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YIELD, PROXIMATE AND MINERAL COMPOSITIONS OF PAWPAW (*Carica papaya L.*) LEAF PROTEIN CONCENTRATES, LEAF MEAL AND BAGASSE

*[1]Agbonghae, W. O, [2]Nwokoro, S. O.

[1,2] Department of Animal Science, Faculty of Agriculture, University of Benin, Edo State, Nigeria

*Corresponding author email: wisdom.agbonghae@uniben.edu, +234(0)7036832998

Abstract: **This study was carried out to determine yield, proximate and mineral compositions of leaf protein concentrates, leaf meal and bagasse obtained from pawpaw leaves in Benin City, Nigeria. Pawpaw leaves were freshly harvested and processed to leaf protein concentrates, leaf meal and bagasse. Their yield and physical properties were determined. The leaf protein concentrates, leaf meal and bagasse were analyzed for their proximate and mineral compositions using standard analytical procedures. The proximate and mineral compositions were significantly ($p<0.05$) different among the major leaf fractions. The yield of the leaf protein concentrates, leaf meal and leaf bagasse were 7.12±1.75, 59.54±5.42 and 23.62±4.09 respectively. The proximate analysis of pawpaw leaf protein concentrates revealed the dry matter to be 82.50±0.71%, crude protein 39.50±071%, crude fibre 2.60±0.14%, ether extract 4.15±0.07%, ash 8.80±0.42% and nitrogen free extract 27.20±1.40%. The dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extracts for pawpaw leaf meal were 81.20±0.28%, 20.95±0.50%, 8.65±0.78%, 2.85±0.07%, 6.85±0.07 and 41.75±0.92% respectively. The pawpaw leaf bagasse had relatively high crude fibre (32.21±2.01%) but lower crude protein (17.65±1.03%) and Ash content (5.40±0.27%). The Calcium (16.95±0.50mg/100g) and Iron (496.7±6.90mg/kg) content of pawpaw leaf protein concentrate were significantly ($p<0.05$) higher than the Calcium (10.85±0.07mg/100g) and Iron (266.7±5.20mg/kg) content of pawpaw leaf meal. Leaf protein concentrate, bagasse and leaf meal obtained from pawpaw leaves have the potential of being used as livestock feed ingredient.**

Keywords: **Pawpaw, Leaf Protein Concentrate, Leaf Meal, Bagasse, Yield, Proximate, Mineral.**

I. INTRODUCTION

Protein supplementation has become one of the current trends among researchers in the field of Nutrition. Besides the fact that about 75% of the total cost of stock production comes from the feed, the protein fraction of the feed ingredients is one of the highest contributory factors to the rising animal feed cost in Nigeria [1]. The increasing human population in the developing countries of the world poses competitions between man, livestock and industries for available food and feed. Hence, [2] advised that in order to optimize food production and meet protein requirement in Nigeria, viable options need to be explored and evaluated.

During 2008-2010, India was the leading pawpaw producer with a 38.61% share of the world production followed by Brazil (17.5%), Indonesia (6.89%) and then Nigeria which is ranked fourth with 6.7 % production [3]. Leaf Protein Concentrates have proven to be a viable alternative protein source. Its crude protein value ranges between 20 and 49.15% [4], [5], [6] and [7]. Method of processing leaf protein concentrate can be adopted locally and the leaf fractionation

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process can enhance crude protein and gross energy by 34.8% and 22% respectively [8]. Its application in feed formulation and administration to animals had yielded significant success [5], [7] and [9]. It was therefore the objective of this study to determine the yield, proximate and mineral compositions of the leaf protein concentrate, leaf meal and bagasse obtained from pawpaw (*Carica papaya*) leaves in Benin City, Nigeria.

