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Original Research Article

Yield, nutrient content and rumen *in vitro* digestibility of giant sensitive tree (*Mimosa pigra*) as dairy feed

Suntorn Wittayakun, Wera Innaree, Pat Pranamornkith
Rajamangala University of Technology Lanna, Lampang Campus, Lampang 52000, Thailand

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Abstract

The objective of this study was to evaluate quantity and quality of *Mimosa pigra* as dairy feed. Parts of *Mimosa pigra* including leaf, leaf with rachis, and seed pods were determined for yield, nutritive value, and *in vitro* digestibility using rumen fluid form a dairy bull. The overall percentage of feed parts including leaf, leaf with rachis, and seed pods accounted for 43.97 % fresh weight of the whole plant. The crude protein (CP) of *Mimosa pigra* was similar among plant parts ranged from 16.36 to 18.87% while seed pods was relatively high in ADF (P<0.05).
It was also observed that *in vitro* true digestibility and *in vitro* digestibility coefficients in leaf and leaf with rachis were higher than those in the seed pods (P<0.05). This study demonstrates that *Mimosa pigra*, especially leaf and leaf with rachis has potential to use for substitution or supplement in dairy ration.

Keywords: *Mimosa Pigra*, Giant Sensitive Tree, Nutritive Value, Digestibility, Dairy Cattle

Introduction

A variety of good feeding programs is important to provide appropriate nutrient balance to achieve nutrient requirement for maintenance, growth and production of dairy cattle, and should be interchanged in the ration by substitution with various local feed ingredients at the lowest cost in determining farm success. *Mimosa pigra* or giant sensitive tree is a leguminous shrub. It has originated from tropical America and presently known as an invasive woody weed (Lonsdale et al., 1995). It becomes a widespread and serious weed throughout the tropical regions especially in wet and moist areas such as river banks, flood plains, abandon paddy fields (Marambee et al., 2004). *Mimosa pigra* is a seed propagation plant and grow well in tropical climates due to its efficient nitrogen fixation by nodule bacteria (Lonsdale et al., 1995; Chen et al., 2005; Barrett and Parker, 2006; Willems et al., 2014). Benefits of *Mimosa pigra* as a feed source have been reported with relation to its high crude protein content in leaf which demonstrated positive responses in swine, rabbit, and goat (Vearasilp et al., 1981; Nakkitset et al., 2008; Natewichai et al., 2011; Kaewwongsa, 2014). However, there is no information available on mass yield and nutritive value of other prospective parts of *Mimosa pigra* such as rachis and seed pods, which may be yielded as the potential feed ingredients.
The objective of this study was to determine quantity and quality of *Mimosa pigra* leaf, leaf with rachis, and seed pods and also *in vitro* digestibility using rumen fluid form dairy cattle. The outcome of this study may lead to an increasing in the use of *Mimosa pigra* as dairy feed and control its invasion.

Materials and Methods

Sampling area and sample collection

The sampling area was in Lampang province (N18°17'32.35", E 99°29'33.97"), northern Thailand. Lampang locates approximately 599 km north of Bangkok and 92 km southeast of Chiang Mai in the valley of the Wang River that is bordered by the Khun Tan Range on the west and Pee Pan Nam Range on the east. Lampang has a relatively dry climate compared to nearby provinces. Rainy season usually runs from May until early November while winter typically follows in late November and lasts until early March. The lowest temperature is usually less than 10 degree Celsius during late December to early February. Summer typically runs from March until June. The highest temperature could reach more than 40 degrees Celsius in April. Total rainfall during the sampling period was approximately 216 mm, with an average temperature of 32 degrees Celsius and average humidity of 76 %.

The assessment of *Mimosa pigra* was randomly sampled at monthly intervals from May to September of 2016 using 1.0 square m^2 quadrat to target the sampling plant near Wang River bank or abandoned paddy fields where *Mimosa pigra* was invaded. At harvesting, plant height and leaf to stem ratio were measured, before cutting and dividing all samples into three parts: 1) leaf including leaflets with pinnae, 2) leaf with rachis and 3) seed pods. All samples were dried at 65 degrees Celsius in hot air oven overnight, followed by grinding for further chemical composition and *in vitro* digestibility analyses.

