Discussions

6.1 Chemical composition

Two most commonly methods in the initial determination of the nutritive value of herbage as ruminant feed are proximate analysis (PA) and fiber detergent system. The PA is a combination of analytical procedures developed about 1865 in Germany (Ammerman and Henry, 1985). This method is used routinely in the description of feedstuffs and although it has several weaknesses from a nutritional point of view, it is still being widely used. PA partitions plant tissue into components heterogenous in composition and variable in digestibility. In addition, the procedure lack the precision which means these feed fractions are not chemical entities but a mixture of substances that cannot be characterized chemically. This method nevertheless is very useful in the approximation of amounts of components that may be present in plants or commercial tree mixtures.

In the fiber detergent system, plant tissue can be divided into uniform fraction predictably related to digestibility. The detergent system provide an easy and more comprehensive description of the fiber fraction into neutral detergent fiber (NDF) and acid detergent fiber (ADF). Taken together, PA and fiber detergent systems provide qualitative data to describe the chemical composition and give an indication of the quality of forages for ruminants.

A promising development in evaluating quality of forage for herbivores is the use of infrared reflectance spectroscopy, to predict plant chemical and physical characteristics. New method such as Near Infrared Reflectance Spectroscopy (NIRS) despite being expensive, is getting popularity in the measurement of forage composition (Ward et al, 1982). However, the use of specific wavelength has prevented its wide application.

Table 6.1 : Difference between leaves (L), shoot (O), stem (S) and / twigs (T) from selected plants

Sample	DM (%)	CP (%)	CF (%)	EE (%)	Ash (%)	NFE (%)	NDF (%)	ADF (%)	Lignin (%)
Premna cordifolia (L)	21.37 ± 4.10	24.62 ± 2.10	12.44 ± 2.66	2.64 ± 0.14	6.71 ± 0.44	46.54 ± 0.94	51.16 ± 1.09	35.31 ± 1.36	10.16 ±0.75
(S)	12.43 ± 1.57	17.78 ± 0.21	12.58 ± 0.59	1.40 ± 0.13	6.71 ± 1.28	53.42 ± 0.55	23.90 ± 3.02	22.21 ± 1.45	3.28 ± 1.16
(T)	11.36 ± 2.14	32.62 ± 5.69	10.91 ± 0.70	2.03 ± 0.51	5.67 ± 2.81	48.07 ± 2.73	51.16 ± 2.45	41.74 ± 2.20	6.57 ± 0.50
Saudropus androgynus (L)	27.85 ± 6.79	26.13 ± 4.53	25.52 ± 2.04	5.66 ± 1.89	10.41 ± 0.71	30.57 ± 1.64	35.09 ± 1.64	22.06 ± 0.96	5.67 ± 0.67
(S)	20.20 ± 2.36	21.57 ± 0.94	25.00 ± 2.52	1.81 ± 0.62	11.51 ± 1.60	41.38 ± 4.51	36.37 ± 1.33	29.39 ± 1.90	3.89 ± 0.86
(T)	29.48 ± 1.15	22.56 ± 2.48	32.34 ± 1.98	2.17 ± 0.38	7.04 ± 0.79	35.58 ± 2.80	46.23 ± 0.68	35.80 ± 2.80	3.53 ± 0.32
Sesbania grandiflora (L)	22.68 ± 4.10	27.84 ± 1.48	12.80 ± 2.04	4.55 ± 0.35	7.74 ± 1.56	47.07 ± 1.36	32.14 ± 3.25	23.30 ± 4.35	3.46 ± 0.28
(S)	12.79 ± 1.88	18.86 ± 1.05	25.40 ± 1.24	1.39 ± 0.28	9.28 ± 0.26	5.07 ± 1.71	42.51 ± 1.22	39.12 ± 0.46	4.22 ± 0.48
(T)	15.86 ± 0.05	19.48 ± 1.07	25.96 ± 4.99	0.99 ± 0.19	8.65 ± 0.63	4.92 ± 1.72	36.24 ± 5.16	29.98 ± 4.65	4.09 ± 0.30
Artocarpus integra (L)	32.77 ± 1.61	22.30 ± 1.81	18.62 ± 2.34	3.13 ± 0.60	8.20 ± 0.44	50.24 ± 2.91	53.41 ± 2.50	47.70 ± 2.69	10.07 ± 0.80
(O)	25.41 ± 4.61	18.05 ± 5.13	13.57 ± 2.52	2.09 ± 0.08	8.11 ± 0.02	57.84 ± 3.88	50.34 ± 2.45	32.22 ± 4.83	6.02 ± 0.96
Leuceana leucocephala (L)	28.43 ± 1.41	38.85 ± 3.37	16.55 ± 2.54	4.33 ± 0.46	7.03 ± 1.14	33.24 ± 3.26	30.43 ± 3.37	22.11 ± 1.48	4.00 ± 1.36
(O)	24.03 ± 0.82	32.44 ± 4.29	8.75 ± 1.63	2.65 ± 0.48	16.49 ± 1.50	39.67 ± 4.07	41.00 ± 3.76	25.21 ± 2.25	6.18 ± 1.21
Moringa oleifera (L)	24.23 ± 2.36	38.22 ± 1.03	22.85 ± 0.85	4.14 ± 0.75	8.50 ± 1.26	26.30 ± 3.33	31.78 ± 11.76	16.10 ± 1.98	4.52 ± 0.28
(O)	22.02 ± 0.49	40.18 ± 0.18	6.89 ± 0.08	2.05 ± 0.23	12.40 ± 3.80	38.49 ± 3.78	32.35 ± 12.74	14.50 ± 0.71	2.90 ± 0.23
Althernanthera triandra (L)	15.98 ± 2.35	37.45 ± 1.14	15.83 ± 2.47	2.71 ± 0.66	11.75 ± 5.58	32.26 ± 2.53	39.06 ± 7.04	28.42 ± 0.95	4.96 ± 0.42
(T)	29.86 ± 3.72	28.13 ± 0.95	23.29 ± 1.11	1.51 ± 0.23	7.48 ± 0.77	39.60 ± 0.77	27.81 ± 3.56	27.67 ± 7.01	6.81 ± 1.13
Diplazium esculentum (L)	19.95 ± 4.53	18.58 ± 7.40	9.54 ± 0.75	3.28 ± 0.79	13.50 ± 1.47	55.13 ± 4.37	45.65 ± 5.30	41.50 ± 4.23	11.97 ± 1.59
(T)	10.75 ± 0.38	14.67 ± 3.22	6.49 ± 0.25	1.46 ± 0.58	11.64 ± 1.70	65.75 ± 1.59	39.93 ± 3.27	35.50 ± 4.67	5.91 ± 0.95
Gnetum gnemon (L)	19.32 ± 1.80	20.88 ± 4.59	12.32 ± 3.97	2.09 ± 0.51	8.76 ± 0.92	56.16 ± 7.03	33.73 ± 1.94	30.76 ± 1.99	2.84 ± 0.97
(T)	21.32 ± 2.10	15.81± 0.49	33.49 ± 3.81	2.30 ± 0.84	9.29 ± 1.05	39.12 ± 3.92	45.09 ± 5.07	30.36 ± 1.69	3.71 ± 0.76
Pdermachera gigantia (L)	25.41 ± 1.09	18.97 ± 0.05	12.76 ± 0.41	3.98 ± 1.49	7.98 ± 0.88	56.31 ± 0.71	29.15 ± 4.95	25.76 ± 2.26	8.79 ± 0.86
(T)	22.35 ± 2.41	15.62 ± 2.14	26.63 ± 0.15	4.45 ± 1.70	6.43 ± 0.06	46.88 ± 1.01	33.34 ± 1.64	25.89 ± 4.46	3.40 ± 0.68
Solanum nigrum (L)	33.11 ± 0.71	27.81 ± 4.54	21.72 ± 0.97	3.77 ± 1.56	10.02 ± 0.39	36.70 ± 1.87	30.66 ± 1.97	22.80 ± 4.64	3.88 ± 1.23
(T)	161.32 ± 0.86	19.94 ± 4.09	19.80 ± 1.32	2.02 ± 0.15	6.58 ± 0.18	51.68 ± 1.44	40.15 ± 6.01	21.00 ± 2.78	4.43 ± 0.86