II. MATERIALS AND METHODS

A. Experimental Location

This research was carried out at the University of Benin, Ugbowo Campus, Benin City, Nigeria; and it's located between Latitude 6°30'N of the Equator and Longitude 5°40' to 6°E of the Greenwich Meridian, in the rain forest zone, with an average temperature of 27.6°C. Benin City has an average annual rainfall, relative humidity and daily sunshine of 2162mm, 72.5% and 6.68 hours respectively [10].

B. Production of Pawpaw Leaf Protein Concentrates, Leaf Meal and Bagasse

Leaves of pawpaw were harvested fresh between October and November (at the beginning of dry season), from Benin City, Edo State, Nigeria. They were weighed and rinsed prior to drying (for leaf meal) and pulping with a pulping machine (for leaf protein concentrates and bagasse). The flow chart or fractionation scheme involved the heat coagulation method adapted from [11] and modified by [1] as shown in Fig. 1. The method involved the pulping and separation of the leaf juice from the bagasse followed by heating to 80-90°C for 10 minutes to coagulate and pasteurize the leaf protein. The protein coagulum was thereafter filtered with a muslin bag and pressed to separate the whey from the curd. The leaf meal, pulverized leaf protein concentrates and bagasse were sun-dried and milled using a laboratory hammer mill (Dietz, Dettingen-Teck, West Germany). They were then kept in airtight containers prior to proximate and mineral analysis after the physical properties had been determined.

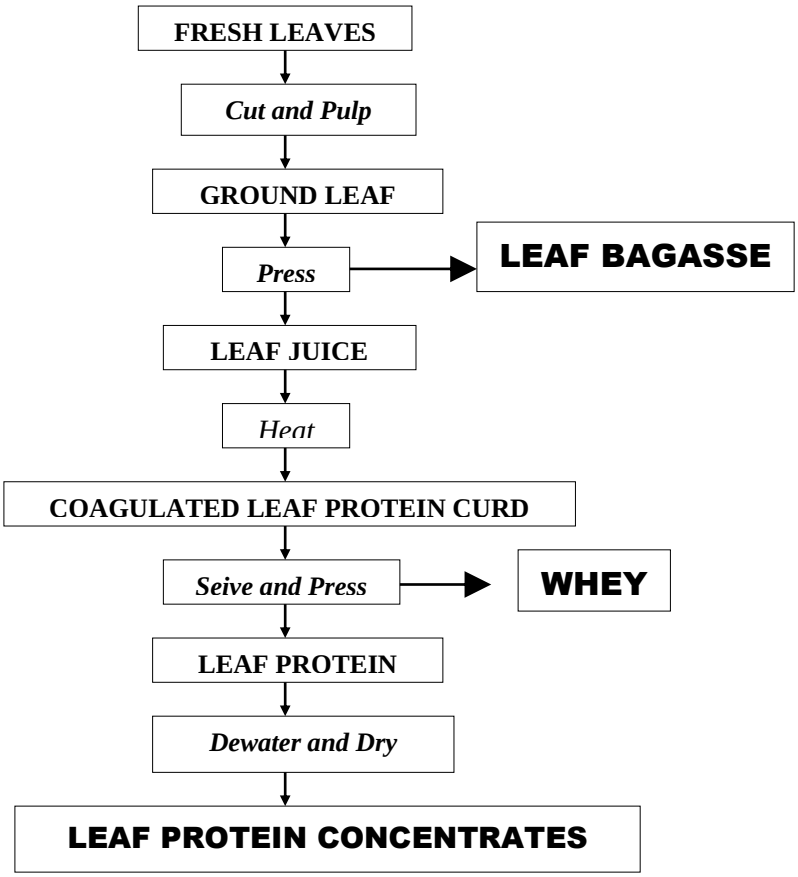

Fig. 1: Flow chart of the production of leaf protein concentrates

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C. Yield and Chemical Analysis

The yield was determined as a percentage of the dry matter weight of the PLPC, PLM and PLB respectively to the dry matter weight of the harvested pawpaw leaves. The proximate composition of these materials were determined by adopting procedures of association of analytical chemist [12]. The minerals were analysed after first dry-ashing at 550°C in a Muffle furnace and dissolved in deionised water to standard volume. Sodium and potassium were determined by flame photometry and phosphorous by vanadomolybdate method of [12]. Magnesium, Calcium, Zinc, Manganese, Iron and Copper were determined using an atomic absorption spectrophotometer, AAS.

