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***Senna siamea* Seed Provenance of Zimbabwe: A Potential Oleic- and Linoleic-Acid-Rich Dietary Protein and Energy Source for Livestock and Poultry Feeds**

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In sub-Saharan Africa (SSA), off-veid ruminant livestock and commercial poultry production fail to meet the demand for meat and eggs. Intensified production to meet the demand requires nutritionally balanced feeds. Competition between humans, livestock and poultry for feed resources present a challenge hence the need for alternative feed resources. Indigenous trees seeds are potential sources of nutrients. *Senna siamea*, widely distributed in SSA, produces an abundance of seed. We evaluated, by chemical analyses, the potential of hulled (HSSM) and dehulled (DSSM) in *S. siamea* seed meal to supply nutrients in feeds. DSSM had higher DM, CP, EE, ash, P and gross energy (92.71±0.08%, 47.89±0.03%, 11.39±0.16%, 6.17±0.07%, 1.01±0.03% and 23.13±0.05 MJ/kg DM, respectively) content than HSSM (P<0.05). Amino acids were more concentrated (P<0.05) in the DSSM. HSSM's CF, NDF, ADF and Ca content was significantly higher (P<0.05) compared to that of the DSSM. The DM, CP, EE and gross energy (GE) content (89.48±0.09%, 21.75±0.09%, 4.71±0.41%, and 20.46±0.04 MJ/kg DM, respectively) of the HSSM though lower compared to in DSSM, are within range of conventional plant-derived dietary protein and energy sources for feeds. DSSM's CP and GE is higher than that of conventional dietary protein and energy sources for feeds. The TSFAs (27.88±1.36% vs 27.53±0.59%) and TPUFAs (50.42±5.18% vs 53.42±2.12%) proportion of the HSSM and DSSM, respectively were similar. HSSM (21.69±0.18%) had a significantly higher proportion of TMUFAs than DSSM (19.03±0.21%). DSSM had a higher concentration of the fatty acids per unit mass since it had more than double EE content of the HSSM. In HSSM and DSSM

palmitic ($19.18 \pm 0.44\%$ vs $18.63 \pm 0.37\%$), oleic ($21.15 \pm 0.09\%$ vs $18.45 \pm 0.01\%$) and linoleic acid (43.35 vs 50.62%), respectively were the dominant saturated, monounsaturated and polyunsaturated fatty acids. *S. siamea* seed meals can potentially be exploited as oleic- and linoleic acid-rich dietary energy and protein sources in livestock and poultry feeds.

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INTRODUCTION

Livestock and poultry products (meat, milk and eggs) are important sources of nutrients in human diets. In the developing world, especially in Asia and sub-Saharan Africa (SSA) the demand for these products is increasing at a greater rate compared to that of the developed world (Thornton, 2010). The demand for meat, milk and eggs in SSA and elsewhere in the developing world is expected to double by 2050 (Van Vuren et al., 2009). The increase in demand is premised on increase in the human population, improvement of the socio-economic statuses of the population, expansion of urban settlements (Thornton, 2010) and the increase in energy intake from the current 200 kcal/person/day to 400 kcal/person/day (Van Vuren et al., 2009).

In SSA, failure to meet human requirements for meat, milk and eggs is compromising household nutrient and food security. The need to intensify the production of livestock and poultry in order to

ensure food security at the household level in SSA has become paramount. However, intensive livestock and poultry production subsist on cereal and legume grains which are staple food crops for human consumption resulting in competition for feed and food resources between livestock and poultry against humans (Delgado, 2005, Pandit et al., 2014). The competition-induced shortages lead to prohibitive livestock and poultry feed costs. The ensuing high feed costs make it costly to intensify livestock and poultry production. Importantly, these high feed costs compromise resource-limited rural and township communities' ability to afford and or even produce animal/poultry-derived products for home consumption (Rosegrant et al., 2009) thus negatively impacting household food security. The human-livestock-poultry competition for food and feed resources militates against the intensification of livestock and poultry product production in order to meet increased and increasing demand (Thornton, 2010; Pelletier and Tyedmers, 2010). A dire need, therefore, exists to develop non-conventional but novel feed crops that can be exploited to meet the needs for

intensification of livestock and poultry production without the challenge of competition with humans for cereal and legume requirements.

