Botanical and mineral composition of dominant wild forages for feeding of dairy goats in Payakumbuh Region

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Abstract. The objectives of this study were (i) to identify the diversity of forages that are usually consumed or fed to the dairy goats, (ii) to assess the mineral composition of dominant forages concerning the soil mineral status of growing areas. Eight dairy goat farms surveyed and collected forage samples to define the diversity and dominant forages used to feed the goat. Samples of three dominant forages (Asystasia gangetica, Axonopus compressus, and Panicum maximum) and soils were then collected in five different areas where the farmers usually derived the forages (banana plantation, idle lands, riverbanks, roadside, and rice field edge). Plant samples were collected by using a plate meter used for the calculation of botanical composition. Fresh samples were then chopped, dried, and then ground in meal form before analysis for dry matter (DM), and minerals of Ca, P, Mg, K, Na, and S. The same minerals were analyzed for soil samples. Data were subjected to analysis of variance (ANOVA) in a completely randomized design of 5x3 consisting of 3 plant species and five growing areas as replications. Data were statistically analyzed using correlation and variance analysis in Random Block Design (RBD). Results showed of the total about 45 types of plants commonly consumed by goat, there were three dominant species, i.e., P. maximum (38.60%), A. gangetica (24.23%), and A. compressus (17.23%). The Ca content of forages highly correlated with the Ca in the soils, while magnesium in the forage was negatively correlated with the magnesium in the soil. It was concluded that the dominant forages were found a good source of Ca and Mg but deficient phosphorus.

Keywords: Wild forages, mineral composition, botanical composition, goat nutrition

1. Introduction
Dairy goat farms in Payakumbuh region, which cover Payakumbuh city and Limapuluhkota district distributed mainly in six sub districts, e.g. Lareh Sago Halaban, Harau, Mungka, Luhak, Payakumbuh Timur, and Payakumbuh Barat [1]. Goat breed is dominated by Peranakan Etawah and Jawarandu with an average population number of 39 goats/farm, age at first kidding of 10.8 months, and milk production of 0.5-1.5 liter per day [1]. Dairy goat mostly raised intensively, kept in a simple stall along, and fed by a cut and carry system. They are almost entirely dependent on feeds consisting of wild vegetation and crop residues with a limited supply of concentrated feed. Goat farming is supported by the local agroecosystem, which annually small-scale crop estates dominate as potential sources of fodder feed. Grasses, legumes, and other herbaceous plants are also available in various natural grazing areas, like riverbanks, rice fields, idle lands, forest edges, and roadsides.
Farm owners usually collected forages daily in various areas, around the farms and villages to provide the dairy goats with palatable green fodder. It is different from other ruminant livestock like cattle and buffalo; goats are browsers, have selective foraging behavior, and tend to select young and soft part of vegetation [2,3]. Farm owners need to select and collect a high proportion of edible plant species to keep sufficient feed intake and satisfy the energy and nutrient requirements for optimal health, milk production, and reproductive performances of dairy goats. Belachew et al. [4] identified palatable browse, shrub, grasses, and other plant species were identified based on goats' preference and farmers' knowledge.

However, farm owners could not offer their animals only the palatable species due to the shortage of quality and growth characteristics of wild vegetation. The constraints in the availability of quality fodder feed often forced the farm owner to collect all types of plants to meet feed requirements. It is also unlikely that the edible species will provide the livestock with a complete nutrient. The edible species typically grow together in a group with other vegetation. In the practices, farm owners cut and carried the intended edible plants together with other vegetation grown around the clumps and then fed to their goats in fresh form. The palatable plant becomes only a dominant species. A different variety of plant species will accompany other dominant species. Therefore, the dominant plant communities' botanical composition and nutritional values will be varied, depending on growing areas and the accompanied species.