6.1.1 Proximate analysis

CP represent all forms of nitrogenous substances in feed. The CP contents in plants increase with age of the tree leaves. Its ranges from 3% to 20% , and even more in very young plants (shoots) (see Table 6.1). CP levels compare favourably with those of other tree fodder (Table 5.7 - a). CP concentration decreased from leaves to stems component (Hintz & Albrecht, 1994). In the present studies, the CP in plants analysed are within the ranges of CP level in the plants of the same family (Table 5.4).

Tree fodder is a major source of nitrogen and CF especially during the dry season. CF is in fact cell walls consisting of hemicellulose, cellulose and lignin. The plant leaves in the present studies contain comparatively low percentage of CF (see Table 5.6 - a and Table 5.6 – d) compared to grass (Table 5.6 – e) because plants fibre are complex and highly lignified at maturity. CF content increases with plant's age. The older the plants, the higher its CF. Published figures for CF ranges from 20% - 25% in the young plants and from 30% to 40% in mature plants (Mould and Robbin, 1981).

The reason for the relatively high digestibility of CF by ruminants lies in the feed that the largest component (~ 95%) of CF is cellulose and the microbes in the rumen are able to break down the cellulose. Relatively high level of CF in these plants are likely of major concern in relation to deer feeding since deer in general cannot digest total fiber as good as sheep and goat. The rumen fractional outflow rate (FOR) of water (15.6%/h) for deer was reported to be faster than those reported for sheep (10.4) and goats (10.0) (Domingue et al. 1991).

Ether extracts (EE) contain fats (oil) and etherial oils; their content is usually in the order of 1% - 3%. Higher EE contents (5% - 6%), usually indicates the presence of etherial oils (Cowan et al. 1970). The EE will differ in composition among different foods. The nutritional usefulness of EE obviously depends in part on the extent to which it is digested. Neutral fats are normally over 90% digested, but the value may be lower for EE from animals fats. Browse plants analysed contained EE in the range 1.27 % to 5.5% (average 3.28%; see Table 5.4 and Table 5.5).

Ash is not considered as important nutrient in ruminant ration unless it is too high which might affect the NFE digestibility. Normal acceptable range is about 8 % to 12 % of DM (Bogdan, 1977). Ash is the inorganic residue from the firing of a sample at about 600°C. The ash components of plant material is highly variable in its component parts, which include silica. In the present studies, all tree samples analysed with the exception of *Solanum nigrum*, contained ash between 4.5 % to 8.0 % (see Table 5.7 – a).