Sub-Saharan Africa is endowed with indigenous fruit-bearing trees whose seeds are largely left to rot in the veld (Chivandi et al., 2011; Chivandi et al., 2015). Exploiting seeds from high yielding indigenous plants/fruit trees with characteristics for domestication could improve the livelihoods of rural households and mitigate against food insecurity (Hughes and Haq, 2003). Such indigenous trees could potentially contribute to the crop-livestock system by becoming feed ingredient sources for livestock and poultry. Furthermore, such novel plants could contribute to the income of rural communities through the collection and marketing of the seeds which would then be exploited as feed resources. An indirect but important benefit will be increased conservation of such trees to the overall improvement of the environment.

Senna siamea (Lam), family Fabaceae, commonly known as the Yellow cassia. It is a medium-sized fast-growing, hardy legume tree widely distributed in tropical SSA where it grows well in the west, east and southern Africa rangelands (Kamagaté et al., 2014). The tree produces an abundance of seeds (Ingweye et al., 2010). Due to its hardiness and ability to thrive in different eco-environments (Okon et al., 1996), *S. siamea* can potentially be used to reclaim degraded rangelands characterised with poor soil fertility. Its fast growth can be exploited in reforestation programs and possibly contribute as a forage crop in crop-livestock production systems. Currently, *S. siamea* is only marginally exploited as a fodder crop with its browse (leaves and pods) used in feeding ruminants (Heuzé et al., 2019). There is limited evidence of its seed being commercially exploited as a feed resource (Heuzé et al., 2019) despite its inherent high crude protein content (Ingweye et al., 2010; Gulewicz et al., 2014). In addition to *S. siamea* seed's high crude protein content, it is also rich in dietary fibre, carbohydrates and polyunsaturated fats (Gulewicz et al., 2014) thus the potential of its seed as a livestock and poultry feed resource requires further interrogation. However, the chemical nutrient characterisation of *S. siamea* seed provenances in Africa has been confined to small

areas such as Nigeria (Ingweye et al., 2010) where its seed is exploited as a source of protein in human diets. Most of the studies on *S. siamea* have largely focused on the chemical nutrient content of the tree's leaves, petals and bark (Alli-Smith, 2009; Bukar et al., 2009; Kamagaté et al., 2014; Gulewicz et al., 2014). To our knowledge, there is no record of the chemical nutrient characterisation of *S. siamea* seed provenances in Southern Africa. In order to gain buy-in from policymakers in African governments and to qualify for possible integration into the crop-livestock systems of SSA, there is a need for wider chemical nutrient characterisation of *S. siamea* seed provenances in other regions of Africa. Thus, our study evaluated the chemical nutrient composition of *S. siamea* seed provenance harvested from Mapfungautsi Forest Reserve, Gokwe, in northwestern Zimbabwe where no characterisation of the seed has been reported.

MATERIALS AND METHODS

Senna siamea Seed: Source and Identification

Fresh *S. siamea* pods containing ripened seed were collected from virgin lands of Mapfungautsi Forest Reserve, Gokwe, in North West Zimbabwe (Latitude: 19° 28' 26.5" South; Longitude: 31° 45' 14" East; Altitude: 1007 m). The pods were collected from ten randomly selected *S. siamea* trees. The area from which the seeds were harvested has a predominance of deep Gusu sandy soils derived from granite rocks and is characterised with annual rainfall averaging 819 mm, high temperatures with an annual average of 26 °C (Gwimbi, 2009). Samples of the pods, seed and leaves of the trees from which the fruit was collected were sent to the C. E. Moss Herbarium (J) of the University of the Witwatersrand and authenticated as *Senna siamea* by Mr. Donald McCallum, a botanist in the herbarium.

