



Nutritional significance of leaf meals, protein concentrates and residues from some tropical leguminous plants

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Abstract

The leaf meals (LMs) from freshly harvested leaves of butterfly pea (*Centrosema pubescens*), devil bean (*Mucuna pruriens*), flamboyant flower (*Delonix regia*), *Bauhinia thoningii*, coast wattle (*Acacia auriculiformis*), quick stick (*Glyricidia sepium*) and ipil-ipil (*Leucaena leucocephala*) were analysed for their proximate composition, mineral constituents, gross energy, polyphenols (as tannic acid equivalent), phytin-P and phytin. Thereafter, leaf protein concentrates (LPCs) were produced from the leaves using village scale fractionation scheme. The LPCs and resulting leaf residues (LRs) were characterized as the LM. On the average, the LM contained 181 g kg⁻¹ DM crude protein (range 100–280 g kg⁻¹ DM), 139 g kg⁻¹ DM crude fibre (range 77–230 g kg⁻¹ DM) and 133 g kg⁻¹ DM ether extract (range 86–165 g kg⁻¹ DM). Gross energy averaged 17.0 MJ kg⁻¹. Leaf protein fractionation enhanced the crude protein, ether extract and the gross energy in the LPC by 39.5, 33.5 and 22.0%, on the average respectively while the crude fibre content of the LMs was reduced on the average by 41% in the LPC. The Ca, Na, K, P and Mg were the most abundant mineral elements in the LMs and LPCs but their quantities in the LPC were generally low. Apart from the crude fibre and some mineral elements, the nutrient contents of the LPC leaf residue were generally lower than that of their LMs and LPCs. The mean phytin content varied from 34.0 mg/100 g in LPC to 86.3 mg/100 g in the leaf meal while the mean phytin-P content varied from 10.0 mg/100 g in LPC to 24.3 mg/100 g in leaf meal. The total phenol levels in the LMs were reduced by 33.7% in the LPC on the average. This analytical information suggests that while the LPCs from these plants could be used as protein supplements in human feeding, the feeding of the LMs or LPC fibrous residues to the ruminant animals either solely or in combination with other forages appears feasible especially under feedlot.

Key words: Leaf protein concentrates, residues, fractionation, mineral constituents, gross energy, polyphenols, phytin.

Introduction

Intensive livestock production in developing countries of the world is hindered by their high dependence on importation of feeding raw materials. Such feeding ingredients, particularly protein resources, are largely imported¹. Soybean meal and fishmeal are some of the major sources of protein in finished feed and their high import content contribute substantially to the high cost of finished feed in most developing countries. Consequently, there is a growing awareness of the need to reverse this trend. One current approach to doing this is to explore alternative feeding ingredients that can be fed to human and/or animals in place of the more expensive conventional ones.

The use of plant leaves as a source of protein is one possible alternative. Leaves are good sources of proteins but their use by non-ruminants is limited because of their high-fibre contents and, in some cases, the presence of some inherent toxic factors. However, if the fibre can be separated mechanically, fibre-free protein from plants can supply as much protein as 10-20 g/person/day².

Leaves from leguminous plants such as butterfly pea (*Centrosema pubescens*), devil bean (*Mucuna pruriens*), flamboyant flower (*Delonix regia*), *Bauhinia* species, coast wattle (*Acacia auriculiformis*), quick stick (*Glyricidia sepium*) and ipil-ipil (*Leucaena leucocephala*) contained appreciable protein³ which if fractionated could be used for non-ruminant feeding. The leaf meals and the fibrous residues, which are by-products of leaf fractionation from these plants, could be fed to the ruminant

either wholly or in enriched form with urea or poultry droppings. They can serve as supplement to grasses, especially during the long dry season, when grasses become extremely deficient in protein, carotene and phosphorus and cannot support the maintenance requirements of livestock⁴. However, the exploitation of these potentials has not received enough research attention. Conceivably, harnessing the potentials of these alternative protein resources for both non-ruminant and ruminant animals will enhance food production and consumption, especially in the tropics.

