Comparative Nutritional Profiling of Leucaena leucocephala (Wondergraze and Taramba varieties) for Enhanced Animal Feed Applications

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***Abstract*.**

Leucaena leucocephala belongs to the family Leguminosae and is one of the fastest-growing leguminous trees. L. leucocephala leaves have a great potential as an alternative protein source for animal feed. However, the presence of anti-nutritional compounds, such as mimosine and tannins, limits their direct utilisation by animals, as these compounds can reduce nutrient digestibility and impair animal performance. Ensiling has been widely recognised as an effective processing method to reduce these compounds. This study evaluated the proximate composition, fibre fractions, mineral composition, and anti-nutritional compounds of unensiled (fresh) and ensiled L. leucocephala leaves from Wondergraze and Taramba varieties to assess their potential as animal feed resources. Overall, the ensiling process significantly influenced the nutritional profiles of L. leucocephala leaves in both Wondergraze and Tarramba varieties. Ensiling enhanced crude protein content while reducing crude fibre, NDF and moisture levels, indicating improved digestibility and feed intake potential. Although slight reductions in ash content, gross energy and certain minerals were observed, most nutrients were largely retained, suggesting that fermentation did not compromise the overall nutritional value of the forage. Varietal differences were evident, with Wondergraze demonstrating better fibre preservation and smaller energy losses compared to Tarramba, highlighting its potentially superior fermentation efficiency. Importantly, ensiling markedly reduced anti-nutritional compounds, particularly mimosine and tannins, thereby improving feed safety and suitability. These findings demonstrate that ensiling is an effective processing method to enhance the nutritional quality and practical utilisation of L. leucocephala leaves as animal feeds, while also revealing cultivar-specific responses that are valuable for targeted feed formulation and forage management strategies.

Keywords: *Leucaena leucocephala; Wondergraze; Taramba; nutritional profiles and animal feeds.*

I. INTRODUCTION

Leucaena leucocephala, commonly known as Petai Belalang, is the most economically important species within the genus Leucaena. It belongs to the tribe Mimoseae of the subfamily Mimosoideae under the family Leguminosae (Fabaceae). This species is an arboreal, long-lived perennial legume tree and is recognized as one of the fastest-growing species in arid and semi-arid regions. Owing to its rapid growth and adaptability, L. leucocephala is widely cultivated in Malaysia as a lead (shade) tree (Wan-Mohd-Nazri et al., 2020). The use of this tropical legume in ruminant nutrition has been widely implemented due to its high content of crude protein (Montoya et.al., 2020). Nevertheless, the utilization of this legume as animal feed is not popular in Malaysia. Among the commonly cultivated varieties, Wondergraze exhibits a more upright growth form, finer stems, and a higher leaf-to-stem ratio, making it particularly suitable for intensive grazing systems (Charmley et al, 2023). In contrast, Taramba is characterized by a bushier growth habit, broader leaflets, and greater tolerance to psyllid infestation (Nulik et al., 2013). Both varieties demonstrate considerable potential as livestock forage due to their high nutritional value and adaptability to diverse environments.

The leaves of L. leucocephala contain approximately 23.3% crude protein, 11.4% ash, 2,573.8 kcal/kg metabolizable energy, 0.38% calcium, 2.9% phosphorus, and 1.6% tannins (Thamaga & Mokoboki, 2021). However, the species also contains anti-nutritional compounds, particularly the non-protein amino acid mimosine and tannins, which can cause toxicity and adverse health effects if consumed in large amounts over prolonged periods (Hardiansyah et al., 2017). Silage has been shown to reduce mimosine and tannin contents to below 1% (Fayemi et al., 2021). Several studies have highlighted the potential of L. leucocephala leaves as an unconventional feed resource; however, to date, the comparison between their nutritional profiling from two Malaysia varieties, Wondergraze and Taramba have yet to be reported. Therefore, this study aims to evaluate and compare the nutritional profiles of both unensiled (fresh) and ensiled leaves of the L. leucocephala (Wondergraze and Tarramba varieties), providing insights into the effects of fermentation on their nutritional value and suitability for animal feed applications.

II. METHODS

2.1 Raw Materials

The leaves of two *L. leucocephala* varieties, Wondergraze and Taramba, were harvested from trees growing at Unit Ladang, Universiti Teknologi MARA (UiTM) Cawangan Pahang, Kampus Jengka, Pahang, Malaysia. A voucher specimen was deposited at the Herbarium of UiTM Cawangan Pahang, Kampus Jengka.

