



COMPARATIVE ANALYSIS OF THE NUTRITIONAL POTENTIALS OF SELECTED TUBER PEEL MEALS AS FEED SUPPLEMENTS FOR RUMINANT ANIMALS

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ABSTRACT

The research explores the nutritional potentials of selected tuber peel meals namely Cassava, (*Manihot esculenta*), Sweet Potato, (*Ipomoea batatas*); and Irish Potato, (*Solanum tuberosum* L.) as sustainable feed supplements for ruminant animals. With the world drifting toward sustainable agriculture to meet the United Nations' 2030 Sustainable Development Goals, the inclusion of agro-industrial by-products such as tuber peel meal is one assured way to advance ruminant productivity with reduced environmental waste. The tuber peels used in this study were collected, processed, and analyzed for their proximate and mineral compositions. The results showed that cassava peel meal (CPM) is energy-dense, with a high crude fiber content; sweet potato peel meal (SPPM) is rich in ether extract; and Irish potato peel meal (IPPM) has the highest crude protein and nitrogen-free extract values. The findings further stated that the selected tuber peels are high in nutrients, fiber, carbohydrates, and minerals and hence nutritionally adequate for supplementing ruminant feeds. These findings project tuber peel meals as cheap and nutritionally adequate supplements in ruminants' diets, especially in dry seasons. The study recommends government support for research funding, machinery, processing, and preservation technologies, to improve tuber peel use in animal feed, thereby reducing production costs, promoting ruminant production, and environmental conservation in the tropics.

Keywords: Feeds, Peels, Ruminants, Sustainable, Tubers.

INTRODUCTION

The increasing global demand for food coupled with the urgency to address environmental challenges, has highlighted the critical need for sustainable agricultural practices which is also aimed at achieving the United Nations' 2030 Sustainable Development Goals (SDGs) (Calicioglu *et al.*, 2019, Khanal, 2024). The global target is to eliminate hunger and poverty by promoting sustainable livestock production; while ensuring a healthy environment. The sustainability of ruminant animal production is hinged on efficient and nutritionally balanced feeding practices that ensure optimal productivity. Tuber peels are abundant in the tropics; with an annual cassava production of 550 million metric tons, yielding 350 MMT waste (Sivamani *et al.*, 2018). Nigeria alone discards over 10 tons of cassava peels from 59. 5 million metric tons produced annually (Oghenejoboh *et al.*, 2021); and between 25 – 30% of cassava waste is considered feed for livestock while 70 – 75% is wasted, and discarded into nearby bushes and rivers causing a nuisance and pollution to the environment (Coker *et al.*, 2015). One promising solution to enhancing ruminant production is the use of agricultural by-products, particularly tuber peels namely cassava (*Manihot esculenta*), Sweet potato (*Ipomoea batatas*), and Irish potato (*Solanum tuberosum* L) peels, as supplemental feed resources for ruminants. These by-products are nutrient-rich and represent a cost-effective and sustainable alternative to conventional feed ingredients. Studies have shown that cassava peels are energy-dense due to their high starch content, with crude protein levels ranging between 4% and 7%, (Aro *et al.*, 2010). Similarly, sweet potato peels are rich in fermentable carbohydrates and moderate crude protein levels, in the range of 5.63% -7.89%, (Coker *et al.*, 2015). Irish potato peel is considered a nutrient-rich feed resource higher in value than some concentrate feeds (Akinsulie *et al.*, 2021).

Despite the significant potential of Cassava, Sweet potato, and Irish potato peels as nutritionally adequate livestock feed supplements, there is still limited information regarding their nutrient value, processing, and preservation. While a small proportion is often fed to ruminant animals in smallholder farms, the greater proportion is usually regarded and discarded as waste, causing environmental nuisance and pollution. Incorporating tuber peels into ruminant diets offers multiple benefits, including reduced feed costs and alignment with circular economy ethics by transforming agricultural waste into a valuable resource, alleviating animal feed scarcity, particularly during dry seasons when grasses are depleted in nutrients. Research has demonstrated that feeding properly processed tuber peels can sustain ruminant productivity without adverse effects on animal health or performance, (Jumare *et al.*, 2024). By reducing dependence on conventional feed resources, enhancing resource use efficiency, and minimizing waste; smallholder farmers stand to gain maximally from tuber peel use. This preliminary study examines and compares the nutritional and mineral composition of the different tuber peel meals designated as CPM, SPPM, and IPPM to estimate their potential as ruminant animal feed supplements, especially in extended dry seasons in the tropics.