Dominant species will significantly contribute to the nutritional value and mineral composition of the entire forage. The wild forages vary in dry matter and nutrient content and are often deficient in minerals [5,6]. Khalil et al. [5] reported that some essential minerals of Ca, P, Zn, Cu, and Se were found in marginal concentration in wild forage in West Sumatra. These nutrients play a critical role in physiological processes related to health, growth and reproduction, and the immune and endocrine systems [7,8]. The negative effect of mineral deficiency may be sub-clinical, leading to suboptimal livestock health and performance [9]. There is little information on the identification, diversity, and mineral composition of dominant wild forages used for feeding dairy goats. This suggests a need for research to identify botanical group and mineral composition of dominant wild forages related to soil mineral status to utilize them efficiently and better understand the mineral availability of the forages. Therefore, the objectives of this study were (i) to identify the diversity of forages that are typically consumed or fed to the dairy goats, (ii) to assess the botanical and mineral composition of dominant forages concerning the soil mineral status of growing areas.

2. Materials and methods

2.1 Sampling of plant
Field surveys were carried out to study dominant wild forages fed to dairy goats and define the diversity of the dominant plant community or a variety of plant species growing together with the dominant forages. We visited eight dairy goat farms with an average flock size of about 24 goats/farms located in five sub-districts in Payakumbuh city and Limapuluh Kota district of West Sumatra for two consecutive days. Samples of fodder feed in fresh form were taken in 5 individual sampling points in the farms at forage bunches or sacks directly after the collected forages arrived in the morning and afternoon. The individual samples were placed in a separate plastic bag, weighed, and then sorted by plant species to calculate botanical composition and identify dominant species. Botanical composition was calculated in percent by dividing the fresh weight of individual species with the total weight of individual samples and then multiplying with 100%. Three plant species of wild forages, which had a proportion of a minimum of 5%, were then identified as dominant species. There were Asystasia gangetica, Axonopus compressus, and Panicum maximum. We interviewed farm owners to gain their experience on the grasses, browse, legumes, trees and shrubs as important feeds for goats and the parts favored by the goats.

We identified the diversity of plant species growing together with the dominant forages by collecting forage samples in five different growing areas, where farm owners usually collected fodder feed to feed
their goats. There were banana plantations, roadsides, idle lands, rive banks, and rice field edges. The sampling areas were distributed in the same subdistricts as the selected goat farms. Samples were collected at five sampling points for each dominant species by using quadrants plate meter of 0.5 x 0.5 m in size. The plate meter was placed directly at the clump of the dominant forages. Plant materials in the plate meter were cut about 10 cm above ground level and placed in plastic whirl pack sample bags plastic bag. The fresh samples were weighed, separated into species, and then weighed for determination of the botanical composition of the dominant plant group.

2.2 Plant sample preparation and analysis
Samples of the dominant species were then chopped and mixed in the same species and sampling area. Three representative samples of about 100-150 g from each species were collected so that there were in total of 15 samples (3 dominant species and five sampling areas as replicates). The representative samples were then dried in a forced draught oven at 60°C for 24 hours and ground in meal form before analysis for dry matter (DM), and macro minerals of calcium (Ca), phosphorus (P), magnesium (mg), potassium (K), sodium (Na), and sulfur (S). Samples for mineral analysis were prepared by wet digestion method using concentrated sulfuric acid and hydrogen peroxide. The concentration of minerals was determined using an atomic absorption spectrophotometer. All analysis results were reported on a DM basis.

2.3 Sampling, preparation, and analysis of soil
Soil samples were taken from the same sampling points where the dominant forage samples were grown. Soil samples of about 500 g were obtained using a stainless steel sampling auger to a depth of 15-20 cm. The fresh samples were freed from plant roots and other foreign contaminants, and their particle sizes were reduced and uniformed by grinding manually using a glass bottle. Representative samples of about 1000 g were then dried under the sun and in an oven at 60°C for 48 h and subsequently ground, and then stored in plastic whirl pack sample bags until analysis. The samples were analyzed for dry matter (DM) minerals of Ca, P, and Mg.

2.4 Statistical analysis
Data were subjected to analysis of variance using a completely random design of 3x5 consisting of 3 dominant plant species and five growing areas as replications. Duncan's Multiple Range Test was applied to compare means. Differences were considered significant at P < 0.05 (Steel et al., 1997). Data on the mineral of Ca, P, and Mg concentration of the dominant forages and soil were then analyzed to establish their correlation using statistical software (SPSS).