Seed Processing and Meal Storage

The pods were hand-shelled and the seeds (beans) dried in the shade on a clean polythene plastic sheet for 7 days. About half the dried seeds were manually dehulled and the other half was kept unhulled. The respective seeds were then ground into the unhulled and dehulled *S. siamea* seed meals (HSSM and DSSM, respectively) using a blender (Waring; Lasec Pty Ltd, Johannesburg). Each meal

was stored in a dark cupboard in an airtight sample bottle pending chemical nutrient determinations.

Chemical Nutrient Assays

The various nutrient assays were done using analytical grade reagents and chemicals purchased from Sigma Aldrich. The assays were done at the Agricultural Research Council's Irene Analytical Services Laboratories, Pretoria, South Africa. Each assay was done in triplicate.

Determination of the Proximate Components

The dry matter (DM), ash, crude protein content (CP), ether extract (EE) and crude fibre (CF) of the unhulled and dehulled *S. siamea* seed meals (HSSM and DSSM, respectively) were determined as described by Association of Analytical Chemists (AOAC, 2005; method numbers 934.01, 942.05, 954.01, 920.39 and 978.10, respectively). Each seed meal's gross energy content value was determined using an MC-1000 Modular calorimeter equipped with a desktop computer and MC1000 software.

Determination of the Meal's' Calcium and Phosphorus Content

The calcium and phosphorus content of the seed meals were determined as described by Zasoski and Bureau (1977). In essence, 0.5 g of the seed meal sample was mixed with concentrated nitric acid and perchloric acid at 200 °C to generate the digest solution from which an aliquot was used for the inductively coupled plasma optical emission spectrometric (ICP-OES) determination of calcium and phosphorus. The assay was then done on a Varian Liberty 200 spectrometer (Varian, Perth, Australia) as described by Huang and Schulte (1985).

Determination of the Seed Meals' Detergent Fibre Content

The neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined as described by Van Soest et al. (1991). In determining NDF, about 0.5 g of the seed meal was refluxed for 1 hour in 100ml of a neutral detergent solution of sodium lauryl sulphate and ethylenediamine-tetra-acetic to which alpha-amylase (20 350 IU ml⁻¹;

Sigma-Aldrich, St Louis, USA) was added. The mixture was then filtered after refluxing for one hour, then dried and weighed. The ADF was determined by refluxing 0.5 g of the sample for 1 hour in acid detergent solution (20 g acetyltrimethyl ammonium bromide dissolved in 1L normal H₂SO₄). The resulting mixture was then filtered and the residue dried and weighed.

Determination of the Meals' Amino Acid Content

The procedures described by Einarsson et al. (1983) were used in determining the amino acid concentration of each seed meal. In summary, a sample of each seed meal sample was hydrolysed with 6 M HCl at 110 °C for 24 hours. Thereafter pre-column fluorescence derivatisation of amino acids was done by reacting them with 9-flourenylmethyl chloroformate following which the amino acids were extracted using pentane and separated by gradient elution on a chromatograph. A SpectraSystem P4000 Quaternary high-performance liquid chromatography (HPLC) equipped with a SpectraSystem FL 3000 fluorescence detector and Rheodyne 7125 valve with 20 µL injection pump made up the chromatograph. The buffer system which varied from sodium citrate buffer (pH 2.95) of acetonitrile in the ratio of 70:30 to sodium citrate buffer (pH 4.5) of methanol-acetonitrile in the ratio of 14: 6: 70 was used to separate the amino acids. The buffer system was delivered at a flow rate of 1.4 mL min⁻¹. An OmniSper 5 C18 150 × 4.6 analytical column and guard-column were used in the separation of the amino acids. The identification of the amino acids in the chromatogram was done at an excitation wavelength of 264 nm and an emission wavelength of 340 nm (Einarsson et al., 1983). A personal computer with a TSP software was used to perform the quantification.

Determination of the Meals' Fatty Acid Content

The solvent extraction method using a Soxhlet apparatus was used for fat extraction. The methylation of the lipid to produce methyl esters and the subsequent profiling and quantification of individual fatty acids was done as described by Christopherson and Glass (1969).

Data Analysis

Data are presented as mean, \pm SD. Data analysis was done using GraphPad Prism version 6 (GraphPad Software, San Diego, California, USA). Means were computed and compared using a t-test. Significance was set at 5%.