NFE contain soluble or near soluble carbohydrates such as sugars and starches, but it also contain some hemicellulose and lignin. Most plants contain NFE in the range of 35% to 55% (Sanches et al, 1993) which remains relatively constant or increase slightly with plant age. In the present studies NFE in browse plants samples ranged as low as 15.25% in *Ipomoea aquatica* to as high as 65.78 % in *Ocimum basilicum* (see Table 5.4 and Table 5.5). Since the NFE were derived by calculation (see 4.2.6), the NFE value may be affected by the chemical errors in the analyses of all 5 of the separate feed composition. NFE is primarily a non - specific source of energy to the animals. Its digestibility is ordinarily a little higher than protein, fat or CF of the same feed. The importance of NFE lies that this fraction makes up 40 % of dry weight of forage feeds and 70 % of the basal feeds.

6.1.2 Mineral

Information about the trace elements in feeds for deer consumption is minimal or limited. Mineral deficiency signs can be confusing as the observed conditions can involve more than one mineral or may be combined with the effect of protein deficiencies and various type of toxic plants. Grazing livestock usually do not receive mineral supplementation except for commonself and must depend almost exclusively upon forages for their requirements. However, tropical forages rarely can completely satisfy all mineral requirements.

Tropical forages normally do not contain sufficient qualities of Na to meet the requirement of grazing livestock throughout the year. Inadequacy can be overcome by providing commercial salt lick or common salt ad libitum. Unlike K and P, most Ca is located in older plants. Mn and Fe located in physiologically active parts of the plants, remain relatively immobile in leaves. As the leaves matured, levels of K, Mn and Na were high. P decreased with the onset of leaf senescense. Because buds and leaves tend to accumulate minerals, they are usually higher in ash concentration (see Table 6.1) than fruit and woody tissue. Investigators generally agreed that mineral concentration are higher in leaves than the other plants parts. Little is known however, about the changes that occur in the minerals and nutrient content of leaves after abscissions.

Actually mineral works as a combination in two and more in each function e.g. Cu, Zn and Mn were important in enzyme pathway. Excess or lack of one of it in the group can affect the animals. Every mineral should be taken at certain amount (optimal quantities), where shortage or surplus can cause side effects or toxicities. All mineral elements whether considered to be essential or potentially toxic, can have an adverse effect on the animals if included in the diet at excessively high levels.

Table 5.8 and Table 5.9 agree with Wilson et al. (1982) that legumes usually have a higher Ca and low Mn content than grass. Ca and P have a vital function in almost all tissues in the body. It must be available in proper qualities or ratio. The Ca to P in browse plants usually in the range 1 : 1 to 4 : 1 compared to the accepted normal dietary requirement of animals of 1:1 to 2:1 (see Table 5.4 and Table 5.5). Ca : P ratio should not be substantially over 2 : 1 (McDowell et al., 1985). Because excessive Ca interferes with P uptake in animal digestive tracts, Ca : P ratios approaching 1 : 1 are desirable (Dietz, 1965). Ca content in tree leaves is 2 - 3 times more than grass (refer Table 5.8). Recent investigation on macromineral (see Table 5.8) and micro mineral (see Table 5.9) content suggest that in general tree leaves contained higher Ca content than common fodders (Murugan et al. 1987). The P content is, in general low resulting in a wide Ca to P ratio (Table 5.9). Unlike K & P, most Ca is located in older leaves.

Cu is important for these ruminant but must not exceed the critical level, as toxicities might be a problem (Mc Dowell et al, 1993). In the 37th plants, the Cu exist from 0.0014 ppm to 2.07 ppm. The least amount of Cu is advisable as Cu can cause toxicity.

Mn and Fe located in physiologically active parts of the plants, remain relatively immobile in leaves. Deer have been able to withstand higher level of dietary Mn then have domestic livestock (Ward and Nagy, 1976). Mn is essential for the proper formation of the carilagenos matrix of bone. Gibson et al. (1963) found that *Gnetum gnemon* can be primary source of Mn. These studies shows that Mn exist in moderate amount in *Gnetum gnemon* with 3.61 ppm compared to *Stenachlaena palustris* (33.60 ppm). Fe content occurred the highest in *Ipomoea aquatica* with 24 ppm than *Barringtonia racemosa* with 0.52 ppm. It occurance in average 1 ppm in most of the plants.

Ash was truly correlated with K and Na (component characteristic) of active tissue. K necessary in the water economy of plants, was truly correlated with ash and P in growing plants. P characteristic of active meristematic tissue, was truly correlated with ash and K.

Mineral analysis has shown that as a rule, Ca, Zn, Fe, K, Mg and Zn level are adequate whereas Cu, Na and P levels are low. Nutrient level (Table 5.8 and Table 5.9) were generally similar to those reported elsewhere (Wheaton and Brown, 1983) for other plant species reading attributed to variation, soil type and plant maturity.

There is a very little information available on mineral content in shrubs and tree for comparison except for several outstanding plants such as *Leuceana leucocephala* (Gutteridge and Rekib, 1994) and *Sesbania grandiflora* (Shelton and Jones, 1994).

