaOH (Sodium hydroxide) solution which had been previously boiled was added and filtered hot while using a Whatman filter paper, and the residue was allowed to drain and transferred to a pyrex heater and dried, weighed and ashed. The residue was cooled in a desiccator and weighed after 1 hour. The loss in weight due to ashing was calculated as the crude fibre content.

Calculation:

$$\text{Sample weight} = A$$

$$\text{Weight before ashing} = P$$

$$\text{Weight after ashing} = Z$$

$$\% \text{ Crude fibre} = (P - Z)/A * 100$$

ASH DETERMINATION

A portion of the combined sample was weighed and put in a weighed crucible and ignited at 5500 for 6 hours in the furnace for ashing. Then the samples were removed and allowed to cool in a desiccator for about 30 minutes, then re-weighed and the value was calculated.

Calculations:

Sample weight = A

Sample weight before ashing = P

Sample weight after ashing = Z

% Ash = $(P - Z) / A * 100$

ETHER EXTRACTION (EE)

A portion of the combined sample was weighed into a fat-free filter paper. It was then folded tightly and placed in the extractor; petroleum ether was then added until is siphoned over. More ether was added until the 300ml barrel was half-filled; the condenser was replaced. The control was adjusted on the apparatus so that the others boiled gently, and it was left to siphon over for 2 hours. The apparatus was washed after 3 hours because it was expected that, by this time, all the fat present in the sample would have been extracted. The flask was then detached when the ether was short of siphoning over. The barrel content was drained properly into the bottle and the filter paper removed and dried. The flask was detached, while the samples were removed and dried in an oven to constant weight.

Calculation:

%EE = $(\text{weight of oil}) / (\text{weight of sample}) * 100$

NITROGEN FREE EXTRACT(NFE)

This was determined by the subtraction of the addition of % ash, ether extract, crude protein, and crude fibre from 100. The difference is the Nitrogen Free Extract.

$$\text{NFE} = 100 - (\% \text{CP} + \% \text{EE} + \% \text{CF} + \% \text{Ash})$$

MINERAL ANALYSIS

Minerals were analyzed after first dry-ashing 1g of the combined sample at 5500 in a Muffle furnace and dissolved in de-ionized water to standard volume. Sodium and Potassium were determined by flame photometry and phosphorus by vanadomolybdate method (AOAC, 2010). Sodium, Calcium, Phosphorus, Potassium, Magnesium, Manganese, Iron and Zinc were determined using an Atomic Absorption Spectrophotometer.

3.7 Experimental Design Statistical Analysis

All the data collected were subjected to statistical analysis using Analysis of Variance ANOVA of GenStat Statistical package and means were separated using Duncan Multiple Range Test of the same GenStat package.

CHAPTER FOUR

4.0 RESULTS

4.1 PROXIMATE COMPOSITION OF THE FEED RESOURCES DEVELOPED

The proximate compositions of the feed resources developed are presented in Table 4.1

1. Dry Matter (DM)

The dry matter of the feed resources developed ranged from 87.19-89.95% with T₂ (100TP) having the highest dry matter value of 89.95% and T₁ (100LM) having the least value of 87.19%. The dry matter of 100TP was significantly higher ($P<0.05$) than that of 100LM.

2. Crude Protein (CP)

The crude protein values obtained from the analysis ranged from 5.89-14.96% with T₁ (100LM) having the highest crude protein value of 14.96% and T₂ (100TP) having the least value of 5.89%. The results shows that the crude protein contents were significantly different ($P<0.05$) across the treatments.

3. Crude Fibre (CF)

The crude fibre of the feed resources developed ranged from 4.827-14.450% with T₁ (100LM) having the highest fibre value of 14.450% and T₂ (100TP) with the lowest value of 4.827%. The crude fibre of T₁ was significantly higher ($P<0.05$) than that of T₂.