Chemical composition analysis

Samples were ground in a cutting mill (Hsiangtai Model CW-1, Taiwan) passing through a 1 mm sieve and analyzed in duplicated for dry matter (DM), crude protein (CP), ether extract (EE) and ash according to the procedures outlined by the AOAC (1984). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed by methods of Goering and Van Soest (1970). Organic matter (OM) was calculated as: 100 – Ash %.

In vitro digestibility determination

For digestibility determination, samples were ground through a cutting mill (Hsiangtai Model CW-1, Taiwan) with a 2 mm sieve. Then, *in vitro* digestibility was conducted for 48 h using the Daisy^{II} incubation system (Ankom Technology, New York, USA). Rumen fluid was obtained from a healthy dairy bull fed diets containing 100 % forage for maintenance allowance to meet NRC recommendation (NRC, 2001). Rumen fluid was taken using esophageal tube under mild vacuum (Oil rotary vacuum pump, Nakabo, Co. Ltd., Japan) from the reticulum near the reticulo-omasal orifice. Then, it was filtered through four layers of cheesecloth and transferred into pre-warmed digestion thermos flask and prepared for the next digestion step. The complete digestion set consisted of four digestion jars with a capacity 2 L each. Each jars contained 400 ml of rumen liquor, 1.33 L buffer A (KH_2PO_4, 10.0 g/L; $MgSO_47H_2O$, 0.5 g/L; NaCl, 0.5 g/L; $CaCl_22H_2O$, 0.1 g/L; urea, 0.5 g/L) and 266 ml of buffer B (Na_2CO_3, 15 g/L; Na_2S9H_2O, 1.0 g/L). The pH in mixture was adjusted to 6.8 and saturated with CO_2. Each sample was digested in triplicate in a nylon filter bag (ANKOM F57, Ankom Technology, New York, USA). After 48 h incubation, jars were removed from the chamber, the incubation solution mixture was discarded, and bags were rinsed with cold tap water 10 times, blotted to remove excess water, and placed in a hot-air oven at 65°C for 48 h. Once samples were dried, they were removed from the oven and weighed. Then, the dried samples were analyzed for dry matter (DM) (AOAC, 1984), neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Goering and Van Soest, 1970). The parameter *in vitro* true digestibility (IVTD) was calculated based on the following equation:

$$\text{IVTD (\%)} = \{(W_{BD} - \text{NDF residue})/W_{BD}\} \times 100$$

Where W_{BD} = dry matter weight of sample before incubation (Phesatcha and Wanapat, 2016). The *in vitro* dry matter digestibility coefficient (IVDMD) was calculated by the following equation:

$$\text{IVDMD (\%)} = [(W_{BD} - W_{AD})/W_{BD}] \times 100$$

Where W_{BD} = dry matter weight of sample before incubation and W_{AD} = dry matter weight of sample after incubation (Tufarelli et al., 2010).

Statistical analysis

Data on yields of potential feed parts including leaf, leaf with rachis or seed pods were estimated using multiple regression with model selections by stepwise method (SPSS, 2006), with stem, or/and rachis weight (g/plant) as independent variables. Data on nutrient content and degradability were analyzed for Analysis of Variance (ANOVA) using the One-way ANOVA procedure which treatment means were compared by Duncan's new multiple range test and significance was declared when P-value <0.05 (SPSS, 2006). The statistical model used was $Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$ where Y_{ij} = dependent variable, μ = overall mean, τ_i = effect of treatment (i=1,2,3), and ε_{ij} = random error (Steel and Torrie, 1980).