This study was therefore conceived with a view to providing some basic information on leaf meals, leaf protein concentrates and leaf residues from butterfly pea (*Centrosema pubescens*), devil bean (*Mucuna pruriens*), flamboyant flower (*Delonix regia*), *Bauhinia thoningii*, coast wattle (*Acacia auriculiformis*), quick stick (*Glyricidia sepium*) and ipil-ipil (*Leucaena leucocephala*) with respect to their proximate compositions and mineral and energy contents. Also of interest are some anti-nutritional factors such as tannins and phytic acids.

Materials and Methods

Experimental material: The experimental material included leaves from seven leguminous species: butterfly pea (*Centrosema pubescens*), devil bean (*Mucuna pruriens*), flamboyant flower (*Delonix regia*), *Bauhinia thoningii*, coast wattle (*Acacia auriculiformis*), quick stick (*Glyricidia sepium*) and ipil-ipil

Abbreviations: LM leaf meal, LPC leaf protein concentrate, LR leaf residue.

(*Leucaena leucocephala*). All the leaves were harvested in August during rainy season from matured trees in case of *D. regia*, *B. thoningii*, *A. auriculiformis*, *G. sepium* and *L. leucocephala* while *C. pubescens* and *M. pruriens* were harvested from an unclear paddock in the university farm. All leaves were harvested within the campus of the Federal University of Technology, Akure, Nigeria. All the samples were collected at the early hours of the day. A completely randomised design was used in the experiment.

Leaf meal preparation: Freshly collected leaves from sampled plants were brought to the laboratory and the leaves were plucked from their stalks. Plucked leaves were put in a tray and later sun-dried outside the laboratory for about four days. The dried leaves were milled prior to analyses.

Leaf protein concentrates production: Leaves from individual plant species were plucked, weighed and washed prior to pulping as described⁵. The pulping ruptured the plant cell walls, and the juice which carried with it most of the proteins was squeezed out by means of a press from the leaf residue. The separated leaf juice was heated in batches to 80-90°C for 10 minutes. This procedure coagulated the leaf proteins from the whey. The protein coagulum was separated from the whey by using a rubber hose to siphon the hot whey as described⁶. The coagulated proteins were thereafter separated from the whey by filtering through muslin cloth and pressed with screw-press to remove the remaining whey. The leaf protein was then washed with water, repressed and sun-dried.

Leaf residue preparation: They are the fibrous fraction after pulping. These were spread in trays and sun-dried. Thereafter, all the 21 samples were finely milled using a laboratory hammer mill (Dietz, 7311 Dettingen-Teck, Germany), sieved and packed in labelled air-tight containers and deep frozen at -18°C until needed for analysis.

Proximate analysis and gross energy (GE) determination: The proximate chemical analysis of the leaf meals, leaf protein coagula and leaf protein fibrous residues was determined in triplicate as described⁷. The crude proteins were calculated by multiplying the gram nitrogen in the samples by a factor of 6.25. The nitrogen-free extract content was determined by difference. The gross energy (GE) contents of the leaf meal, leaf protein concentrates and leaf protein fibrous residues were determined against thermochemical grade benzoic acid standard using a Gallenkamp Ballistic bomb calorimeter (Cam Metric Ltd., Cambridge, England).

Mineral analysis: Sodium and potassium were determined by flame photometry (Jenway Ltd, Dunmond, Essex, UK) and phosphorus was determined by vanadomolybdate method⁷ using Corning colorimeter 253. Other minerals were determined after wet digestion with a mixture of sulphuric, nitric and perchloric acids using atomic absorption spectrophotometer (Buck Scientific, East Norwalk, CT 06855, USA).

Determination of anti-nutrients

Phytin and phytin-P analyses: Samples (8 g) of each finely ground leaf meal, leaf protein concentrate and leaf residue were soaked in 200 ml of 2% hydrochloric acid and allowed to stand for

three hours. The extract was thereafter filtered through two layers of hardened filter papers. 50 ml of the filtrate was pipetted in triplicate into 400 ml capacity beakers before the addition of 10 ml of 0.3% ammonium thiocyanate solution as an indicator and 107 ml of distilled water to obtain the proper acidity (pH 4.5). The solution was then titrated with a standard iron chloride (FeCl₃) solution containing Fe 0.00195 g/ml until a brownish yellow colour persists for 5 minutes. Phytin-phosphorus was determined and phytin content was calculated by multiplying the value of phytin-phosphorus by 3.55⁸. Where extracts were deeply coloured, they were decolourised with activated charcoal⁹. Each milligram of iron is equivalent to 1.19 mg of phytin-phosphorus.