4. Ether Extract (EE)

The ether values obtained ranged from 4.280-4.737% with T₁ (100LM) having the highest ether extract value of 4.737% and the lowest being T₂ (100TP) with 4.280%. The results shows that there was significant difference ($P<0.05$) across the treatments.

5. Ash

The ash values obtained ranged from 6.180-13.163% with T₁ (100LM) having the highest ash value of 13.163% and T₂ (100TP) had the lowest ash value of 6.180%. The ash value of T₁ was significantly higher ($P<0.05$) than that of T₂.

6. Nitrogen Free Extract (NFE)

The values of NFE ranged from 52.69-78.82% the highest NFE was recorded for T₂ (100TP) with 78.82% and the lowest value was analyzed for T₁ (100LM) with 52.69%. The NFE value of T₂ was significantly higher ($P<0.05$) than that of T₁.

Table 4.1: Proximate composition (%) of a feed resource developed using sweet potato leaf meal and tuber peels

Parameters	T1	T2	T3	T4	T5	SEM
Dry matter (%)	87.19 ^b	89.95 ^a	89.76 ^a	89.51 ^a	88.51 ^{ab}	0.660
Crude protein (%)	14.96 ^a	5.89 ^c	8.46 ^d	9.81 ^c	11.55 ^b	0.407
Crude fibre (%)	14.450 ^a	4.827 ^c	7.503 ^d	9.517 ^c	11.863 ^b	0.442
Ether extract (%)	4.737 ^a	4.280 ^a	4.422 ^a	4.432 ^a	4.404 ^a	0.251
Ash (%)	13.163 ^a	6.180 ^c	7.606 ^d	9.326 ^c	10.795 ^b	0.392
Nitrogen free extract (%)	52.69 ^c	78.82 ^a	72.01 ^b	66.92 ^c	61.39 ^d	0.526

SEM: Standard error of the mean

a,b,c,d,e Means bearing different letters of superscript within the same row differ significantly (P<0.05)

Treatment 1: 100% Leaf meal (LM)

Treatment 2: 100% Tuber peels (TP)

Treatment 3: 25% Leaf meal (LM) and 75% Tuber peels (TP)

Treatment 4: 50% Leaf meal (LM) and 50% Tuber peels (TP)

Treatment 5: 75% Leaf meal (LM) and 25% Tuber peels (TP)

4.2 MINERAL COMPOSITION OF THE FEED RESOURCES DEVELOPED

The mineral compositions of the feed resources developed are presented in Table 4.2

1. Sodium

The values obtained for the sodium composition of the feed resources ranges from 28.17-285.72% with T₁(100LM) having the highest sodium value of 285.72% and T₂ (100TP) having the lowest value of 28.17%. The sodium content of T₁ was significantly higher (P<0.05) than that of T₂.

2. Calcium

The values obtained for the calcium composition of the feed resources ranges from 1405-2671% with T₁(100LM) having the highest calcium value of 2671% and T₃ (25%LM + 75%TP) having the lowest value of 1405%. The calcium content of T₁ was significantly higher (P<0.05) than that of T₃.

3. Potassium

The values obtained for the potassium composition of the feed resources ranges from 2813-3334% with T₂ (100TP) having the highest potassium value of 3334% and T₁ (100LM) having the lowest value of 2813%. The potassium content of T₂ was significantly higher (P<0.05) than that of T₁.

4. Magnesium

The values obtained for the composition of magnesium in the treatments ranges from 265.3-936.0% with T₁ (100LM) having the highest magnesium value of 936.0% and T₂

(100TP) having the lowest value of 265.2%. The magnesium content of T₁ was significantly higher (P<0.05) than that of T₂.

5. Phosphorus

The values obtained for the composition of phosphorus in the treatments ranges from 320.3-325.4% with T₄ (50% LM + 50% TP) having the highest phosphorus value of 325.4% and T₂ (100% TP) having the lowest value of 320.3%. The phosphorus content of T₄ was significantly higher (P<0.05) than that of T₂.