Plate 1: Women peeling cassava with a view of massive cassava peels discarded as waste.



Credit: D. Dufour (2024), CIRAD: <https://www.cirad.fr/en/cirad-news/news/2024/choosing-new-root-tuber-and-plantain-varieties>.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Federal University Oye-Ekiti, Ikole campus located between Longitude 5°29'0"E and Latitude 7°48'0"N mainly on the upland zone rising to about 250 meters above the sea level with an average annual rainfall of about 1778mm. The minimum and maximum temperatures during the experimental period were 26.54°C and 34.02°C, respectively.

Sample Collection

Freshly harvested tubers of tropical Cassava peels (*Manihot esculenta*), Sweet Potato Peels (*Ipomoea batatas*) and Irish Potato (*Solanum tuberosum*) tubers were collected from different food processors around the Ikole and Oye environs within Ekiti-State. The tuber peels which were hand-peeled and are about 0.6 – 1.00mm thickness were cleaned under running water to remove sand and dirt. The tuber peel samples were then sorted, thoroughly mixed and rinsed again with distilled water and then airdried on a polythene sheet for seven days, till samples were fully dried, and peels weighing approximately 1kg per sample were collected from each peel type. The cassava, sweet potato, and Irish potato peel samples were then labeled as: CP, SPP, IPP respectively.

Sample Preparation

5 grams of each peel were placed in a pre-weighed crucible. The samples were dried in a hot-air oven at 105°C for 3 to 4 hours until they reached a stable weight. After cooling in a desiccator, the samples were reweighed. The dehydrated samples were ground, cooled, and sieved through a 2 cm



sieve to make a fine powder. Each peel meal was mixed well to ensure homogeneity and stored in airtight plastic bowls labeled as CPM, SPPM, and IPPM for future chemical analyses.

Sample Analysis

The chemical analysis of samples was conducted in triplicates at the Diagnostic and Nutrition Laboratory, Department of Animal Production and Health, Federal University Oye-Ekiti, Nigeria. The parameters evaluated were moisture, Dry matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether extract (EE), Ash, and Nitrogen Free Extract (NFE) using AOAC standard methods (2010). The gross energy of the feed was calculated with a bomb calorimeter, and mineral analyses of calcium, phosphorus, potassium, sodium, and magnesium were performed using an Atomic Absorption Spectrophotometer (AAS – Model MFAA320N).

Statistical Analysis:

The data collected were statistically analyzed to calculate the mean and standard error (mean \pm SE). The differences observed between the control and treated groups were tested for significance by the one-way analysis of variance (ANOVA). The standard deviation and coefficient of variation were also calculated, and where significant differences were found, the Duncan's Multiple Range Test (Duncan, 1955) was used to separate the treatment means. Differences were considered significant at $P < 0.05$ level using SPSS version 16 Computer Program (Ridgman, 1990). ANOVA was the preferred choice as it may compare the mean of three or more groups.

RESULTS AND DISCUSSIONS

Cassava Peels (*Manihot esculenta*)

Manihot esculenta, or cassava, is a woody shrub in the Euphorbiaceae family, producing over 250 million tonnes of fresh roots annually. It is the third-largest carbohydrate source in tropical diets, supporting over 500 million people (Howeler *et al.*, 2013). Cassava has sweet and bitter varieties and are cultivated as an annual crop in tropical and subtropical regions for its starchy tuberous root (Bill Gates, 2012). The results of the proximate composition and the minerals recorded in this study are presented in Tables 1 and 2.

The cassava peel, a by-product of root peeling, accounts for 20% of fresh root weight and can be used in fresh, hay, or ensiled animal feeds (FAO, 2001). Cassava peels can serve as roughage and energy feed for ruminants. Cassava peels, abundant and high in energy, are extensively studied tuber by-products, accounting for 5 to 15% of the root (Aro *et al.*, 2010). In the tropics, it has been emphasized as a high-energy source for animal feed (Negesse *et al.*, 2009). According to Howeler *et al.*, 2013, cassava peels contain 65–75% carbohydrates, particularly fermentable starch, but are low in protein (2–5%) which aligns with the findings of (CP: 5.28% and NFE: 62.57) from this study. The crude fibre was highest in CPM at 13.14%, which was higher than values observed in the other peel meals; this agrees with Aro *et al.*, (2010) who opined that cassava peel is high in fibre. Cassava peel contains a considerable amount of minerals like K, Mg, P, Na, and Ca as observed in this study, similar reports were also given (Khalil, 2022).