RESULTS

The proximate (DM, CP, EE, CF and ash), NDF, ADF, Ca and P as well as the GE of the seed meals are shown in *Table 1*. The DM, CP, EE, ash, P and

gross energy ($92.71\pm 0.08\%$ vs 89.48 ± 0.08 , $47.89\pm 0.03\%$ vs $21.75\pm 0.09\%$, $11.39\pm 0.16\%$ vs $4.71\pm 0.41\%$, $6.17\pm 0.07\%$ vs $3.45\pm 0.03\%$, $1.01\pm 0.03\%$ vs $0.41\pm 0.01\%$ and 23.13 ± 0.05 MJ/kg DM vs 20.46 ± 0.04 MJ/kg DM, respectively) content of the DSSM were significantly higher ($P<0.05$) than those of the HSSM. The CF ($6.81\pm 0.08\%$ vs $4.30\pm 0.29\%$), NDF ($20.26\pm 0.30\%$ vs $8.05\pm 0.12\%$), ADF (10.71 ± 0.12 vs $2.70\pm 0.05\%$) and Ca ($0.44\pm 0.01\%$ vs $0.26\pm 0.01\%$) content of the HSSM was significantly higher ($P<0.05$) compared to that of the DSSM.

Table 1: Proximate, neutral and acid detergent fibre, calcium and phosphorus and gross energy content of unhulled and dehulled *S. siamea* seed meal

Constituent	Unhulled seed meal	Dehulled seed meal	Sig. level
Proximate (% DM)			
Dry matter (DM)	89.48 ± 0.09^a	92.71 ± 0.08^b	*
Crude protein (CP)	21.75 ± 0.09^a	47.89 ± 0.03^b	**
Ether extract (EE)	4.71 ± 0.41^a	11.39 ± 0.16^b	**
Crude fibre (CF)	6.81 ± 0.08^b	4.30 ± 0.29^a	*
Ash	3.45 ± 0.03^a	6.17 ± 0.07^b	*
Detergent fibre (% DM)			
Neutral detergent fibre	20.26 ± 0.30^b	8.05 ± 0.12^a	**
Acid detergent fibre	10.71 ± 0.12^b	2.70 ± 0.05^a	**
Minerals (% DM)			
Calcium	0.44 ± 0.01^b	0.26 ± 0.01^a	*
Phosphorus	0.41 ± 0.01^a	1.01 ± 0.03^b	**
Energy (MJ/kg DM)			
Gross energy	20.46 ± 0.04^a	23.13 ± 0.05^b	*

^{a,b}Means with different superscripts are significantly different at $P<0.05$; * $P<0.05$; ** $P<0.01$; Data presented as Mean \pm SD; $n = 3$.

Table 2 shows the amino acid content of the meals. Essential and non-essential amino acid concentration was higher ($P<0.05$) in the DSSM. The TSFAs ($27.88\pm 1.36\%$ vs $27.53\pm 0.59\%$) and TPUFAs ($50.42\pm 5.18\%$ vs $53.42\pm 2.12\%$)

proportion of the HSSM and DSSM, respectively were similar, HSSM ($21.69\pm 0.18\%$) had a significantly higher proportion of TMUFAs than DSSM ($19.03\pm 0.21\%$).

Table 2: Amino acid content of unhulled and dehulled *S. siamea* seed meal

Amino acid (g/100g DM)	Unhulled seed meal	Dehulled seed meal	Sig level
Alanine	1.53 ± 0.01^a	1.53 ± 0.01^a	ns
Arginine	2.22 ± 0.02^a	4.89 ± 0.07^b	*
Aspartic acid	1.50 ± 0.00^a	3.00 ± 0.04^b	*
Glutamic acid	4.45 ± 0.10^a	9.55 ± 0.09^b	**
Glycine	0.91 ± 0.02^a	1.86 ± 0.02^b	**
Histidine	0.54 ± 0.07^a	0.86 ± 0.15^b	*
Hydroxyproline	0.07 ± 0.02^b	0.04 ± 0.02^a	*
Isoleucine	0.69 ± 0.00^a	1.46 ± 0.02^b	**