Results and Discussion

Plant morphological characteristics and yields

The data regarding to morphological characteristics and mass yield of *Mimosa pigra* are shown in Table 1. *Mimosa pigra*, an erect and much branched prickly shrub, averaged 216.17 cm in height and ranged from 143 to 298 cm**.** The stem and prickly vegetative branches consisted of 56.02 % of the mass plant fresh weight, which ranged from 64 to 831.92 g/plant. The leaf including leaflets with pinnae or leaf fodder of *Mimosa pigra* consisted of 22.52 % of the whole plant fresh weight while the main part was stem and branches, comprised of 56.02 % of the whole plant fresh weight. The leaf parts of *Mimosa pigra* are reported to be of good quality and can be utilized as a supplement in animal's ration (Nakkitset et al., 2008; Natewichai et al., 2011). Yields of potential parts such as leaf and leaf with rachis as dairy feed could be well estimated using multiple regressions with model selections by stepwise method stem using stem or/and rachis weight (g/plant) as independent variables (Table 1). However, seed pods could not be estimated using multiple regressions with stem, or/and rachis weight (g/plant) as independent variables (P>0.05). Leaf yield showed highly significant relationship to stem weight (P<0.01) for Equation [1] with correlation coefficient of 0.660 while leaf with rachis yield had highly significant relationship to stem weight for Equation [2] or stem weight and rachis weight for Equation [3] (P<0.01) with correlation coefficients of 0.720 and 0.758, respectively. However, it is worth to note that seed pods yields and plant height had no relationship to any independent parameters including stem weight, leaf weight, leaf with rachis weight or seed pod weight (P>0.05). For this reason, the predicted equation for seed pods yield was unable to estimate in this current study.

Nutrient content

Nutrient content of *Mimosa pigra* collected during the experimental period is shown in Table 2. Dry matter content of leaf, leaf with rachis, and seedpods were 40.14, 40.22 and 48.98 %, respectively (P>0.05). All the plant samples had similar organic matter (OM) content and ranged from 92.93 to 95.95% DM (P>0.05). However, OM content in this study was slightly higher than values of Nakkitset et al., (2008), who reported that OM content of *Mimosa pigra* ranged from 92.3 to 92.4 %. The crude protein (CP) content was similar among plant parts with leaf containing 18.87 % CP, leaf with rachis with 18.11% CP, and seed pod with 16.36% CP in dry matter basis (P>0.05). The CP content in the current study is in agreement with previous study (Nakkitset et al., 2008; Natewichai et al., 2011). According to Nakkitset et al., (2008) and Natewichai et al., (2011), the CP contents in mixed *Mimosa pigra* (leaves and stem included) ranged from 17.7 to 18.03 % in dry matter basis. Both leaf and leaf with rachis were higher in ether extract (EE) content than those in the seed pods (P<0.05) with 4.81 % EE in leaf, 5.30 % EE in leaf with rachis, and 0.77 % EE in seed pods. According to Nakkitset et al., (2008) and Natewichai et al., (2011), the EE content in mixed *Mimosa pigra* (leaves and stem included) was approximately 3.4%, lower than the present results. The NDF content was similar in leaf, leaf with rachis, and seedpod (P>0.05). The NDF content in this report was in agreement with Hong and Quac (2005) and Nakkitset et al., (2008), but higher than those reported by Natewichai et al., (2011). The ADF contents in leaf and leaf with rachis were lower than those in the seed pod (P<0.05). The ADF content in leaf and leaf with rachis was similar to those reported by Hong and Quac (2005), but higher than those reported by Nakkitset et al., (2008) and Natewichai et al., (2011). Ash contents in leaf and leaf with rachis were similar to those reported by Nakkitset et al., (2008), but lower than that of Natewichai et al., (2011). Overall nutritive value of *Mimosa pigra* is slightly lower than other legume tree such as *Leucaena* leaf (Phesatcha and Wanapat, 2016), but higher than those vegetable crop residues and fruit crop residues (Datt et al., 2008)

In vitro digestibility

In vitro true digestibility (IVTD) and *in vitro* digestibility coefficients are shown in Table 3. In this study, IVTD of leaf was higher than in IVTD in the seed pods (P<0.05). However, IVTD of leaf with rachis was similar to both leaf and seed pods (P>0.05). This may imply that seed pods are composed of more structural carbohydrate such as cellulose and hemicellulose which are less digestible than the cell content of leaf with resulting in lower IVTD. *In vitro* digestibility coefficients of dry matter (DM) and organic matter (OM) showed a higher trend for leaf and leaf with rachis when compared to seed pods (P<0.05). *In vitro* digestibility coefficient of CP was the highest in seed pods compared to other parts (P<0.05).