Total phenol analysis: Finely milled leaf meal, leaf protein concentrate and leaf residue samples (200 mg in 10 ml of 70% aqueous acetone) were extracted for 2 hours at 30°C in water-bath using Gallenkamp orbital shaker at 120 revolutions per minute. Fat was first removed from the samples by extracting with di-ethyl ether containing 1% acetic acid. Thereafter, the concentration of total polyphenols (as tannic equivalent) was determined in 0.05 ml aliquot in test tubes by the addition of distilled water to make it to 1.0 ml in the test tubes, 0.5 ml of the Folin-Ciocalteu reagent (Sigma) and 2.5 ml of the sodium carbonate solution. The tubes were vortexed and absorbance recorded at 725 nm after 40 min.¹⁰. The amount of total polyphenols (as tannic acid equivalent) was calculated from the standard curve.

Results

Proximate composition and energy contents: Table 1 indicates appreciable variations in crude protein (CP), ash, crude fibre (CF), crude fat and nitrogen-free extract (NFE). The crude protein of the leaf meal ranged from 100 g kg⁻¹ DM in *Bauhinia* to 280 g kg⁻¹ DM in *Leucaena*. The ash content varied from 61 g kg⁻¹ DM in *Delonix* to 150 g kg⁻¹ DM in *Bauhinia*. The crude fibre ranged from 77±1.5 g kg⁻¹ DM in *Glyricidia* to 230±0.9 g kg⁻¹ DM in *Centrosema*. The crude fat ranged from 86±0.5 g kg⁻¹ DM in *Delonix* to 165±1.0 g kg⁻¹ DM in *Mucuna* leaf meal. The NFE varied from 415±1.0 g kg⁻¹ DM in *Centrosema* to 634±3.2 g kg⁻¹ DM in *Delonix* leaf meal.

When compared with their corresponding leaf meals, the leaf protein fractionation process enhanced the levels of CP and crude fat with an attendant reduction in ash, CF and NFE contents (Table 2). The crude protein content of the concentrates ranged from 201±1.3 g kg⁻¹ DM in *Bauhinia* to 430±1.5 g kg⁻¹ DM in *Glyricidia* while crude fat ranged from 151±0.7 g kg⁻¹ DM in *Glyricidia* to 263±0.5 g kg⁻¹ DM in *Mucuna*. The CP, ash and crude fat contents of the fibrous residues were lower than those of leaf meals or the LPCs. However, values of the crude fibre were higher than their corresponding leaf meals and LPCs (Table 3). The crude fibre ranged from 154±1.6 g kg⁻¹ DM in *Leucaena* to 360±0.7 g kg⁻¹ DM in *Acacia*. Tables 1-3 show the gross energy (GE) contents of the leaf meals, the LPCs and the fibrous residues, respectively. The gross energy in leaf meal ranged from 14.9 MJ kg⁻¹ in *Delonix* to 20.0 MJ kg⁻¹ in *Mucuna*. It also ranged from 20.4 MJ kg⁻¹ in *Delonix* LPC to 23.3 MJ kg⁻¹ in *Mucuna* LPC. The gross energy (GE) values were lower in the fibrous residues and ranged from 10.1 MJ kg⁻¹ in *Leucaena* to 14.6 MJ kg⁻¹ in *Glyricidia*.

Mineral constituents: The trace and major mineral constituents in the leaf meals of the under-utilized leguminous leaves and their corresponding leaf protein concentrates and leaf residues are

Table 1. Proximate composition (g/kg DM) and gross energy (MJ/kg) of leaf meals from some under-utilized leguminous leaves.