D. Statistical Analysis

Data collected from the experiment were subjected to Analysis of Variance at 5% ($p<0.05$) level of significance to test for significance using the Computer Statistical Package of [13] 8th edition for windows. Significant means were separated using the same statistical package.

III. RESULTS AND DISCUSSIONS

A. Yield and physical characteristics of pawpaw leaf fractions

Yield of the pawpaw leaf fractions (Pawpaw Leaf Protein Concentrates (PLPC), Pawpaw Leaf Meal (PLM), Pawpaw Leaf Bagasse (PLB) and Pawpaw Whey) are presented in TABLE I. Range of percentage yield of pawpaw leaf protein concentrates was from 4.8% to 8.9% with a mean value of 7.12±1.75. Percentage yield of pawpaw leaf meal was on the average of 59.54±5.42 with a range between 50.8 and 65.3. Pawpaw leaf bagasse had percentage yield of 23.62±4.09 which ranged from 19.3 to 24.1. Proportions for pawpaw whey was not determined. The yield of pawpaw leaf protein concentrates was higher than the 5% reported by [11] for fodders.

Physical characteristics of the leaf fractions are presented in TABLE II. Whey was the only liquid fraction from the leaf fractionation process and the other three fractions were solid in state. PLPC, PLM and PLB had a dark green, pale green and green colour respectively while pawpaw whey was golden yellow in colour. PLPC had a fine texture but PLM and PLB were coarse in texture.

TABLE I: YIELD OF PAWPAW LEAF FRACTIONS (PERCENTAGE)

Leaf Fractions (%DM)	Number of processing times						
	1	2	3	4	5	MEAN	SEM
Pawpaw leaf protein concentrates (PLPC)	7.4	8.9	8.6	5.9	4.8	7.12±1.75	0.78
Pawpaw leaf meal (PLM)	62.3	59.2	50.8	65.3	60.1	59.54±5.42	2.42
Pawpaw leaf bagasse (PLB)	24.1	19.3	19.6	26.8	28.3	23.62±4.09	1.83
Pawpaw Whey	ND	ND	ND	ND	ND	ND	ND

DM; Dry matter, SEM; Standard error of the mean, ND; Not determined

TABLE 2: PHYSICAL CHARACTERISTICS OF PAWPAW LEAF FRACTIONS

FRACTIONS	STATE	COLOUR	TEXTURE
Pawpaw leaf protein concentrate	Solid	Dark green	Fine
Pawpaw leaf bagasse	Solid	Pale green	Fibrous and Coarse
Pawpaw leaf meal	Solid	Green	Fairly Fibrous and Coarse
Pawpaw whey	Liquid	Golden yellow	Not available

B. Proximate Compositions of Pawpaw Leaf Protein Concentrates (PLPC), Pawpaw Leaf Meal (PLM) and Pawpaw Leaf Bagasse (PLB)

The results from the proximate analysis in TABLE III revealed that crude protein of pawpaw leaf protein concentrates (39.50%) was significantly ($p<0.05$) higher than that of the pawpaw leaf meal (20.95%) and bagasse (17.65%). The crude protein for PLPC was higher than 35.2% crude protein for Amaranthus leaf protein concentrate [5] and 32.64% crude