3. Results and discussion

3.1 Diversity and dominant forages
Wild vegetation plays a significantly important role in goat production in Payakumbuh region. Results of a field survey on the diversity of forages fed to dairy goat presented in Table 1. There were 45 kinds of plant species that were grouped into grasses, shrubs, browse, and broad leaves, tuber leaves, legumes, and tree leaves. Wild plants of grasses, herbaceous, broad leaves, and legumes were found the most dominant forages, which counted to about 85% of the botanical composition. Tuber and tree leaves were wilted under shade before offered to the goats and usually prioritized for young kids and pregnant goats. Fodder choice influenced the diet conformation of goats [10]. Farm owners were able to select palatable plants for their goats. The present results are supported by Malechek and Provenza [11], who reported that goats consumed 60% shrub, 30% grass, and 10% big leaves by grazing in a grassland. Lee et al. [10] confirmed that forages consumed by goats are composed of 34% of wild and 66% herbaceous plants. A study on feeding behavior in Mediterranean woodland found that goats preferred forested plant species compared to herbaceous ones [12].
As shown in Table 1, this study revealed that *Asystasia gangetica* (41.0%) was the first favored browse feed and consumed by goats, followed by cassava leaves (10.0%), *Axonopus compressus* (7.6%), and *Panicum maximum* (5.0%). The dominant species favored by goats, identified and ranked by goat owners as necessary feed. The present results are consistent with the previous research on the diversity of forages fed to meat-type goats in Payakumbuh region by Khalil [6]. Khalil [6] reported that of the 47 total kinds of vegetation fed to goats in Payakumbuh, there were six predominant forages, including *Axonopus compressus* (23.4%), *Centrosema pubescens* (6.8%), *Asystasia gangetica* (5.5%), *Panicum maximum* (5.3%) and foliage of *Glyricidia sepium* (5.2%) and *Manihot utilissima* (5.0%). *A. gangetica*, *A. compressus*, and *P. maximum* were the dominant forages fed to meat-type goats. These plants were very palatable for goat and grew widely in various lands Payakumbuh region.

**Table 1.** Diversity of forages for feeding dairy goat in Payakumbuh Region.

| Forage group          | Plant species (Botanical composition, %)                                                                 | Number of plant (%) |
|-----------------------|--------------------------------------------------------------------------------------------------------|---------------------|
| Grasses               | *Axonopus compressus* (7.63), *Panicum maximum* (5.03), *Cyperus rotundus* L. (3.94), *Bracharia* decumbens (3.17), *Setaria spathaceae* (2.19), *Pennisetum purpureum* (1.24), *Pennisetum purpureum* cv. *Mott* (0.65), *Paspalum dilatatum* (0.50), *Eleusine indica* L. (0.39), *Digitaria eriantha* (0.38), *Hedyotis corymbosa* L. (0.13), *Lopatherum gracile* (0.05), *Leersia hexandra* (0.04) and *Cynodon dactylon* (0.02). | 14 (31.11)            |
| Broad leaves and fern | *Asystasia gangetica* (41.04), *Mimosa pudica* (3.16), *Commelina nudiflora* L. (2.38), *Ageratum conyzoides* (1.50), *Cleome rutidosperma* DC (1.45), *Mikania micrantha* (1.27), *Stachytarpheta jamaicensis* (0.39), *Momordica charantia* (0.33), *Craspodephalum crepidoide* (0.26), *Amaranthus spinosus* (0.19), *Centella asiatica* (0.16), *Borreria alata* (0.11), *Synedrella nodiflora* (0.10), *Isotoma longiflora* (0.10), *Anthurium cystalinum* (0.10), *Commelina benghalensis* (0.09), *Emilia sonchifolia* (0.08), *Nephrolepis exaltata* (0.02), and *Euphorbia hirta* (0.01). | 19 (42.22)            |
| Tuber leaves          | *Manihot utilissima* (10.04), *Ipomoea batatas* L. (2.29), *Emilia sonchifolia* (0.13), *Colocasia esculenta* L. (0.05), and *Caladium sp* (0.01). | 5 (11.11)             |
| Legumes               | *Centrosema pubescens* (4.82), *Glycine max* (1.90), *Pueraria phaseoloides* (0.13), and *Calopogonium mucunoides* (0.01). | 4 (8.89)             |
| Tree leaves           | *Glyricidia sepium* (1.69), *Tectona grandis* (0.50), and *Indigofera tinctoria* (0.50). | 3 (6.67)             |
| Total number of plants|                                                                                                         | 45                  |