6. Iron

Results showed that the Iron composition of the feed were significantly different (P<0.05) across the treatments with the highest Iron value recorded for T₁ (100% LM) to be 673.3% and the lowest value for T₂ (100% TP) which is 127.6%.

7. Manganese

Results showed that the Manganese composition of the feed were significantly different (P<0.05) across the treatments with the highest Manganese value recorded for T₅ (75% LM+25% TP) to be 286.23% and the lowest value recorded for T₃ (25% LM + 75% TP) which is 32.86%.

8. Zinc

The values obtained for the composition of zinc in the treatments ranges from 8.08-43.67% with T₁ (100% LM) having the highest zinc value of 43.67% and T₂ (100% TP) having the lowest value of 8.08%. The zinc content of T₁ was significantly higher (P<0.05) than that of T₂.

Table 4.2: Mineral composition (mg/g) of a feed resource developed using sweet potato leaf meal and tuber peels at different grades

Parameters	T1	T2	T3	T4	T5	SEM
Sodium (mg/g)	285.7 ^a	28.2 ^c	80.9 ^d	148.9 ^c	246.5 ^b	11.072
Calcium (mg/g)	2671 ^a	1119 ^c	1405 ^d	1860 ^c	2277 ^b	33.876
Potassium (mg/g)	2813 ^c	3334 ^a	3276 ^{ab}	3185 ^b	2890 ^c	37.382
Magnesium (mg/g)	936.0 ^a	265.2 ^c	496.2 ^d	673.7 ^c	895.2 ^b	6.495
Phosphorus (mg/g)	321.7 ^a	320.3 ^a	320.6 ^a	325.4 ^a	322.9 ^a	3.434
Iron (mg/g)	673.3 ^a	127.6 ^c	238.1 ^d	405.3 ^c	481.3 ^b	23.432
Manganese (mg/g)	77.53 ^a	47.18 ^a	32.86 ^a	49.61 ^a	286.23 ^a	97.593
Zinc (mg/g)	43.67 ^a	8.08 ^c	14.68 ^d	19.15 ^c	23.43 ^b	0.720

SEM: Standard error of the mean

a,b,c,d,e Means bearing different letters of superscript within the same row differ significantly (P<0.05)

Treatment 1: 100% Leaf meal (LM)

Treatment 2: 100% Tuber peels (TP)

Treatment 3: 25% Leaf meal (LM) and 75% Tuber peels (TP)

Treatment 4: 50% Leaf meal (LM) and 50% Tuber peels (TP)

Treatment 5: 75% Leaf meal (LM) and 25% Tuber peels (TP)

CHAPTER FIVE

5.0 DISCUSSION

The results indicate that sweet potato (*Ipomoea batata* [L.]) leaf meal and tuber peels are a reliable source of nutrition with consistent proximate composition, which can have implications for its utilization. Ash content is used to determine the purity and quality of food products. It indicates the mineral content left behind after the organic material has been incinerated. High ash content in food can be an indicator of adulteration or contamination. The ash content in this study also indicated significant ($p < 0.05$) difference across grades. This suggests that the mineral composition of the soil or other environmental variables in these grades lead to influence the ash content of sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels at different grades. Sanoussi *et al* (2016) reported similar ash content of 5.0 which is similar to the lowest ash content in this study. The highest content recorded in this study is higher than that of Offor *et al.*, (2018) who recorded 3.72 ash content. Fiber content in sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels at different grades differ significantly ($p > 0.05$). Dietary fiber, often simply referred to as fiber, is a type of carbohydrate found in plant-based foods. It is a crucial component of a healthy diet and offers several important benefits. Fibre aids in maintaining regular bowel movements and preventing constipation. It adds bulk to stool, softens it, and helps it move through the digestive tract more easily. This can reduce the risk of digestive disorders like diverticulitis and hemorrhoids (Chinelo *et al.*, 2018).