2.2 Sample Preparation

The fresh *L. leucocephala* leaves (Wondergraze and Taramba varieties) were subjected to two treatments: unensiled (fresh) and ensiled. For the ensiled treatment, the leaves were stored in an airtight container for four weeks. Both samples were then oven-dried at 60 °C for two days. The dried leaves were ground using a grinder mill to obtain an average particle size of 0.5 mm and stored in airtight containers.

2.3 Determination of Proximate Composition

Determination of nutritional composition (moisture content, crude protein, fat, ash, carbohydrate, and energy) of the unensiled and ensiled *L. leucocephala* leaves (Wondergraze and Taramba varieties) was conducted according to the AOAC method (2023).

2.4 Determination of Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) Content

The Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) digestibility of the unensiled and ensiled *L. leucocephala* leaves (Wondergraze and Taramba varieties) were determined according to the method of Mokoboki et al. (2019).

2.5 Determination of Mineral Content

The mineral content (calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu)) in the unensiled and ensiled *L. leucocephala* leaves (Wondergraze and Taramba varieties) was determined using an Inductively Coupled Plasma (ICP) Spectrometer (Agilent 5800).

2.6 Determination of Tannin Content

The determination of tannin content in *L. leucocephala* leaves (Wondergraze and Taramba) was conducted using spectrophotometric method according to Oyun (2006). The tannin concentration was determined from a standard curve and expressed as tannic acid equivalent on a dry matter basis (mg TAE/g DW).

2.7 Quantification of Mimosine

The quantification of mimosine in the unensiled and ensiled *L. leucocephala* leaves (Wondergraze and Taramba varieties) was conducted according to Honda and Borthakur (2019) using High-Performance Liquid Chromatography. The mimosine content was expressed as percentage (%).

III. RESULT AND DISCUSSION

This study evaluated and compared the nutritional profiles of unensiled and ensiled *L. leucocephala* leaves. Table 1 presents the nutritional profiling including proximate composition, fibre fraction, mineral composition and anti-nutritional compound content of unensiled and ensiled leaves of *L. leucocephala*

(Wondergraze and Taramba varieties). Based on the table, moisture content ranged from 3.82% DM to 7.60% DM, which these values are within WHO guidelines of <10% for optimal feed storage (FAO/WHO, 1991). Ensiling reduced moisture content in both varieties, with unensiled Wondergraze and Taramba leaves recording 7.60% DM and 6.20% DM, respectively. The ensiling process creates anaerobic conditions that limit air exposure, promote fermentation, and improve feed preservation (Wang et al., 2025). Well-produced silage is more suitable for animal feed than high moisture unensiled leaves (Kung et al., 2018).

Table 1. Nutritional Profiling of Unensiled and Ensiled Leaves of *L.leucocephala* (Wondergraze and Taramba Varieties)