Samples	Crude protein	Ash	Crude fibre	Ether extract	Nitrogen-free extract	Gross energy
<i>Centrosema pubescens</i>	115 ±0.5	77±0.5	230±0.9	163±1.1	415±1.0	17.2
<i>Mucuna pruriens</i>	269±0.9	48±0.0	100±0.8	165±1.0	418±1.1	20.0
<i>Leucaena leucocephala</i>	280 ±0.5	74±0.4	92±0.7	136±0.9	418±0.2	18.0
<i>Delonix regia</i>	109 ±0.7	61±0.0	130±1.1	86±0.5	634±2.3	14.9
<i>Bauhinia thoningii</i>	100±0.5	150±0.1	125±1.4	123±0.4	502±3.2	15.4
<i>Acacia auriculiformis</i>	140± 1.3	62±0.1	218±1.7	136±0.0	445±3.1	16.3
<i>Glyricidia sepium</i>	254 ±1.0	81±0.3	77±1.5	121±1.2	467±1.3	17.5
Mean	181	79	138.9	132.9	471.3	17.0
Standard deviation	82.3	33.3	61.1	27.1	78.5	0.17
Coefficient of variation %	45.5	42.1	44.0	20.4	16.7	10.1

Table 2. Proximate composition (g/kg DM) and gross energy (MJ/kg) of leaf protein concentrates from some under-utilized leguminous leaves.

Samples	Crude protein	Ash	Crude fibre	Ether extract	Nitrogen-free extract	Gross energy
<i>Centrosema pubescens</i>	286±0.6	53±0.4	41±1.5	214±1.1	406±0.5	22.8
<i>Mucuna pruriens</i>	352±0.2	69±0.6	46±0.7	263±0.5	270±0.7	23.3
<i>Leucaena leucocephala</i>	362±1.4	65±0.1	76±0.2	160±0.1	337±0.7	21.4
<i>Delonix regia</i>	220±0.7	55±0.0	82±0.1	153±1.3	536±1.3	20.4
<i>Bauhinia thoningii</i>	201±1.3	94±0.1	37±0.8	231±0.9	437±0.9	21.6
<i>Acacia auriculiformis</i>	242±0.7	59±0.6	84±0.6	226±1.0	389±1.0	21.3
<i>Glyricidia sepium</i>	430±1.5	60±0.1	33±0.0	151±0.7	326±0.7	21.8
Mean	299.0	65.1	57.0	199.7	385.9	21.8
Standard deviation	84.9	13.9	22.6	44.7	86.6	0.1
Coefficient of variation %	28.4	21.4	40.0	22.46	22.4	4.6

Table 3. Proximate composition (g/kg DM) and gross energy (MJ/kg) of leaf residues from some under-utilized leguminous leaves.

Samples	Crude protein	Ash	Crude fibre	Ether extract	Nitrogen- free extract	Gross energy
<i>Centrosema pubescens</i>	38±1.1	49±0.4	289±0.9	89±0.8	436±1.4	10.7
<i>Mucuna pruriens</i>	36±0.7	59±0.2	329±0.6	87±0.7	389±0.4	10.5
<i>Leucaena leucocephala</i>	40±0.6	40±0.3	154±1.6	70±1.0	596±1.0	10.1
<i>Delonix regia</i>	27±0.0	32±0.0	157±1.3	98±0.3	536±0.9	14.0
<i>Bauhinia thoningii</i>	20±0.0	80±0.7	357±0.8	97±0.1	319±0.2	12.0
<i>Acacia auriculiformis</i>	30±0.0	41±0.0	360±0.7	93±0.4	351±1.8	11.1
<i>Glyricidia sepium</i>	42±0.7	53±0.3	221±1.2	101±0.2	310±1.3	14.6
Mean	33.3	50.6	266.7	90.7	419.6	11.9
Standard deviation	7.9	15.8	89.5	10.4	110.1	0.18
Coefficient of variation %	23.7	31.2	33.6	11.5	26.2	15.1

Table 4. Mineral constituents (mg/kg) of leaf meals from some under-utilized leguminous leaves.