Amino acid (g/100g DM)	Unhulled seed meal	Dehulled seed meal	Sig level
Leucine	1.21±0.00 ^a	2.58±0.03 ^b	*
Lysine	1.40±0.02 ^a	2.94±0.09 ^b	**
Phenylalanine	0.80±0.02 ^a	1.69±0.01 ^b	**
Proline	0.69±0.02 ^a	1.42±0.02 ^b	**
Serine	0.82±0.02 ^a	1.65±0.03 ^b	**
Threonine	0.59±0.02 ^a	1.19±0.02 ^b	**
Tyrosine	0.57±0.02 ^a	1.13±0.01 ^b	*
Valine	0.80±0.02 ^a	1.60±0.03 ^b	**
Total	18.18	37.83	

^{a,b}Means with different superscripts are significantly different at $P < 0.05$; * $P < 0.05$, ns – not significantly different, ** $P < 0.01$; Data presented as Mean±SD; $n = 3$.

Table 3 shows the fatty acid content of the meals. DSSM had a higher concentration of the fatty acids per unit mass by virtue of it having more than double EE content of the HSSM. In HSSM and DSSM the dominant saturated, monounsaturated and polyunsaturated fatty acids were palmitic (19.18±0.44% vs 18.63±0.37%), oleic (21.15±0.09% vs 18.45±0.01%) and linoleic acid (43.35 vs 50.62%), respectively.

Table 3: Fatty acid profile of unhulled and dehulled *S. siamea* seed meal

Fatty acid (%)	Unhulled seed meal	Dehulled seed meal	Sig. level
<i>Saturated fatty acid</i>			
C 12:0 (lauric acid)	0.02 ± 0.01 ^a	0.01 ± 0.01 ^a	ns
C 14:0 (myristic acid)	0.07 ± 0.02 ^a	0.07 ± 0.02 ^a	ns
C 15:0 (pentadecanoic acid)	0.04 ± 0.01 ^a	0.13 ± 0.04 ^b	**
C 16:0 (palmitic acid)	19.18 ± 0.44 ^a	18.63 ± 0.37 ^a	ns
C 17:0 (margaric acid)	0.13 ± 0.01 ^a	0.14 ± 0.01 ^a	ns
C 18:0 (stearic acid)	6.35 ± 0.68 ^a	6.77 ± 0.03 ^a	ns
C 20:0 (arachidic acid)	1.07 ± 0.15 ^a	1.13 ± 0.03 ^a	ns
C 21:0 (heneicosanoic acid)	0.06 ± 0.01 ^a	0.07 ± 0.01 ^a	ns
C 24:0 (lignoceric acid)	0.96 ± 0.04 ^b	0.58 ± 0.11 ^a	**
TSFAs	27.88 ± 1.36 ^a	27.53 ± 0.59 ^a	ns
<i>Monounsaturated fatty acid</i>			
C 15:1 (pentadecenoic acid)	nd	0.05 ± 0.02	
C 16:1 (palmitoleic acid)	0.21 ± 0.02 ^a	0.17 ± 0.01 ^a	ns
C 17:1 (heptadecenoic acid)	0.06 ± 0.01 ^a	0.05 ± 0.01 ^a	ns
C 18:1n9c (oleic acid)	21.15 ± 0.09 ^b	18.45 ± 0.10 ^a	**
C 18:1n9t (elaidic acid)	nd	0.04 ± 0.01	
C 20:1 (11-eicosenoic acid)	0.22 ± 0.04 ^a	0.21 ± 0.02 ^a	ns
C 22:1n9 (erucic acid)	0.03 ± 0.02 ^a	0.05 ± 0.04 ^a	ns
TMUFAs	21.69 ± 0.18 ^b	19.03 ± 0.21 ^a	*
<i>Polyunsaturated fatty acid</i>			
C 18:2n6c (linoleic acid)	48.24 ± 4.92 ^a	50.98 ± 2.01 ^a	ns
C 18:2n6t (linolelaidic acid)	0.04 ± 0.01 ^a	0.05 ± 0.01 ^a	ns
C 18:3n3 (α-linolenic acid)	0.60 ± 0.07 ^a	0.62 ± 0.02 ^a	ns
C 18:3n6 (γ-linolenic acid)	0.02 ± 0.01 ^a	0.04 ± 0.02 ^a	ns
C 20:2 (eicosadienoic acid)	0.04 ± 0.01 ^a	0.05 ± 0.01 ^a	ns
C20:5n3 (eicosapentaenoic acid)	1.32 ± 0.14 ^a	1.49 ± 0.02 ^a	ns
C 22:2 (docosadienoic acid)	0.16 ± 0.02 ^a	0.19 ± 0.03 ^a	ns