The use of these tropical root crop peels in ruminant diets has been explored, with promising results. Cassava peels have been used as a feed source for ruminants, including cattle, sheep, and goats, for they are inexpensive, readily accessible, and provide a significant source of energy. (Agustin, *et al.*, 2020). Cassava peels have been successfully incorporated into silages as an energy source in dairy cows' feeds (Lounglawan *et al.*, 2011). Khalil, (2022) observed improved growth performance and digestibility in sheep fed fermented CPM, emphasizing its potential as an energy source when combined with protein-rich forages. Santos, *et al.*, (2015) recommended that cassava peels be completely substituted for corn in the diets of sheep, as there were no adverse changes in nutrient intake, digestibility, or ruminal parameters when fed.

Despite the nutritional advantages of cassava peels, for a balanced diet, they should be supplemented with protein and micronutrients (Heuzé *et al.*, 2016). They however contain cyanogenic glucosides, which can release hydrogen cyanide (HCN), posing a potential toxicity risk. Effective processing methods, such as fermentation, drying, and soaking, have demonstrated a significant



reduction in HCN levels, as well as in bulkiness and rapid spoilage (Lounglawan *et al.*, 2011), and also preserve their nutritive quality.

Sweet Potato Peel (*Ipomoea batatas*)

Sweet potato, a dicot in the Convolvulaceae family, is known for its sweet, starchy tuberous roots (Sarkar, 2022). Numerous cultivars exist in the tropics, with peel colors ranging from cream and white to purple (Ayeleso, 2018). Sweet potato peels are rich in fiber, antioxidants, vitamins, and minerals, benefiting ruminants and enhancing the health and productivity of small ruminants (Akoetey *et al.*, 2017).

The results of the proximate composition and the minerals recorded in this study are presented in Tables 1 and 2. Feeding trials have also reported positive outcomes with sweet potato peel-based diets. Sweet potato peels are useful as a source of energy, as they contain large amounts of readily digestible carbohydrates (Heuzé, 2020) as observed from this study. The crude fibre value observed in this study (5.42%) was higher than the value range of (3.41%, and 3.68%), reported by (Agubosi, 2021) and 1% by (Ibrahim, 2018) but lower than values of (8–10%) reported by (Akoetey *et al.*, 2017) making them easily digestible and suitable for small ruminants with high energy demands. The sweet potatoes contain high levels of fiber, vitamins with most of the fiber content mainly comes from the peel (Marconato *et al.*, 2020). (Akoetey *et al.*, (2017) opined that protein in the tuber is unevenly spread, with more in the outer layer near the peel depending on the methods of peeling. The crude protein value observed for the SPPM in this study (6.65%) was within the range of what was published for differently processed sweet potato peels (7.89%, 5.63%) by Agubosi, (2021). Values lower than what was reported by Agubosi, (2021) was observed for calcium (2.2g/kg DM) and magnesium (1.17(g/kg DM) in this study.

Sweet potato peels are high in energy, fibre, and cause improved feed intake in ruminants. Feeding trials by Aruna *et al.* (2020) demonstrated improved growth rates and milk production in sheep-fed sweet potato peel-based diets. He further opined that sweet potato peels are protein-rich as also observed in this study; and that they lack significant anti-nutritional factors, making them good for ruminant diets. Okoruwa and Bamgboye (2015) reported sweet potato peels as a valuable animal feed resource which when fed with other supplements improved and enhanced growth indices in goats. Potato peel is a notable food waste that can serve as an alternative animal feed, as it provides natural sources of energy and fiber along with moderate protein content. (Ncobela, *et al.*, 2017).

Irish Potato Peel (*Solanum tuberosum* L)

Solanum tuberosum L, the Irish potato, is a key global staple food and a perennial tuber in the Solanaceae family (Maiti and Singh, 2022). Potato waste is estimated at 12 million tonnes globally, and this peel waste contains significant starch, cellulose, hemicelluloses, and fermentable sugars (Mridula and Mahendra, 2018). The results of the proximate composition and the minerals recorded in this study are presented in Tables 1 and 2

According to (Mridula and Mahendra, 2018), IPPM contains 1.7% protein and 2.5% crude fibre which were lower than values of 8.21 CP and 3.93% CF observed in this study. Kpanja *et al.*, 2024 reported an ash content of 7.11 which was higher than the 5.55 observed in this study while the NFE reported (74.02) was also higher than the value of (71.03%) in Irish potato peels evaluated in this study.