6.1.3 Fiber Composition

In the present studies, NDF was determined in the absence of sodium sulfite in contrast to Goering and Van Soest (1970) whom original approach of adding used sodium sulfite in the neutral detergent boiling to improve protein extraction. NDF digestibility was generally higher when sodium sulfite was not used in the fiber determination (Hanley et al., 1992). In addition Bailey and Ulyatt (1970), Bailey et al. (1978), Van Soest and Robertson (1980) and Mould and Robbins (1981) also recommended that sodium sulfite not to be used because of the loss of some hemicellulose and the potential for lignin degradation.

The NDF, ADF and lignin concentrations increase as plants mature. Cellulose content in the plant analysed was determined as the difference between ADF and lignin whereas hemicellulose was estimated by subtracting ADF from cell wall constituent (Van Soest, 1966). Hemicellulose together with cellulose constitute principal parts of the plant cell-wall structure (Colburn and Evans, 1967). In trees, twigs shows a higher percentage of hemicellulose than those leaves in shrubs. However when shoots were compared to leaves, hemicellulose content in leaves was lower by 3 times than those in shoots. Hemicellulose in stem shows the lowest percentage than other part of plants (see Table 6.1). Cellulose values of *Stenalaena palustris* and *Panicum maximum* were higher than CF values as determined in other studies (Lowry et al, 1981; Ivor and Chen, 1985). The percentage of cellulose contents varies greatly in different parts of the plants (see Table 6.1). When stems, twigs, shoots and leaves in 11 plants were compared, cellulose was found highest in twig (7 % - 16 % more than those in leaves and 16 % more than those in stem) whereas leaves contained 11 % more cellulose than those in shoot. Hence, as the plants mature, the percentage of cellulose in the stems and leaves increase accordingly.

Most tropical forages especially wooden plants have a characteristically high lignin content (see Table 5.7 – a and Table 5.7 – d). Due to its very low degradability, lignin influences both digestibility and the amount the animals will eat. Lignin also affects the quality and level of intake of mature tropical grasses especially in *Panicum maximum* (see Table 5.7 – e). Lignin is the chemical component of dietary that is most frequently associated with plant indigestibility and that has been shown as useful for predicting extent of fiber (Van Soest, 1963).

Lignin content increased with maturity where shoots has the least lignin than in stem, twig and leaves. But in *Leuceana leucocephala, Alternanthera triandra* , *Gnemon gnetum* and *Solanum nigrum*, the occurance of lignin shows differently. Leaves for instance has lower percentage of lignin than than those in other parts (see Table 6.1). Lignin has a lower feeding value than cellulose (see Table 5.7) except for in *Dipalazium esculentum, Panicum maximum, Asystasia gangetica* and *Calopogonium mucunoides* which implies that the plants may be less digestible especially when it forms a physical combination with cellulose and yield ligno – cellulose (CF and ADF, Hvelplund et al, 1995).

6.2 Plant selection

The availability of preferred forage species appeared to be the most important factor determining the extent of deer browsing in its habitat. Deer can be generalist browser. They may consume certain variety of plants to maintain themselves especially high-quality plants with less allelochemicals (McArthur et al., 1993). When feed resources were abundant, deer would forage more selectively than when resources are scarce whereby deer were reported to use wider range of forages including more items of lower quality (Murden and Risenhoover, 1993).

Diet selection also depend upon the diversity of forage. Some forages are well consumed if they are provided as a sole choice but may be rejected if offered with other alternative feeds which are better. In most deer farms visited, forages are often given in mixed diet. Not all biomass is useful for browse because older portions are lignified and become less palatable than leaves and twigs.

Various information were collected regarding the potential of plants eaten by the deer. Deer are known to choose plants species which were high in CP, P and *in vitro* digestibility (IVOMD) (Carlton et. al. 1993). In fact deer readily use feeds with high contents of soluble carbohydrate and protein more efficiently than sheep and goats (Domingue et al, 1991). Table 5.4 presented a list of plants known to be eaten by the deer. The wild deer in the forest tend to browse or eat old fallen leaves (Ahmad Suhaimi, pers. comm) whereas the animals in captivity were grazers in pastures land. It was found in the present studies that all species of grass, legumes, forbs, herbs, weeds, shrubs and trees within the paddock are readily consumed by deer.

Preference for one species is affected by the availability of another species within the same area. A plant that is highly preferred when surrounded by unpalatable neighbours might be rejected. For the purpose of plant sampling from each location, the forage, especially the browse plants, were collected from trees which had evidence of being browsed by deer (see Table 5.1). Several other plants were also included in this study because of their high availability and are known to be readily consumed by deer (see Table 5.4 and Table 5.5).

Both deer and goat were reported to also select one forages against the other which have unpleasant odours (Tuen & Kuan, 1990). In most cases however, plants eaten by deer were not selected based on their protein or energy contents alone but rather on availability and palatability (Qin and Liang, 1983; Semiadi et al, 1995). Eventhough *Sapium baccatum* have 8.69 % of CP and 7.46 KJ/kg of ME, which were generally lower than other plants analysed, it is widely observed that deer cherish this plants species and for that reason was made available in most of the deer farms visited. In another extreme case, Nag and Matai (1992) found that *Trema orientalis* has a high percentage of ash (18.57%) but was found suitable as fodder for browsing herbivore such as deer.