3.2 **Botanical group of dominant forages**

Of the four dominant plants, three species of *A. gangetica*, *A. compressus*, and *P. maximum* were wild plants. The dominant species correlated with their dominance in the growing areas of *P. maximum* (87.6%), followed by *A. gangetica* (75.3%) and *A. compressus* (64.8%). Table 2 showed the botanical group on the dominant wild forages—different dominant plants that other species cluster and vegetation composition grown around their clumps. There were about 10 to 15 plant groups grown and fed to dairy together with the dominant forages. *A. gangetica* showed the highest number of browse and shrubs...
grown around their clumps, followed by \textit{A. compressus} and \textit{P. maximum}. The dominant cluster of \textit{A. compressus} were \textit{Cyperus rotundus}, \textit{L. gracile}, \textit{I. Cylindrica}, and \textit{A. conyzoides}. \textit{P maximum} accompanied mostly by \textit{I. cylindrica} and \textit{A. gangetica}, while \textit{A. gangetica} grown in group primarily with \textit{L. gracile}, \textit{A. conyzoides}, \textit{B. decumbens}, \textit{A. compressus}, and \textit{C. rotundus}. According to Darch et al. [9], proportional species composition in a field environment varied due to competition between plants.

The present result showed that the dominant species were rich diversity of vegetation of indigenous browse species found widely distributed and used as a feed source for dairy goats. According to Tolera and Abebe [13], browse species have high crude protein content ranging from 10 to more than 25%, making them a more reliable, high-quality feed resource.

### Table 2. Botanical group of dominant forages.

| Dominant forage (%) | Botanical group (%) | Number of plants |
|---------------------|---------------------|-----------------|
| \textbf{Axonopus compressus (64.75)} | \textit{Cyperus rotundus (17.09)}, \textit{Lophatherum gracile (6.29)}, \textit{Imperata cylindrica (2.78)}, \textit{Angeartum conyzoides L (2.28)}, \textit{Tinospora cordifolia (1.91)}, \textit{Bracharia decumbens (1.54)}, \textit{Panicum maximum (1.44)}, \textit{Asystacya gangetica (0.90)}, \textit{Zoysia matrella, L (Merr) (0.74)}, \textit{Cyperus rotundus L (0.18)}, and \textit{Eleusine indica (0.10)} | 11 |
| \textbf{Panicum maximum (87.61)} | \textit{Imperata cylindrica (3.98)}, \textit{Asystasia gangetica (3.30)}, \textit{Angeartum conyzoides L (1.11)}, \textit{Bracharia decumbens (0.94)}, \textit{Ipomea sp (0.89)}, \textit{Cyperus rotundus (0.68)}, \textit{Lophatherum gracile (0.61)}, \textit{Axonopus compressus (0.54)}, \textit{Bautelova dactyloides (0.26)}, and \textit{Eleusine indica (0.10)} | 10 |
| \textbf{Asystasia gangetica (75.34)} | \textit{Lophatherum gracile (4.07)}, \textit{Angeartum conyzoides L (3.96)}, \textit{Brachiaria decumbens (2.99)}, \textit{Axonopus compressus (2.80)}, \textit{Cyperus rotundus (2.37)}, \textit{Echinochloa crussgalli (1.72)}, \textit{Bautelova dactyloides (1.55)}, \textit{Tinospora cordifolia (1.36)}, \textit{Eleusine indica (1.13)}, \textit{Pennisetum purpahoides (1.06)}, \textit{Amaranthus hybridus (0.69)}, \textit{Bracharia mutica (0.49)}, \textit{Ipomea sp (0.32)}, \textit{Diplazium esculentum (0.11)}, and \textit{Leersia hexandra (0.05)} | 15 |