Fatty acid (%)	Unhulled seed meal	Dehulled seed meal	Sig. level
TPUFAs	50.42 ± 5.18 ^a	53.42 ± 2.12 ^a	ns
Trans FA	0.04 ± 0.02 ^a	0.04 ± 0.01 ^a	ns
Cis fats	69.52 ± 7.07 ^a	69.25 ± 0.91 ^a	ns
Omega-3 fats	1.95 ± 0.22 ^a	2.09 ± 0.01 ^a	ns
Omega-6 fats	48.41 ± 4.94 ^a	50.70 ± 1.03 ^a	ns
Omega-9 fats	21.20 ± 2.18 ^a	18.69 ± 0.01 ^a	ns
EPA (eicosapentaenoic acid)	1.32 ± 0.15 ^a	1.49 ± 0.02 ^a	ns
TPUFAs: TSFAs	1.80:1	1.93:1	
n3PUFA: n6PUTA	0.04:1	0.04:1	

^{a,b}Within row means with different superscripts are significantly different at $P < 0.05$, $**P < 0.01$; ns – not significantly different; nd – not detected; EPA – Eicosapentaenoic acid, TSFAs - Total saturated fatty acids, TMUFAs - Total monounsaturated fatty acids, TPUFAs - Total polyunsaturated fatty acids, $n = 3$; Data presented as mean ± SD.

DISCUSSION

We sought to characterise the proximate (DM, CF, CP, EE and ash), gross energy, calcium and phosphorus, NDF and ADF, amino acid and fatty acid content of the *S. siamea* seed provenance from Zimbabwe and evaluate its potential as a source of nutrients in livestock and poultry feeds. We determined the chemical nutrient content of unhulled (HSSM) and dehulled (DSSM) *S. siamea* seed meal. The CP and GE content of the meals ranged from 21.75±0.09% to 47.89±0.03% and 20.46±0.04 MJ/kg DM and 23.13±0.05 MJ/kg DM for the HSSM and DSSM, respectively. The DSSM had about more than twice the EE content of the HSSM. Both meals' fatty acid profiles were dominated by TPUFAs and TSFAs making up about 50% and 28% of the seed meals' oil/lipid content, respectively. Oleic and linoleic are the dominant fatty acids in the seed meals.

The determination of the proximate and amino acid composition are critical in the evaluation of the nutritional quality of potential feed resources. In intensive livestock and poultry production, maize meal and soybean meal (SBM) are the major dietary energy and protein sources, respectively, in feeds. Yellow maize, one of the global cereal grains largely used in livestock and poultry feeds, typically contains 8-10% protein, 4%-5% oil/fat, 1.4% ash, 71.7% starch (Watson, 2003; Prasanthi et al., 2017) and about 17.5 to 18 MJ/kg DM gross energy (Bhuiyan et al., 2010). Hexane-extracted SBM's CP content is about 44% though it can range from 44% to 49% (Banaszkiewicz, 2011) depending on cultivar. Sunflower seed meal

(SFSM) which contains 28%-34% CP when partially dehulled and about 41% CP when fully dehulled and canola seed meal (CSM) with about 40% CP (Lardy and Anderson, 2002) constitute other major plant-derived dietary sources for feeds. We report a CP content of 21.75% and 47.89% and GE content of 20.46 MJ/kg DM and 23.13 MJ/kg DM in the hulled and dehulled *S. siamea* seed meals, respectively. While the CP of the hulled *S. siamea* seed meal is lower than that of SFSM, CSM and SBM, it is adequate to meet the nutritional requirements of ruminants. Thus hulled *S. siamea* seed meal can be a potential protein source in ruminant animal feeds.