McMahan (1964) found that over 50% of deer diet consisted of browse plant which are similar to goat diets, and goats seems to be the most competitive with deer for food especially browse plants. It appears that when given choice the animals in confinement preferred browse to grass (Westoby, 1974; Fletcher, 1991; Dulphy et al, 1994). Grass on the other hand is normally preferred by cow and sheep. Other studies also found that deer prefers shrubs and trees species whereas cow prefer grass (Smith and Novellie, 1982). Equal preference for grass by deer and other livestock probably occured when grass is in succulent stage and no other forages are available in adequate quantity (Mc Mahan, 1964).

Deer eat certain browse plants, occasionally in large amounts since single plants is not likely to support life for a very long time. Deer consumed the small plants and ignored older plants of the same species and preferred new sprout (Kohn and Mooty, 1971). The reason may be because of the level of CF is higher and the chemical composition is low in older plants. The EE and NFE level in tree leaves also decrease as the leaves advances in maturity. Since buds and leaves tend to accumulate minerals, they are usually higher in ash concentration than those in woody tissue With the onset of leaf senescense, the EE decreased but the NFE increased. Fallen tree leaves are readily consumed by deer.

When compared to Sambar deer (Habsah, 1986), rusa deer seems to prefer certain shrubs such as *Ficus* sp. and fern to concentrate. According to Habsah (1983), *Trema orientalis* and *Melastoma malabathricum* were also some of the deer favourite plants. Das and Lahiri (1990) reported that Sambar deer, spotted deer and barking deer at Bethuadahari Reserve eat 49.2% herbs, 12.4 % shrubs and 26.4 % trees including *Barringtonia racemosa* and at least 24 introduced plants.

Deer, like other concentrate selector, select highly digestible forages and plants parts over forages with higher fiber content (Strey & Brown, 1989). Domingue et al. (1991) found that farmed red deer utilize forages with a high content of soluble carbohydrate and protein more efficiently than sheep and cattle whereas the goat with its superior fibre digestion is best able to utilize low-quality diets. Herbivores eat when the forages is green and when its nutritional value is high. It is possible that deer in captivity eat whatever plant materials that is given or available in either to satisfy their hunger and to survive or they are already adapted to the plants, even though they dislike the smell or the taste (Dawend and Tuen, 1995; Semiadi et al, 1995). In other occasion the animals may choose to eat certain plant in small amount, either because its not palatable enough or to minimise effects of toxicity.

It is interesting to note that deer may also eat flowers of certain species, which were relatively high in cellulose content, but low in cellulose digestibility when compared with leaves from the same species. *Hibiscus rosa-sinensis* and *Mussaenda erythrophylla* for instance was introduced as alternative source of feed to the fallow deer (*Dama dama*) at Taman Tasik Perdana, Kuala Lumpur (DBKL, person. com). The flowers may be eaten probably because they are succulent, taste good or even looks attractive because or its colours. Cowan et al (1970) presented evidence that plants may be more nutritious and palatable during the periods of early growth and flowering.

6.2.1 Browse plants

The forage selected for analysis in the present studies, especially the browse plants were chosen from evidence indicating deer bites (see Table 5.1). The potential of tree and shrubs as livestock feed is being increasingly recognised (Akram et al.1989; Joshi and Singh, 1989; Rajaguru, 1989; Raghavan; 1989).

Tree fodder play an important parts in contributing towards the national fodder resources, to benefit livestock as a major role in ruminant diets (Hopkins, 1985) and the agricultural sector. There are more than 5000 trees which has the potential as deer feed in the tropical country like Malaysia (Chardonnet, per. com.). Some tree fodder are almost as nutritious as leguminous fodders. The goverment should established effort to exploits the use of these plant fodder as deer feed or other small ruminant feed, in order to overcome the feed problems. It is fairly well established that tree leaves, when fed alone cannot support growth although they contain 13 - 20 % protein.

The digestibility of browse plants as measured by their DM disappearance rate is related to fibre composition such as NDF and ADF (Blanchart et al, 1993). Most of the indigenous forage species can provide adequate quantities of nutrient for growth as long as there is no restriction on feed intake. Feed unavailability seems unlikely under natural or seminatural environment since the forages are abundant in the under - storey of logged (Dawend and Tuen, 1995). Browse plants intake by deer however may be restricted by rumen fill which regulate feed consumption by the presence of stretch and mechano – reseptors in the rumen wall, and the rate of removal of material from the rumen (Forbes, 1994). Due to this, the plants of choice should be of high CP contents to offset the limitation of intake. Chemical analysis of forages showed a wide range in CP (9 - 31%) and Ca (0.1- 0.3%). It is also known that dry matter digestibility, DMD is related to lignin content which is indigestible in ruminant In shrubs, the DMD ranged from 10 % to 33 %.

Palatability has been shown to be related to moisture and CP content as well as to a high percentage of minerals (especially Na) whereas negative palatability characteristics are related to high fibre content, the presence of tannins (McArthur et al, 1994) and aromatic substances (Walker, 1980). Palatability and utilization of forages are also related to availability factors such as the abundance of species, height of plants in relation to animals and season of use. It is perhaps for this reason that certain plants such as *Imperata cylindrica, Lantana camara* and *Clidemia hirta* (Dolmat and Basiron, 1995) although grown in farm, was not consumed by deer (Tuen and Kuan, 1990).