Samples	Ca	Na	K	P	Mg	Mn	Fe	Cu	Zn	Ni
	Macro					Micro				
<i>Centrosema pubescens</i>	826.3	711.9	663.6	10593.2	472.9	6.1	85.3	43.2	100.3	27.3
<i>Mucuna pruriens</i>	228.6	478.0	405.5	10989.0	380.8	9.2	32.4	26.4	43.6	13.1
<i>Leucaena leucocephala</i>	196.0	337.3	275.0	5952.4	353.6	3.8	48.3	24.2	27.3	10.6
<i>Delonix regia</i>	225.2	291.3	283.8	6889.8	283.5	2.8	43.4	11.8	22.0	6.6
<i>Bauhinia thoningii</i>	513.2	493.4	402.6	6578.9	444.1	7.9	43.8	15.1	44.5	21.2
<i>Acacia auriculiformis</i>	250.0	407.4	339.6	4050.9	412.5	5.6	29.0	16.0	40.3	11.0
<i>Glyricidia sepium</i>	293.6	315.6	262.3	8196.7	339.3	6.9	14.8	12.3	16.5	11.0
Mean	361.8	433.5	376.1	7607.3	383.8	6.0	42.4	21.3	42.1	14.4
Standard deviation	230.8	145.6	139.8	2505.3	65.7	2.2	22.1	11.2	27.9	7.2
Coefficient of variation %	63.8	33.6	37.2	32.9	16.9	36.7	52.1	52.6	66.3	50.0

Table 5. Mineral constituents (mg/kg) of leaf protein concentrates from some under-utilised leguminous leaves.

Samples	Macro					Micro				
	Ca	Na	K	P	Mg	Mn	Fe	Cu	Zn	Ni
<i>Centrosema pubescens</i>	301.4	203.9	212.4	2793.3	208.7	1.3	66.3	20.7	29.8	5.5
<i>Mucuna pruriens</i>	208.4	230.9	212.8	4415.8	166.3	2.6	71.3	20.9	25.4	7.6
<i>Leucaena leucocephala</i>	182.5	254.4	173.7	4386.0	205.3	3.5	49.4	21.6	29.3	4.5
<i>Delonix regia</i>	159.0	204.8	174.7	4986.7	153.2	2.6	53.1	9.3	14.5	3.4
<i>Bauhinia thoningii</i>	150.6	176.0	129.6	2306.9	114.0	2.1	50.2	20.2	17.9	5.4
<i>Acacia auriculiformis</i>	295.5	300.7	221.9	3906.3	226.6	2.5	56.5	60.1	22.7	7.3
<i>Glyricidia sepium</i>	125.9	170.8	113.4	3228.8	155.6	3.0	92.2	12.3	20.9	3.8
Mean	203.2	220.2	176.9	3717.7	175.7	2.5	62.7	23.6	22.9	5.4
Standard deviation	70.0	45.9	42.5	971.6	39.5	0.7	15.4	16.8	5.7	1.6
Coefficient of variation %	34.4	20.8	24.0	26.1	22.5	28	24.6	71.2	24.9	29.6

Table 6. Mineral constituents (mg/kg) of the fibrous leaf residues from some under-utilised leguminous leaves.

Samples	Macro					Micro				
	Ca	Na	K	P	Mg	Mn	Fe	Cu	Zn	Ni
<i>Centrosema pubescens</i>	1266.7	1102.6	934.6	8012.8	519.2	15.4	82.8	42.3	108.3	34.1
<i>Mucuna pruriens</i>	737.8	1108.1	1038.8	13513.5	668.9	6.5	143.8	29.7	108.9	22.7
<i>Leucaena leucocephala</i>	243.8	392.9	237.1	5580.4	313.4	1.1	38.2	18.3	24.4	15.6
<i>Delonix regia</i>	239.5	330.8	165.8	4699.2	247.0	4.5	25.7	11.7	27.4	5.8
<i>Bauhinia thoningii</i>	891.9	976.7	564.1	14534.9	334.9	5.6	77.3	30.2	52.9	26.1
<i>Acacia auriculiformis</i>	308.8	531.3	295.3	9375.0	405.0	6.0	49.9	15.0	25.2	13.1
<i>Glyricidia sepium</i>	443.1	700.0	603.0	8333.3	540.0	12.0	83.9	9.2	62.8	19.8
Mean	590.2	734.6	548.4	9149.9	432.6	7.3	71.7	22.3	58.6	19.6
Standard deviation	390.4	330.6	341.6	3710.3	149.4	4.8	39.2	12.0	37.2	9.2
Coefficient of variation %	66.1	45.0	62.3	40.6	34.5	65.8	54.7	53.8	63.5	46.9

Table 7. Some anti-nutrients content (mg/100 g DM) of the leaf meals from some under-utilized leguminous leaves.