Composition	Var. Wondergraze		Var. Taramba	
	Unensiled	Ensiled	Unensiled	Ensiled
Proximate Composition:				
Moisture (% DM)	7.62 ± 0.070	3.82 ± 0.042	6.20 ± 0.028	5.14 ± 0.028
Protein (% DM)	19.66 ± 0.007	22.93 ± 0.028	22.01 ± 0.014	23.16 ± 0.014
Ash (% DM)	8.39 ± 0.021	7.53 ± 0.035	7.56 ± 0.035	6.44 ± 0.028
Crude fibre (% DM)	5.74 ± 0.063	4.71 ± 0.021	3.23 ± 0.028	2.39 ± 0.021
Fat (% DM)	1.78 ± 0.021	0.99 ± 0.028	1.50 ± 0.014	0.51 ± 0.035
Carbohydrate (% DM)	62.57 ± 0.120	64.73 ± 0.014	62.74 ± 0.028	64.76 ± 0.021
Gross Energy (MJ/kg)	21.17 ± 0.021	20.74 ± 0.021	21.31 ± 0.028	20.24 ± 0.035
Fibre Fraction:				
NDF (% DM)	32.93 ± 0.035	29.73 ± 0.035	36.00 ± 0.021	28.33 ± 0.028
ADF (% DM)	39.81 ± 0.028	40.03 ± 0.021	37.23 ± 0.014	41.18 ± 0.035
Mineral Composition:				
Calcium (Ca) (mg/Kg)	1.87 ± 0.026	1.24 ± 0.035	1.72 ± 0.025	1.49 ± 0.036
Copper (Cu) (mg/Kg)	3.40 ± 0.015	3.50 ± 0.025	4.27 ± 0.020	3.70 ± 0.030
Iron (Fe) (mg/Kg)	24.6 ± 0.026	21.7 ± 0.152	36.73 ± 0.015	34.33 ± 0.028
Potassium (K) (mg/Kg)	3658.17 ± 0.020	3608.93 ± 0.026	4218.73 ± 0.025	4172.03 ± 0.015
Manganese (Mn) (mg/Kg)	27.33 ± 0.015	24.73 ± 0.025	33.37 ± 0.025	30.37 ± 0.020
Sodium (Na) (mg/Kg)	640.93 ± 0.015	628.20 ± 0.026	625.37 ± 0.02	610.10 ± 0.015
Anti-nutritional Compound:				
Mimosine (%)	5.00 ± 0.041	0.85 ± 0023	5.50 ± 0.002	0.60 ± 0.003
Tannin (mg TAE/g DW)	22.71 ± 0.021	20.12 ± 0.028	29.47 ± 0.035	25.21 ± 0.035

Crude protein content increased following ensiling, particularly in Wondergraze (from 19.66% DM to 22.93% DM), while Taramba exhibited a smaller increase (from 22.00% DM to 23.16% DM). This enhancement is attributed to microbial synthesis and fermentation, which degrade complex proteins into more soluble, digestible forms (Jiang et al., 2021). The beneficial microorganisms degrade complex protein structures into more soluble and digestible forms, thereby improving protein availability for ruminant animals. Ash content declined after ensiling, from 8.39% DM to 7.53% DM in Wondergraze and 7.56% DM to 6.44% DM in Taramba. This reduction in ash content suggests possible mineral losses during the ensiling process, likely due to the leaching of soluble minerals and microbial activity during fermentation. Nevertheless, despite the reduction in total mineral content, ensiling may enhance mineral bioavailability and overall nutritional digestibility (Knez et al., 2023). Crude fibre content decreased in both varieties, from 5.74% DM to 4.71% DM in Wondergraze and 3.23% DM to 2.39% DM in Taramba. This reduction in fibre content is consistent with findings reported in the literature, which indicate that anaerobic fermentation enhances microbial activity and alters the structural composition of plant materials.

Lactic acid bacteria and other fermentative microorganisms degrade structural carbohydrates such as cellulose and hemicellulose, leading to partial fibre breakdown (Li et al., 2022), thus improving forage digestibility and animal intake (Kung et al., 2018). Fat content also decreased in both varieties, from 1.78% DM to 0.99% DM in Wondergraze and 1.50% DM to 0.50% DM in Taramba. This reduction in lipid content may be attributed to several factors, including microbial degradation of lipids during fermentation (Shahidi & Oh, 2020), oxidation of unsaturated fatty acids (Wang et al., 2022), and the production of organic acids during fermentation, which can promote lipid hydrolysis (Zhao et al., 2025).Carbohydrate content increased slightly following ensiling, from 62.57% DM to 64.73% DM in Wondergraze and 62.74% DM to 64.76% DM in Taramba. This increase suggests that certain carbohydrate fractions, particularly soluble sugars and non-structural polysaccharides, were either preserved or became relatively concentrated during fermentation. Studies on Napier grass silage have reported that ensiling can reduce lignocellulosic (structural) carbohydrate fractions while altering non-structural carbohydrate composition, thereby influencing the retention of sugars and overall carbohydrate content in the silage (Desta et al., 2016). Energy analysis is essential for evaluating the nutritional value of forages, as it provides a measure of the total energy content of feed materials.