Palatability of the browse plants varies much more than the palatability of grass. The plants can be unpalatable if they are bitter, aromatic and have some other unpleasants taste to ruminants In addition, they could be prickly or exceedingly hairy. Grass palatability on the other hand can be very low because they can be unduly fibrous or aromatic. It is difficult, however, to lay down general rules about what makes a good browse species because browse productivity were not well known and were very difficult to measure accurately. Generally the plant species which is prominent in the animals diets were taken only in trace amount, commensurate with their availability.

Forages usually contain all the essential nutrient needed by ruminants but the amount vary with the conditions under which they were produced (see Table 5.1). Assessment of forage nutritive value facilitates its appropriate inclusion in diets for ruminants (Andrighetto et al., 1992). The choice of using tree and shrub fodder is because of their easy accessibility, wide variety and because they reduce the requirement for expensive concentrates.

According to Blair (1990), *Trema sp.* leaves and branches were known to be eaten by ruminants. Table 4 shows that rusa deer in four farms, were found eating *Trema cordifolia*. *Trema cordifolia* has a low percentage of CP (14.37 %), CF (13.60 %) (see Table 5.6 - d) and cellulose (13.88 %) but higher percentage of lignin (10.02 %) and hemicellulose (30.73 %) (see Table 5.7 - d) compared to other tree samples. ANF such as terpenoid and saponin only exist in one of the three extraction whereas alkaloid was not present in *Trema cordifolia* (see Table 5.10). *Trema cordifolia* also has an average mean 7.24 kJ/kg of ME.

Sanches et al. (1993) found that deer exercise selectivity, mostly preferred leaves to stems and rejected dead materials. This is because green material has a higher nutritive value than dead material (Ivor and Chen, 1985). Grass and green leaves, for instance were adequate in meeting the nutrient requirement for ruminants, such as goat (Rahman and Khusahry, 1984). Leaves are of higher nutritional quality than twigs and were found to have higher chemical composition except for *Saudropus androgynus* and *Alternanthera triandra* (which were low in DM, CF, NFE and cellulose) especially CP (see Table 6.1) and minerals (Scheider and Flett., 1975). *Saudropus androgynus* has a high content of Zn (5.06 ppm) and Mn (12.54 ppm), whereas *Alternanthera triandra* has a high content of Al (8.54 ppm), K (703 ppm) and Mg (2130. 83 ppm).

In general, the leaves of herbaceous plants (shrubs) are higher in digestibility than the leaves of woody forages (trees) (Robbins and Moen, 1975; Vercoe, 1980). In the present studies *Sapium baccatum* was shown to contain a higher percentage of CP (40.18 %) and higher mean of ME (7.46 kJ/ kg) than those in *Sesbania grandiflora* or *Moringa oleifera*. In addition its DM digestibility is determined in RUSITEC showed that *Sapium baccatum* had higher digestibility than *Fragraea fragrans*. Shrubs also showed a higher DM digestibility than those observed in tree leaves, i.e. *Artocapus integra* and *Fragraea fragrans* (see figure 5.3).

Acacia mangium, a tree species from *Acacia sp.* were widely planted for soft wood production. This tree is also suitable to be planted along the fence to provide shade in deer farm in Malaysia. Farmed deer are known to eat the tree leaves as they stroll along the fence. Vercoe (1979) reported that *Acacia mangium* was one of the browse plant species which were seen eaten by livestock in Australia.

Ficus hispida in Table 5.7 - d were compared to Rahman and Khusahry (1984). It shows that all chemical composition were higher than listed except for CP were within ranged with 14.64 %. Substantial amount of studies on the use of *Glicidia sepium* and *Manihot esculenta* (Ravindran, 1993) as sources of feeds have been carried out. These species thrives well in the tropics and are also suitable to be planted as multipurpose plants (as feed, tree fencing or tree - shades in / within the confinement).

Dolmat and Basiron (1995) presented that rusa deer dislike *Stenachlaena palustris* and *Melastoma malabathricum* but Table 5.1 shows differently in Behrang and Taman Tasik Perdana.

6.2.2 Shrub legumes

Browse and tree legumes offer considerable potential to enhance animals productivity in the tropics. A good number of plants have been analysed for their potential as deer feed (Mc Arthur et al, 1992) but similar studies in tropics are lacking. Several tropical plants purposely planted in the deer farm consist of tree legumes such as *Leuceana leucocephala*, *Sesbania grandiflora* and *Calliandra callothyrsus*. In addition (n = 6) more species were found in the present studies to be suitable to be used as rusa deer feed. Further agronomic studies are require to establish optimum conditions for planting browse plants including shrub legumes as feed for deer must be carried out to ensure predictable growth performance.

Calopogonium mucunoides and *Centrosema pubescens* are the two most common legume plants planted in most farm. These plants can be easily grown and are well known for their high yield as persistency (Skerman, 1977). *Calopogonium mucunoides* has the lowest percentage of cellulose (3.99 %), lignin (5.42 %), CP (20.52 %) and EE (3.14%) but high in CF (31.05 %). *Centrosema pubescens* on the other hand, had a high content of ash compared to *Calopogonium mucunoides* (8.44 % and 6.37 % respectively).