Sample	Phytin	Phytin-P	Tannin
<i>Centrosema pubescens</i>	83.1	23.4	17.4
<i>Mucuna pruriens</i>	139.5	39.3	115.8
<i>Leucaena leucocephala</i>	111.5	31.4	138.4
<i>Delonix regia</i>	71.4	20.1	139.4
<i>Bauhinia thoningii</i>	74.6	21.0	35.1
<i>Acacia auriculiformis</i>	95.9	27.0	99.9
<i>Glyricidia sepium</i>	28.0	7.9	24.8
Mean	86.3	24.3	81.5
Standard deviation	34.9	9.8	54.1
Coefficient of variation %	40.4	40.3	66.4

Table 8. Some anti-nutrient content (mg /100 g DM) of the leaf protein concentrates from some under-utilized leguminous leaves.

Sample	Phytin	Phytin-P	Tannin
<i>Centrosema pubescens</i>	52.9	14.9	8.2
<i>Mucuna pruriens</i>	42.2	11.9	4.3
<i>Leucaena leucocephala</i>	44.0	12.4	23.6
<i>Delonix regia</i>	30.2	8.5	48.0
<i>Bauhinia thoningii</i>	26.3	7.4	11.7
<i>Acacia auriculiformis</i>	22.0	9.0	88.1
<i>Glyricidia sepium</i>	20.6	5.8	8.8
Mean	34.0	10.0	27.5
Standard deviation	12.4	3.2	30.6
Coefficient of variation %	36.5	32.0	111.3

Table 9. Some anti-nutrient content (mg /100 g DM) of the leaf residues from some under-utilized leguminous leaves.

Sample	Phytin	Phytin-P	Tannin
<i>Centrosema pubescens</i>	27.0	7.6	7.2
<i>Mucuna pruriens</i>	69.6	19.6	5.1
<i>Leucaena leucocephala</i>	66.7	18.8	8.6
<i>Delonix regia</i>	54.7	15.4	42.7
<i>Bauhinia thoningii</i>	19.5	5.5	9.7
<i>Acacia auriculiformis</i>	40.5	11.4	10.8
<i>Glyricidia sepium</i>	22.0	6.2	11.0
Mean	42.9	12.1	13.6
Standard deviation	21.1	5.9	13.0
Coefficient of variation %	49.2	48.8	95.6

presented in Tables 4-6, respectively. In all the samples, P was the most abundant and the values were higher in the fibrous residues than in the leaf meals and LPCs. Generally, the values of the minerals measured in the fibrous residues were higher than those found in the leaf meals and LPCs.

Anti-nutritional constituents: Table 7 shows that while the level of phytin in leaf meals varied from 28.0 mg/100 g DM in *Glyricidia* to 139.5 mg/100 g DM in *Mucuna*, total phenol varied from 17.4 mg/100 g DM in *Centrosema* to 139.4 mg/100 g DM in *Delonix*. Also the levels of phytin in the leaf protein concentrates varied from 20.6 mg/100 g DM in *Glyricidia* to 52.9 mg/100 g DM in *Centrosema* while the tannic acid content varied from 8.2 mg/100 g DM in *Centrosema* to 88.1 mg/100 g DM in *Acacia* (Table 8). The phytin, phytin-P and the tannin for the leaf residues averaged 42.9, 12.1 and 13.6 mg/100 g DM, respectively (Table 9).