The protein content of sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels at different grades also exhibited significant ($p < 0.05$) differences across the grade. This suggests a consistent protein profile of sweet potato across the plant part. Isaac *et al* (2016) revealed that sweet potato contain an average amount of protein and carbohydrate. Also, that it contain some free sugar

which give the tuber its sweet taste. In addition, Sanoussi *et al* (2016) added that sweet potato is a nutritious food, low in fat and protein but rich carbohydrate.

The result in this study showed that the mineral composition of sweet potato (*Ipomoea batata L.*) leaf meal and tuber peels were adequate. According to Lusia *et al* (2015), minerals are naturally occurring chemical elements that the body uses to help perform certain chemical reactions and they are essential for the normal functioning of muscles, heart, nerves and in the maintenance of body fluid composition as well as for building strong bones. Therefore, sodium and potassium play an important role in body regulation. Sodium in the form of sodium chloride is used as flavor in food and also serves as food preservative. This element is required in a small amount in the body to conduct nerve impulses, contract and relax muscles. According to Alinnor and Oze (2011), sodium is an important mineral that assists in the regulation of the body fluid and in the maintenance of electrical potential in the body tissue. Solomon *et al.* (2015) further revealed that increase of sodium intake can cause increased blood pressure which in turn can increase the risk for cardiovascular and renal disease. More so, according to Alinnor and Oze (2011) a food source having Na/K ratio of less than 1 has impact on lowering blood pressure. Potassium on the other hand, is required by the body to help balance the level of sodium in the body. Potassium has been found to play an important role in reducing the risk of hypertension which can lead to stroke. Sanoussi *et al* (2016), assert that intake of potassium in the body contributes to the regulation of heart beat, neurotransmission and water balance of the body.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study was conducted to examine the development of feed grades (25%, 50%, 75%) using sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels. The experimental work was carried out in the main laboratory Unit of the Faculty of Agriculture, University of Benin, Ugbowo, Benin City, Edo State, Nigeria.

The feed grades of sweet potato (*ipomoea batata* L.) leaf meal and tuber peel include 100% Leaf Meal, 100% Tuber peels, 25% Leaf Meal + 75% Tuber peels, 50% Leaf Meal + 50% Tuber peels and 75% Leaf Meal + 25% Tuber peels. Data collected include proximate and mineral composition and were subjected to statistical analysis using Analysis of Variance (ANOVA of GenStat Statistical package and means were separated using Duncan Multiple Range Test of the same GenStat package.

Based on the analysis presented in this study, it is evident that the proximate composition of sweet potato (*Ipomoea batata* L.) leaf meal and tuber peels varies significantly across different grades. The highest dry matter content (89.95%) was observed in the 100% tuber peels grade, indicating its potential as a concentrated source of nutrients. Conversely, the 100% Leaf Meal grade showed the highest (14.96%) crude protein content, suggesting its suitability for protein supplementation in animal diets. Moreover, the 100% Leaf Meal grade also indicate the highest (4.737%) ether extract content, which could contribute to energy density in feed formulations. Furthermore, the significance differences in crude fiber content highlights the importance of considering the proportion of leaf meal and tuber peels in animal diets. While 100% Leaf Meal

grade contained the highest (14.450%) crude fiber content, indicating potential for roughage, formulations incorporating a combination of leaf meal and tuber peels exhibited intermediate levels of crude fiber, offering a balance between fiber and nutrient concentration. Additionally, the ash content was higher (13.163%) in leaf meal grades compared to tuber peels, indicating differences in mineral composition. This suggests the potential for utilizing leaf meal as a mineral supplement in animal diets.

6.2 Recommendations

1. Based on the findings of this study, it is recommended that a study should be carried out to incorporate sweet potato leaf meal and tuber peels in feed formulations, tailored to meet specific dietary requirements.
2. By combining different grades in appropriate proportions, one can capitalize on the diverse nutritional profiles of both components, thereby promoting balanced and efficient animal growth and health.
3. 100% Leaf Meal grade consistently gave the highest proximate and mineral element, 100% Leaf Meal grade it therefore recommended as diet for animal production.

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