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protein for rubber leaf protein concentrate [14] but was however lower than 41.7% crude protein for cassava leaf protein concentrate [5]. Fibre adds bulk to feed and reduces the intake of excess starchy food and feed. The high fibre of pawpaw leaf bagasse make it a potential livestock feed ingredient particularly the ruminant and pseudo ruminant animals. The crude fibres of PLB (32.21%) was significantly ($p<0.05$) lower than that of the PLM (8.65%) and PLPC (2.60%) obtained from pawpaw leaves respectively. Ether extracts (4.15%) and ash content (8.80%) of PLPC were also higher than the ether extracts (2.85%) and ash content (6.85%) of PLM and PLB (0.60%). Ash present in food explains largely the amount of minerals found in food or feed substance. The value for pawpaw leaf protein concentrates was higher than those reported for Amaranthus leaf protein concentrate (5.60%) [5] and other vegetable species: *Talium triangulare* (0.62%). *Rosselle* (0.46%), *Cochorus Olitorius* (0.32%) *Telfaira Oceidentalis* (0.68%) and *Amaranthus hybridus* (0.41%) [15]. The value recorded for ash indicated that they were good sources of some mineral element. However, the ash value were lower than the leaf protein concentrate of cassava (8.1%) and Rubber (8.64%) reported by [5] and [14] respectively

TABLE III: PROXIMATE COMPOSITIONS OF PAWPAW LEAF PROTEIN CONCENTRATE (PLPC), PAWPAW LEAF MEAL (PLM) AND PAWPAW LEAF BAGASSE (PLB)

Proximate Composition (%)	PLPC	PLM	PLB	SEM
Dry matter (DM)	82.50 ± 0.71^{b}	81.20 ± 0.28^{c}	90.11 ± 0.80^{a}	0.32
Crude protein (CP)	39.50 ± 0.71^{a}	20.95 ± 0.50^{b}	17.65 ± 1.03^{c}	0.40
Crude fibre (CF)	2.60 ± 0.14^{c}	8.65 ± 0.78^{b}	32.21 ± 2.01^{a}	0.70
Ether extract (EE)	4.15 ± 0.07^{a}	2.85 ± 0.07^{b}	0.60 ± 0.12^{c}	0.05
Ash	8.80 ± 0.42^{a}	6.85 ± 0.07^{b}	5.40 ± 0.76^{c}	0.27
Nitrogen free extract (NFE)	27.20 ± 1.40^{c}	41.75 ± 0.92^{a}	35.00 ± 2.77^{b}	1.00

^{abc} Means on the same row with different superscript are significantly ($p<0.05$) different.

SEM – Standard error of the means, PLPC = Pawpaw leaf protein concentrates,

PLM = Pawpaw leaf meal, PLB = Pawpaw leaf bagasse

C. Mineral Compositions of Pawpaw Leaf Protein Concentrates (PLPC), Pawpaw Leaf Meal (PLM) and Pawpaw Leaf Bagasse (PLB)

The mineral contents of the major leaf fractions (leaf protein concentrates, leaf meal and leaf bagasse) presented in TABLE IV revealed that the three fractions were high in calcium with values of 16.96mg/100g, 10.85mg/100g and 6.45mg/100g for PLBC, PLM and PLB respectively compared to other macro minerals. The phosphorus content present in the PLPC (0.11mg/100g), PLM (0.10mg/100g) and PLB (0.21mg/100g) were low and were not significantly different ($p>0.05$). Calcium and phosphorous containing substances are required by young, pregnant and lactating dam as well as sire for bones and teeth development. Sodium and potassium are important sources of electrolytes within the body. The potassium value (5.13mg/100g) of pawpaw leaf protein concentrates was higher than 0.23mg/100g reported for *Moringa oleifera* leaf protein concentrate [6]. The sodium recorded for PLPC, PLM and PLB were 0.81mg/100g, 0.92mg/100g and 1.58mg/100g respectively. The Magnesium content in PLM (8.42mg/100g) was significantly ($p<0.05$) higher compared to PLBC (6.38mg/100g) and PLB (5.44mg/100g). Among the micro minerals analyzed, Iron was the most abundant in the leaf protein concentrate (496.7mg/kg), leaf meal (266.7mg/kg) and leaf bagasse (104.70mg/kg) and was significantly different ($p<0.05$). The values recorded in these pawpaw leaf fractions were higher than the 97mg/kg and 9.7mg/kg reported by [5] for Amaranthus leaf protein concentrates and Cassava leaf protein concentrates respectively. Zinc recorded a value of 32.25mg/kg, 13.80mg/kg and 16.31mg/kg for pawpaw leaf protein concentrates, leaf meal and leaf bagasse respectively. However, the zinc present in PLBC was significantly higher compared to PLM and PLB but lower than 54.8mg/kg reported by [6] for *Moringa oleifere* leaf protein concentrates. The Manganese (57.00mg/kg) content of PLPC were significantly higher than the values recorded for PLM (28.30mg/kg) and PLM (17.77mg/kg). Same was observed with copper as its content in PLPC (71.50mg/kg) was higher than that of PLM (35.80mg/kg) and PLB (10.56mg/kg).