However, the digestibility coefficients of NDF were similar among leaf, leaf with rachis, and seed pods (P>0.05). In general, *in vitro* digestibility reflects the amount of feed to be degraded by rumen bacteria and the time for batch fermentation is commonly 48 hours for digestibility estimation (Van Soest, 1994). In the present study, both leaf and leaf with rachis were shown to have potential as feed supplement in dairy feed due to outstanding of digestibility compared to seed pods. Variation in the results of *in vitro* digestibility of *Mimosa pigra* would be attributed to several factors such as stage of plant maturity, leaf to stem ratio or geographical location.

Table – 1: Morphological characteristics and estimated mass yield of *Mimosa pigra*

Items	Minimum	Maximum	Mean	%
Plant height (cm)	143	298	216.17	
Plant fresh weight (g/plant)				
Leaf	22	400	98.88	22.52
Rachis	9	60	24.60	5.60
Seed pods	10	200	69.57	15.85
Stem and vegetative branches	64	831.92	245.95	56.02
Whole plant	148	1155.28	439.02	100

Estimated equations for potential yields as feed:

Leaf yields (Y_1) (g/plant) :

$Y_1 = 29.974 + 0.28 X_1$; with $r = 0.660$, $r^2 = 0.436$; P-value < 0.001 [1]

Yield of leaf with rachis (Y_2) (g/plant) :

$Y_2 = 38.449 + 0.346X_1$; with $r = 0.720$, $r^2 = 0.519$; P-value < 0.001 [2]

$Y_2 = 20.457 + 0.207X_1 + 2.116X_2$; with $r = 0.758$, $r^2 = 0.574$; P-value < 0.001 [3]

where X_1 = stem weight (g/plant), X_2 = rachis weight (g/plant)

Table – 2: Comparison of nutrient composition in different parts of *Mimosa pigra* (%DM)

Items	Leaf	Leaf with rachis	Seed pods	SEM	P-value
DM	40.14	40.22	48.98	2.58	0.065
OM	93.10	92.93	95.95	1.04	0.105
CP	18.87	18.11	16.36	1.74	0.441
EE	4.81[a]	5.30[a]	0.77[b]	0.19	0.001
NDF	50.13	53.91	57.69	9.71	0.765
ADF	37.06[a]	37.37[a]	48.59[b]	1.82	0.013
Ash	6.89	7.07	4.05	1.04	0.105

Table – 3: *In vitro* digestibility in different parts of *Mimosa pigra* (% DM)

Items	Leaf	Leaf with rachis	Seed pods	SEM	P-value
In vitro true digestibility					
IVTD	69.90[a]	64.64[ab]	52.57[b]	6.56	0.043
In vitro digestibility coefficients					
DM	46.74[a]	40.81[ab]	30.55[b]	5.26	0.025
OM	42.17[a]	40.63[a]	30.62[b]	4.14	0.028
CP	79.36[a]	83.12[b]	85.98[c]	1.37	0.003
NDF	33.61	32.07	27.75	4.95	0.113

Conclusion

Leaf, leaf with rachis, and seed pods of *Mimosa pigra* yielded for 43.97 % of the whole plant. Yields of leaf could be estimated by using multiple regression models with stem weight (g/plant) as independent variable (r=0.660). While yields of leaf with rachis could be well estimated by using multiple regression models using stem weight (g/plant) or stem and rachis weight (g/plant) as independent variables with r value of 0.720 and 0.758, respectively. The crude protein content of *Mimosa pigra* was similar among plant parts as feed ranged from 16.36 to 18.87% in dry matter basis while ADF was quite higher in the seed pods than those in two other parts. It could be observed that leaf and leaf with rachis possessed IVTD values above 60% indicating that their nutritional quality are relatively good and have a potential as dairy feed. However, their palatability and feed intake of dairy cattle may require exploring as well as efficient methods for harvesting and quality preservation.

References

AOAC, 1984. Official Methods of Analysis. 14th ed. Association of Official Analytical Chemists: Arlington, Virginia.