Irish potato peels are rich in minerals, Akinsulie *et al.*, (2021) reported 0.12% Mg, 0.10% Ca, 0.05% Na, 0.27% K, and 0.25% P, for the Irish potato peels evaluated, while values observed from this study are 1.53% Mg, 0.81% Ca, 0.34% Na, showing higher values. Cozma *et al.* (2024) reported 7.00 mg/100 g Na, 414 mg/100 g K, 6.76 mg/100 g Ca, and 20.40 mg/100 g Mg values for the Irish potato peels assessed; higher values were observed in this study. Previous reports indicated that feeding Red Sokoto bucks varying levels of Irish potato peels leads to increased weight gain and reduced costs (Yashim, 2017).



Table 1: Proximate Composition of Selected Tuber Peel Meals

PARAMETERS (% DM)	CPM	SPPM	IPPM	SEM
Dry Matter (% as fed)	88.16	85.84	89.23	2
Crude Protein	5.28 ^c	6.65 ^b	8.21 ^a	0.3
Crude Fibre	13.14 ^a	5.42 ^b	3.93 ^b	0.6
Ether Extract	1.46 ^b	3.49 ^a	0.57 ^c	0.1
Ash	5.71 ^a	4.41 ^b	5.5 ^a	0.3
Nitrogen Free Extract	62.57 ^{ab}	65.88 ^a	71.03 ^a	2.2
Gross Energy (MJ/Kg Dm)	18.95 ^a	16.64 ^{ab}	17.7 ^a	0.6

CPM: Cassava Peel Meal, SPPM: Sweet Potatoes Peel Meal, IPPM: Irish Potato Peel Meal

a, b, c, d, e Means along the same row with different superscripts are significantly different ($P < 0.05$).
SEM = Standard error of the mean.

Table 2: Mineral Composition of Selected Tuber Peel Meals

MINERALS (g/kg DM)	CPM	SPPM	IPPM	SEM
CALCIUM	4.31 ^a	2.2 ^b	0.81 ^c	0.22
POTASSIUM	7.14 ^c	10.5 ^b	26.4 ^a	0.64
PHOSPHORUS	0.78 ^c	1.71 ^b	2.8 ^a	0.13
MAGNESIUM	1.14	1.17	1.53	0.17
SODIUM	1.42 ^b	5.88 ^a	0.34 ^c	0.83

CPM: Cassava Peel Meal, SPPM: Sweet Potatoes Peel Meal, IPPM: Irish Potato Peel Meal

a, b, c, d, e Means along the same row with different superscripts are significantly different ($P < 0.05$).
SEM = Standard error of the mean.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this study underscore the nutritional variability among the three types of tuber peel meals. CPM exhibits the highest crude fiber content, while IPPM is noted for its superior crude protein and nitrogen-free extract values. Additionally, SPPM is characterized by a comparatively high ether extract content. The gross energy analysis indicates that CPM is the most energy-dense option among the three. These compositional variations emphasize the importance of adequate evaluation and balancing in formulating ruminant diets. The distinct nutrient profiles of the tuber peel meals suggest that, despite their differences, all can contribute to dietary fiber and energy when processed correctly. Discrepancies with previous studies may arise from variations in soil type, cultivars, growth locales, processing, and preservation methods employed. The examined tuber peels can be processed and preserved as peel meals, thereby mitigating environmental pollution and addressing the rising demand for cost-effective and nutritionally adequate feed supplements for ruminants, particularly during dry seasons. Further studies to compare the effect of feeding the different tuber peels to ruminants could be carried out.

The government could fund research on value addition to tuber peels and provide an enabling investment environment. Modern processing technologies and equipment should be provided to smallholder farmers as subsidies or cooperative loans to encourage effective processing. Tuber peels could be used for biofuel production, aiding energy supply to the tropics. Extension agents should educate farmers on the nutritional importance of tuber peels and processing methods to increase shelf life. Additionally, tuber peels could be processed into pellets and feed meals to enhance accessibility for ruminants' feeding.

ACKNOWLEDGEMENT

The authors are grateful to the Federal University Oye-Ekiti for the facility provided for undertaking this study.



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