Leuceana sp. serves as an important source of high quality feed for ruminants in tropical feeding system (Vadiveloo, 1985) and has been used as sole feeds for ruminants and as supplement to low quality feeds (Norton et al., 1989). Substantial variation in the quality of leaves, due to location, fertilizer application and strain used may pose problem in routine of use *Leuceana* as deer feed. When the *Leuceana leucocephala* level in Table 5.7 - e were compared to those reported by Jalaludin (1987), the DM, EE and Ash levels were higher but CF and NFE were lower. Only CP with 23.14 % was within ranged 20 % - 25 %. *Leuceana leucocephala* also appeared not to contain alkaloid but saponin as determined by three solvents extraction on TLC plates. High inclusion of *Leuceana leucocephala* in the diet is recommended for ruminants because of the toxic effect of mimosine (Quirk et al, 1988).

The use of shrub legumes is being encouraged to supplement low quality grasses which comprise most of the diet of ruminants in many tropical areas (Devendra; 1993; Wiegand, 1996). Shrubs legumes such as *Leuceana leucocephala* and *Neptunia oleraceae* have many advantages over herbaceous legumes including the ability to trap subsoil moisture and nutrients, to produce high yeilds and to retain good levels of nitrogen and other nutrients in the leaves and to persist mild drought. Most legumes are high in fibre (Skerman, 1977) that was also evident in CF content in four legume plants which ranged from 9.52% - 31.05 % (average 20.98 %). The legume plants also have a high percentage of fat (average EE : 4.18 %). CP and ash in legume plants ranged from 20 % - 45 % and 6.37 % - 8.44 % respectively. Such a high level of CP in these shrub legumes are highly recommended for deer in captivity, especially in feeding system whereby grass (*Brachiaria deumbens*.) were offered. Protein supplementation (from legumes) of grass diets containing less than 7 % CP/kg DM was shown to increase DM intake and animals performance (Minson and Milford, 1967).

In the present studies, legume plants were found to have a moderate amount of mineral except for Ca with more than 200 ppm although in some species the concentration could be as low as 109 ppm in *Neptunia oleraceae*. *Neptunia oleracea* appeared to be the least nutrious compared to other legume plants analysed. It contained highest amount of lignin (10.27 %) and hemicellulose (26.26 %) (see Table 5.7 - b) and relatively low mean of ME (6.8286 kJ/kg DM).

6.2.3 Undergrowth (weeds)

The abundant availability of undergrowth in secondary forest can also be used as a feed resource for ruminants (Dahlan et al., 1993). *Asystasia gangetica* and *Mikania micrantha* are two most commonly found weeds in tree crops plantation (e.g. oil palm), which can easily be controlled by grazing ruminants (Dolmat and Basiron, 1995). Dolmat and Basiron (1995) also presented evidence that deer like to eat *Mikania micrantha, Melastoma malabathricum* and *Asystasia gangetica*. *Melastoma malabathricum* is regarded as a weed in Taman Tasik Perdana and as browse plants in Ulu Kati farm. These three weeds and *Mimosa invisa* were eaten in most certain deer farms visited (see Table 5.1).

Melastoma malabathricum, a shrub, has a high DM and CP. Other nutrient occured in moderate level. Table 5.8 shows that *Melastoma malabathricum* has a low content of K, Mg and Al (43.39 ppm, 17.89 ppm and 0.37 ppm respectively). The low amount in Al content is desirable as Al is a toxic mineral if present in more than 15 ppm (McDowell et al., 1993). The Ca : P for the plant is higher than the average ratio (15.4 : 1 to 1 : 1) (see Table 5.8).

There was limited research on *Mikania micrantha* as ruminant feed. This weed species contained higher DM, CP, EE and Ash but lower CF (20.70% to 23.8%) when compared to those reported by Rahman and Khusahry (1984). Alkaloid presents in all extraction in *Mikania micrantha* but saponin and terpenoid exist only in petrolium ether extraction and methanol extraction respectively.

Asystasia gangetica is a herbaceous dicot weed, widely found in many primary crop plantation which rapidly spread. It has 7 % - 20 % CP content (see Table 5.6 - c), with 42 % - 71 % NDF and 43 % - 78 % of ADF (see table 5.7 - c). The higher intake of *Asystasia gangetica* is an asset which can be expose. According to Suparjo et al. (1988). *Asystasia gangetica* has a higher nutritive value with CP digestibility around 7% -22 %. Table 5.6 - c shows that *Asystasia gangetica* has 18.05 % of CP. Yeoh and Wong (1993) agree that *Asystasia gangetica* was a potential feed source with high protein content and good nutritive value where ANF not detected and have a favourable amount of mineral The Ca : P in *Asystasia gagentica* is 4.4 : 1 and the Na is rather low with 8.92 ppm. The other minerals content were moderate (see Table 5.8 and Table 5.9). Table 5.10 shows the present of saponin, terpenoid and alkaloid except in MeOH extraction in *Asystasia gangetica*.

Mimosa invisa is in the same family with *Mimosa pudica*, which is the different was its bigger size. These weed exist in only one farm in Sg Perak However Rashid (per. comm) stated that deer eat the plant in many deer farm despite it thorny stems. The plant has high percentage of cellulose (30.35 %) but low in hemicellulose (10.43 %) (see Table 5.7 - c). Table 5.8 and Table 5.9 shows that *Mimosa invisa* has the lowest amount of Na (7.03 ppm) and Al (0.37 ppm).