Discussion

Data on the proximate composition, energy, mineral and anti-nutritional constituents of these leguminous plants and their corresponding LPCs reveals their potentials as sources of food or feed for the non-ruminants. For instance, the CP content of the leaves (100–280 g kg⁻¹ DM) and their corresponding LPCs (201–430 g kg⁻¹ DM) compared favourably with, and in some cases, surpassed those reported for most legumes grown in West Africa¹¹⁻¹³ and those reported for leaves and LPCs^{3,6}. The study

further showed that the fractionation of the leaves enhanced their protein and energy contents. Also the CF contents were higher in leaf fibrous residues when compared to their corresponding LPCs and leaf meals. However, the protein and energy contents of the LPCs were generally higher than those reported for the leaves of several tropical leafy vegetables including cassava leaves^{14, 15} but lower than the value (489 g kg⁻¹ DM) reported for LPC elsewhere⁶. This suggests that the LPCs from *M. pruriens*, *L. leucocephala* and *G. sepium* with crude protein values of 352, 362 and 430 g kg⁻¹ DM could be used as supplements or act as substitutes for the more conventional commercial plant protein and energy sources, such as soybean, in animal or human nutrition. Thus corroborating the results reported earlier¹⁶ and recently^{6, 17} that LPCs nutrient contents are capable of comparing with that of soybean and egg. During prolonged dry season when forages are in short supply the fibrous leaf residues could be used either with urea or poultry manure as multi-nutrient block for ruminant nutrition.

The leaves contain appreciable levels of nutritionally valuable minerals. Both the leaf meals and their corresponding LPCs and fibrous leaf residues are high in the macrominerals (Ca, Na, K, P and Mg) but most of these minerals are present in the leaf residues. This suggests that though the fibrous leaf residues appeared low in crude protein, feeding any of them as supplement to the ruminants will help to provide some of the nutritionally needed minerals in the feed. Generally, the macromineral contents in the LMs, LPCs and LRs fall within the range reported for some varieties of cowpea¹⁸ and leaves¹⁴.

It is common knowledge that the leguminous plants have high potentials in meeting animal dietary protein needs, but their inherent ability to synthesize myriad anti-physiological factors remains a primary drawback to their direct use as food by man and non-ruminant animals. The present study shows that the leaf meals, leaf protein concentrates and the leaf residues from the plants under study contain phytin and total phenol, the contents of which varied with the plant species and the leaf products. It is of interest that fractionation of these leaves (LPCs) reduced the phytin and total phenol contents suggesting that the nutritive qualities of the leaves from the plants could be enhanced by fractionation process^{2, 5, 16}. Similarly, the leaf residues if fed to the ruminants may not pose any serious threat to their health as they have the ability to efficiently utilize feeding materials containing these anti-physiological factors owing chiefly to their special endowment with intestinal microflora and -fauna. Earlier studies have shown phytic acid to be a potent chelating agent for divalent cations and consequently interfere with mineral bioavailability¹⁹⁻²¹. Phytic acid also interferes with basic residues of proteins in a way that inhibits the activities of certain digestive enzymes such as α -amylase, pepsin and pancreas²². Dietary phytin is of particular importance in non-ruminant animals including man, who lack phytase to breakdown phytin to release phosphorus for metabolism. The nutritional significance of dietary tannins (especially in non-ruminants) derives largely from its ability to bind dietary proteins and digestive enzymes into complexes that are not readily digestible²³. The poor palatability generally associated with high tannin diets are ascribed to its astringency properties, which is a consequence of its ability to bind with proteins of saliva and mucosa membrane²⁴.

Conclusions

The high crude protein and gross energy coupled with low crude fibre of the LPCs from these leguminous plants clearly suggest that they could serve as alternative feed resources for humans and/or non-ruminants especially where feed supply is limited. It is clear that the tropical grasses cannot support the level of animal production in most developing countries in sub-Saharan Africa. Conceivably, the use of the leaf meals or leaf residues from these plants as supplement for ruminants either wholly or in an enriched form with poultry manure or urea in the region represents a veritable nutrition intervention strategy especially during the dry season. Similarly, the use of these leaves either as leaf meals or leaf protein concentrates holds tremendous promise in narrowing down the protein and mineral supply deficits that are prevalent in non-ruminant production in sub-Saharan Africa. The LPCs from the plants studied may not be suitable as sole protein sources in non-ruminants (including man) nutrition but their use to complement other protein sources in the diets may help to reduce the cost of production of these animals. Meanwhile research and development efforts geared towards the enhancement of the nutritive values of the LPCs from these plants in the non-ruminant animal nutrition are currently being undertaken.

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