Gross energy (GE) decreased slightly after ensiling, from 21.17 MJ/kg to 20.74 MJ/kg in Wondergraze and 21.31MJ/kg to 20.24MJ/kg in Taramba. The relative decrease was greater in Taramba (≈5.02%) than in Wondergraze (≈2.03%). Fermentation alters chemical composition and can lead to energy losses relative to the initial forage values (Sakhawat, 2011). Such decreases are minor and indicate that most of the original energy is retained, meaning the ensiled still provides sufficient energy to support maintenance, growth, and production in animals. Various strategies have been explored to enhance the energy availability and overall nutritional value of *L. leucocephala*, including reducing anti-nutritional factors, improving digestibility through microbial breakdown of mimosine, applying feed processing techniques, and supplementing with other forages (Angelis et al., 2021). Studies on the gross energy of *L. leucocephala* highlight its potential as a high-energy feed source while emphasising the importance of proper management and processing to maximise its utilisation in animal feeding programs (Khamseekhiew et al., 2022).Fibre fraction analysis revealed a reduction in NDF, from 32.93% DM to 29.73% DM in Wondergraze and 36.00% DM to 28.33% DM in Taramba, indicating partial degradation of hemicellulose and other fermentable cell wall components during fermentation. This reduction in NDF is nutritionally beneficial, as lower NDF levels are associated with improved voluntary feed intake and enhanced rumen microbial activity.

Reports from Zhao et al. (2025) confirm this observation, which ensilation lowers NDF content in tropical forages, hence improving digestibility by fragmenting indigestible fibre fractions. In contrast, ADF content increased in both varieties after ensiling, suggesting a relative concentration of more recalcitrant fibre fractions such as cellulose and lignin as soluble carbohydrates and hemicellulose were preferentially utilised during fermentation. ADF increased slightly, from 39.81% DM to 40.03% DM in Wondergraze and from 37.23% DM to 41.18% DM in Taramba. The comparatively smaller increase in ADF observed in Wondergraze suggests better preservation of digestible fibre, which may contribute to improved digestibility and energy utilisation relative to Taramba. Overall, the observed changes in fibre composition following ensiling indicate enhanced feed intake potential while highlighting varietal differences in fibre degradation and fermentation efficiency that influence the nutritional suitability of *L. leucocephala* silage for animal feeding. Ensiling also affected mineral composition. Calcium showed the greatest reduction, particularly in Wondergraze, decreasing by 33.7% (from 1.87 to 1.24 mg/kg), while Taramba exhibited a smaller decline of 13.4% (from 1.72 to 1.49 mg/kg). Copper levels remained relatively stable in Wondergraze but declined by 13.4% in Taramba. Iron content also decreased after ensiling, with reductions of 11.8% in Wondergraze and 6.5% in Taramba. Potassium was largely retained in both varieties, showing only minimal reductions, while manganese and sodium also decreased slightly.

Similar reductions in calcium and iron content following ensiling of Leucaena leaves have been reported by Raju et al. (2025).Two anti-nutritional compounds were substantially reduced. Mimosine content decreased from 5.00% to 0.85% in Wondergraze and from 5.50% to 0.60% in Taramba. Similar reductions in mimosine have been reported using other processing methods, such as drying and soaking, which decreased mimosine from 4.35% to 0.22% (Chanchay & Poosaran, 2009). Tannin levels also declined slightly, from 22.71 to 20.12 mg TAE/g DW in Wondergraze and 29.47 to 25.21 mg TAE/g DW in Taramba. Overall, the marked reduction in mimosine and tannin indicates that ensiling effectively lowers this anti-nutritional compound to safer levels further support the suitability of ensiled *L. leucocephala* leaves for animal feed applications.

IV. CONCLUSION

Ensiling markedly improves the nutritional quality and safety of L. leucocephala leaves while preserving most of their energy content. The process enhances crude protein, reduces crude fibre and NDF, and lowers anti-nutritional compounds, mimosine and tannins, making the silage more digestible and safer for animal consumption. Although some mineral losses occur, ensiling does not compromise the overall nutritional value. Between the two varieties, Wondergraze demonstrated better preservation of digestible fibre and a smaller reduction in energy, suggesting its superior suitability for silage-based animal feeding programs. Overall, ensiling represents an effective strategy to convert L. leucocephala leaves into a high-quality, safe, and energy-rich feed for livestock.

V. ACKNOWLEDGMENTS

The authors would like to express their gratitude for the generous support from Universiti Teknologi MARA (UiTM) Cawangan Pahang, Kampus Jengka, Malaysia. The Ministry of Higher Education (MoHE), Malaysia, provided financial support for the research (FRGS/1/2021/WAB04/UITM/02/3).

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