The comparatively higher fibre (CF, NDF and ADF) could be of great value to ruminant nutrition as the fibre can be fermented by rumen resident microbes to generate the volatile fatty acids (VFAs) acetic, butyric, propionic, iso-valeric and valeric acid. On metabolism, the VFAs generate energy which ruminants can utilise thus less cereal grain would be required in the ruminant feeds especially where pen fattening is practised. Additionally, the higher CF, NDF and ADF besides being a source of energy, also can provide dietary fibre necessary for gastrointestinal health. Our findings show that the dehulling of the *S. siamea* seed resulted in more than a 100% increase in CP to 47.89% which is higher than the mean CP content of SBM and CSM. This is of significance as it shows that dehulled *S. siamea* seed meal has a greater protein and indeed amino acid concentration per unit mass than the conventionally used SBM and CSM. It, therefore, means less *S. siamea* seed meal would be required in livestock and poultry feeds which translates to

reduced feed cost since the protein component of feeds is the most expensive component (Iji et al., 2017). Our findings show that dehulling *S. siamea* seed substantially increased the seed's nutrient density, especially CP, both non-essential and essential amino acids, P and GE which were masked by the fibre fraction in its seed hull. Monogastric animals and poultry species, especially broiler chicken are poor utilisers of fibrous feeds. Thus, due to its lower fibre content, dehulled *S. siamea* seed meal could be an ideal dietary protein source in monogastric livestock and poultry feeds.

Both the hulled (HSSM) and dehulled (DSSM) *S. siamea* seed meal had GE content higher than that of maize. Maize, a major dietary energy source in feeds, constitutes about 65%-70% of monogastric livestock and poultry feeds (Panda et al., 2014). Due to their high mean GE energy values, both HSSM and DSSM can provide a substantial portion of the energy component of livestock and poultry feeds. Therefore, their use as feed ingredients could potentially reduce the maize component (energy source) in the feeds that might translate into cheaper feeds and reduced competition for maize between humans and the livestock and poultry feed industry. Compared to maize which has a fat content of 4% to 5% (Watson, 2003), the hulled and dehulled *S. siamea* seed meals had 6% and 11% fat, respectively. Fat has a high energy density compared to carbohydrates. We thus contend that the higher GE content of the *S. siamea* seed meals compared to that of maize meal could be due to the former's higher fat content.

It has been demonstrated that dietary and ingredient fatty acid profile is closely mirrored in the livestock and poultry (meat, eggs and milk) products lipid profile (Butler et al., 2019). In our findings, we report the *S. siamea* seed meals oil to have a preponderance of oleic (18.45% to 21.15%) and linoleic acid (43.35% to 50.62%). We, therefore, contend that the use of *S. siamea* seed meals as feed ingredients livestock and poultry feeds can mediate the production of eggs and meat with higher concentrations of oleic acid (OA) and linoleic acid (LA). Oleic acid (OA), a monounsaturated fatty acid, exhibits hypocholesterolaemic activity (Haim et al., 2012) and antioxidant activity (Wei et al., 2016). It also has high oxidative stability (Ali et al.,

2016). Linoleic acid (LA), is an essential fatty acid, has with health beneficial activities and necessary for normal prenatal and early postnatal development of the human brain (Harris and Baack; 2015; Taha, 2020). Thus, the use of *S. siamea* seed meals as feed ingredients could result in the fortification and production of livestock and poultry products of a higher nutritional status with a longer shelf life.

CONCLUSION

The Zimbabwean *S. siamea* provenance seed meals can potentially be exploited as oleic- and linoleic acid-rich dietary energy and protein sources in livestock and poultry feeds. Importantly, they can potentially be used to improve the nutrient status, especially the OA and LA acid content, of eggs and meat.

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