Barrett CF and Parker MA, 2006. Coexistence of *Burkholderia*, *Cupriavidus*, and *Rhizobium* sp. nodule bacteria on two *Mimosa* spp. in Costa Rica. Appl. Environ. Microbiol. 72(2): 1198–1206.

Chen WM, James EK, Chou JH, Sheu SY, Yang SZ, and Sprent JI, 2005. Beta-rhizobia from *Mimosa pigra*, a newly-discovered invasive plant in Taiwan. New Phytol. 168:661–675.

Goering HK and Van Soest PJ, 1970. Forage Fiber Analysis. ARS. Handbook. No. 379. United States Department of Agriculture, Washington, D.C.

Hong NTT and Quac VA, 2005. Feeding value of Mimosa pigra L. for goat. pp. 23-25. *In*: Proceeding from Workshop on Livestock Based Sustainable Farming Systems in the Lower Mekong Basin, T.R. Preston and B. Ogle (eds.). Agriculture Publishing House, Ho Chi Minh, Vietnam.

Kaewwongsa W, 2014. Replacing soybean meal by *Mimosa pigra* (L.) meal on nutrient digestibility and rumen fermentation in growing goats. Khon Kaen Agr. J. 42 (suppl.) 4: 41-46.

Lonsdale WM, Miller IL, Forno IW, 1995. Mimosa pigra. In Groves RH, Shepherd RCH and Richardson RG (eds.). pp. 169–188.

R.H., Sheppard R.C.H., Richardson R.G. The biology of Australian weeds R.G. and F.J. Richardson Publishers, Melbourne, Australia.

Marambe B, Amarasinghe L, Silva K, Gamage G, Dissanayake S. and Seneviratne A, 2004. Distribution, biology and management of *Mimosa pigra* in Sri Lanka. Online available at http://www.weeds.org.au/WoNS/mimosa/docs/awc15-17.pdf.

Nakkitset S, Mikled C and Ledin I, 2008. Effect of feeding head lettuce, water spinach, ruzi grass or *Mimosa pigra* on feed intake, digestibility and growth in rabbits. Asian Aust. J. Anim. Sci. 21(8): 1171-1177.

Natewichai V, Sengsai A and Noi-uthai S, 2011. Use of *Mimosa pigra* L. in hay as supplement for native crossbred goat in growth period. pp. 137-148. *In* Animal

Nutrition Division Annual Research Report, 2011. Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand.

NRC, 2001. Nutrient Requirements of Dairy Cattle. 7th revised ed., National Academy Press, Washington D.C.

Phesatcha K and Wanapat M, 2016. Improvement of nutritive value and *in vitro* ruminal fermentation of *Leucaena* silage by molasses and urea supplementation. Asian Aust. J Anim Sci. 29(8):1136-1144.

SPSS, 2006. Statistical Package for the Social Sciences: Version 15th ed. for Windows, Chicago, Illinois.

Steel RGD and Torrie JH, 1980. Principles and Procedures of Statistics; A Biometrical Approach, 2nd ed. Mc Graw-Hill Book Co., NY, USA.

Tufarelli V, Cazzato E, Ficco A and Laudadio V, 2010. Evaluation of chemical composition and *in vitro* digestibility of Appennine pasture plants using yak (*Bos grunniens*) rumen fluid or faecal extract as inoculum source. Asian Aust. J. Anim. Sci.23:1587–1593.

Van Soest, PJ, 1994 . Nutritional Ecology of the Ruminant, 2nd ed. Cornell University Press, New York, USA.

Vearasilp, T, Phuagphong B and Ruengpaibul S, 1981. A comparison of *Leucaena leucocephala* and *Mimosa pigra* L. in pig diets. Thai J. Agric. Sci. 14:311-317.

Willems A, Tian R, Bräu L, Goodwin L, Han J, Liolios K, Huntemann M, Pati A, Woyke T, Mavrommatis K, Markowitz V, Ivanova N, Kyrpides N and Reeve W, 2014. Genome sequence of *Burkholderia mimosarum* strain LMG 23256T, a Mimosa pigra microsymbiont from Anso, Taiwan. Stand. Genomic Sci. 9:484-494.