### 3.3 Dry Matter and Mineral composition

The dry matter and mineral composition of dominant forages are presented in Table 3. There were significant differences in DM content between dominant species, that \textit{A. gangetica} had significantly lower dry matter than \textit{A. compressus} and \textit{P. maximum}. There were no significant differences in mineral content. The dominant forages hat relatively high calcium, potassium, sodium, and magnesium with mineral content of about 4-7 g/kg DM. On the contrary, our previous study found that only \textit{A. gangetica} was a good source of Ca (8.2 g/kg DM), while \textit{A. compressus} and \textit{P. maximum} hat low Ca content of 2.1 and 2.2 g/kg DM, respectively [6]. Phosphorus and sulfur were found considerably low (Table 3). There a need to provide a dairy goat with mineral supplements to alleviate deficiency minerals, especially phosphorus.
Table 3. Dry matter (DM) and macromineral composition of dominant forages.

| DM/Mineral | Dominant forages: | Asystasia gangetica | Axonopus compressus | Panicum maximum |
|------------|------------------|---------------------|---------------------|----------------|
| Dry matter (% FW) | 12.83±1.26<sup>b</sup> | 19.35±2.06<sup>a</sup> | 24.08±4.05<sup>a</sup> |
| Minerals (g/kg DM) | Calcium | 7.46±0.68 | 7.37±0.65 | 7.77±0.35 |
| | Phosphorus | 3.31±0.75 | 2.62±0.54 | 2.24±0.34 |
| | Magnesium | 5.78±3.25 | 4.30±0.49 | 4.44±0.38 |
| | Potassium (K) | 7.10±1.03 | 6.96±0.75 | 7.12±0.65 |
| | Sodium (Na) | 7.73±0.67 | 7.36±0.42 | 6.93±0.41 |
| | Sulfur (S) | 0.21±0.32 | 0.07±0.01 | 0.07±0.01 |

As shown in Table 4, the calcium of dominant plants was a highly positive correlation with the calcium in the soil, where they are grown, while phosphorus in the plant correlated relatively good on A. gangetica, but very low in P. maximum and negative by A. compressus. The same finding was also reported by Khalil et al. [14], who reported that the Ca content in the pasture had a positive correlation with the Ca concentration in the soils. In contrast, P and Mg were found negatively correlated with the P and Mg concentration in the soils in the pasture of the National Beef Cattle Breeding Center of Padang Mangatas, Payakumbuh.

Table 4. Correlation of minerals in soil and dominant forages.

| Dominant forages: | Asystasia gangetica | Axonopus compressus | Panicum maximum |
|------------------|---------------------|---------------------|----------------|
| Dry matter content (% fresh weight): | 12.83±1.26 | 19.35±2.06 | 24.08±4.05 |
| The mineral content of forages (g/kg DM) | Calcium | 7.46±0.68 | 7.37±0.65 | 7.77±0.35 |
| | Phosphorus | 3.31±0.75 | 2.62±0.54 | 2.24±0.34 |
| | Magnesium | 5.78±3.25 | 4.30±0.49 | 4.44±0.38 |
| The mineral content of the soil | Calcium | 6.66±0.76 | 7.00±0.52 | 6.76±0.64 |
| | Phosphorus | 1.44±1.10 | 0.72±0.93 | 2.92±0.58 |
| | Magnesium | 8.41±1.20 | 8.56±1.02 | 8.88±0.94 |
| Coefficient Correlation (r) | Calcium | 0.92 | 0.91 | 0.67 |
| | Phosphorus | 0.64 | -0.10 | 0.26 |
| | Magnesium | -0.25 | -0.68 | -0.80 |

4. Conclusion

Forages fed for dairy goats in Payakumbuh comprised about 45 plant species derived primarily from wild forages. There were three dominant wild forages, i.e., A. gangetica, A. compressus, and P. maximum. Different dominant plants had other species cluster and composition of vegetation grown around their clumps. Dominant forages were good sources of calcium, potassium, sodium, and magnesium but relatively poor phosphorus and sulfur.

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