TABLE IV: MINERAL COMPOSITIONS OF PAWPAW LEAF PROTEIN CONCENTRATE (PLPC), PAWPAW LEAF MEAL (PLM) AND PAWPAW LEAF BAGASSE (PLB)

MINERALS	PLPC	PLM	PLB	SEM
Calcium (mg/100g)	16.96 ± 0.50^{a}	10.91 ± 0.94^{b}	6.45 ± 0.40^{c}	0.38
Phosphorus (mg/100g)	0.11±0.09	0.12±0.01	0.21±0.01	0.03
Sodium (mg/100g)	0.81 ± 0.08^{c}	0.92 ± 0.02^{b}	1.58 ± 0.10^{a}	0.04
Potassium(mg/100g)	5.13 ± 0.70^{c}	9.64 ± 0.50^{a}	8.35 ± 0.35^{b}	0.31
Magnesium(mg/100g)	6.38 ± 0.40^{b}	8.42 ± 0.40^{a}	5.44 ± 0.20^{c}	0.20
Iron (mg/kg)	496.50 ± 14.70^{a}	266.70 ± 3.00^{b}	104.70 ± 4.00^{c}	5.16
Manganese (mg/kg)	57.01 ± 2.00^{a}	28.30 ± 1.00^{b}	17.77 ± 1.00^{c}	0.82
Zinc (mg/kg)	32.25 ± 3.00^{a}	13.80 ± 0.60^{b}	16.31 ± 0.30^{b}	1.03
Copper (mg/kg)	71.50 ± 1.00^{a}	35.80 ± 2.00^{b}	10.56 ± 0.60^{c}	0.77

^{abc} Means on the same row with different superscript are significantly ($p<0.05$) different.

SEM – Standard error of the means, PLPC = Pawpaw leaf protein concentrates,

PLM = Pawpaw leaf meal, PLB = Pawpaw leaf bagasse

IV. CONCLUSION

This research was done to determine the yield, proximate and mineral composition of pawpaw leaf protein concentrates, pawpaw leaf meal and pawpaw leaf bagasse. Pawpaw leaf protein concentrates has a high yield compared to other leaves and fodder plants. The crude protein of pawpaw leaf protein concentrate was higher than the leaf meal. Pawpaw leaf protein concentrates have high nutrient constituents and could serve as protein supplement in livestock feed. The high yield and fibre content of pawpaw leaf bagasse suggests that it has the potential of being used as feed ingredient for ruminant and pseudo ruminant animals. The mineral contents of the leaf protein concentrates, leaf meal and bagasse suggest that they are viable animal feed ingredients. The phytochemical content and functional properties of pawpaw leaf protein concentrate should be researched on. Also, *in vitro* and *in vivo* studies of the pawpaw leaf protein concentrate and bagasse should be investigated in livestock.

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