The other weed that has the potential is *Hyptis brevipes*, which have 24.63 % of CP, 10.54 % of DM and 11.35 % of CF which is the lowest DM and CF among the weeds and 3.51 % of EE and 17.58 % of ash, which is the highest EE and ash in weeds. *Hyptis brevipes* has a high K (606.74 ppm). The requirement of this mineral in the diet of deer is not known. If the K requirement of deer is similar to the 0.5% - 0.6 % as reported for sheep and cattle (Minson et al, 1983), these plant has sufficient level of K.

Table 5.5 list out plants that were introduced as potential deer feed in several deer farms. *Gynandropsis gynandra,* despite of having the highest content of Al (30.09 ppm) has the least lignin (3.30 %). CP and EE were also low relatively (15.91 % and 1.27 % respectively; see Table 5.7 - c). This leafy weeds, however can be easily grown in sandy soil. Saponin was not present in the all TLC extraction on this plant (see Table 5.10).

6.2.4 Grasses

Tropical grasses generally has lower herbage quality due to its higher lignin content (Van Soest, 1975) than temperate grasses (Norton, 1982). According to McIvor (1981), tropical grass species tend to have lower CP and minerals which decline rapidly during dry season. *Panicum maximum* and *Pennisetum purpureum* are two grass species recommended by MARDI to be planted in deer farms (Nasir et al., 1992). It was observed in the present studies that whenever there were enough browse plants on offer, only limited amount of grass was grazed by rusa deer

(*Cervus timorensis*). In fact grass was not regarded as an important forage in any habitat type for deer (Kohn and Mooty, 1971). Nevertheless deer in oil - palm plantation was found to prefer *Panicum maximum* and *Pennisetum purpureum* to other pastures (Dolmat and Basiron, 1995).

From Table 5.6 - e, *Panicum maximum* had the highest DM (26.56 %), CP (31.24 %) and ash (16.00 %) compared to other grassess. *Pennisetum purpureum* had the highest percentage of EE (3.45 %) and cellulose (24.35 %) but low in lignin (3.74 %) than the other two grasses species. The hemicellulose and lignin were higher in *Panicum maximum* (12.15 % and 12.83 % respectively) but contained the lowest percentage of cellulose when compared to *Pennisetum purpureum* and *Brachiaria mutica* (6.58 %, 24.35 % and 22.55% respectively; see Table 5.7 - e).

Brachiaria mutica (paragrass) had a very low Zn (0.065 ppm) and hemicellulose (4.78 %) contents than those in other plants except for *Homalanthus populifolius* (hemicellulose with 4.30 %).

6.3 *In Vitro* Methods : Estimation of ME contents and DM digestibilities

In vitro methods such as gas production test and RUSITEC system were used in the present studies to estimate ME contents and DM digestibilities in selected plant species. These two methods, despite their oversimplification of *in vivo* methods, are widely used in initial ascessment of feed nutritional quality (Ammerman and Henry, 1985).

6.3.1 Metabolizable Energy

Metabolizable Energy (ME) is defined as intake energy minus energy lost in the feces, urine and combustible gas .The ME of forage is expressed in megacalories (Mcal)/kg DM and kilocalories and usually ranges from 1.5 to 2.5 Mcal. ME values of feedingstuff are essential as a starting point for net energy systems for formulating livestock rations to fulfill specific energy requirements. The gas test methods by Menke et al, (1979) is one of the *in vitro* methods for ME estimation which has been regarded to be much better in the sense of simplicity, consistency and accuracy than the two stage enzyme methods by Tilley and Terry (1963).

ME levels are similar in browse plants range to grass. Energy from tree fodder may not be as important as the protein derived from it. Goats have been shown to be more efficient in digesting fibre than sheep or cattle, the ME intake is higher per unit of feed intake. ME may also be reported in MJ or kJ and it was suggested that the ME for the deer is 0.85 MJ/kg w 0.75 (Delholme, 1984).

Of the 9 plants analysed using the gas test (see Figure 5.2), the average level of ME was found to range from 5.82 kJ/kg to 8.16 kJ/ kg. Time of plant sampling may influence the ME value obtained. Feb and Mac was the growing month of the year. For instance, certain plant species e.g. *Gnetum gnemom* showed that an increase in growth towards the end of the year from 7.60 kJ/kg to 8.57 kJ/kg DM whereas *Ficus hispida, Saudropus androgynus* and *Neptunia oleraceae* showed vice -versa. *Trema orientalis* appeared not to be influenced by time of sampling. The ME value remained relatively constant at about 7 kJ/kg DM. *Moringa oleifera* on the other hand, had a higher growth during the early and the end of the year (8.50 kJ/kg DM and 8.22 kJ/kg DM) .

6.3.2 RUSITEC fermentation system

A total of 11 plants (1 grass, 3 tree leaves and 7 shrubs) were analysed for their digestibility potential which was measured by the rate of DM disappearance after fermentation in RUSITEC system. Fermentation were carried out using rumen liquor collected from a slaughtered captivity rusa deer at UPM, Serdang. The donor deer was fed with diet consisting of higher proportion of roughage :

concentrate to ensure that the microbial population in the rumen reflects those of cellulolytic type.

Figure 5.3 shows a steady increase of digestibility disappearance from 24 h to 120h. *Ficus hispida* has a mean digestibility less than 0.2 to more than 0.6 which show the same digestibility disappearance with *Pennisetum purpureum* at 120 h. At 120 h, *Artocarpus integra* and *Fragreae fragrans* also have the same digestibility disappearance with more than 0.8 whereas *Dipalazium esculentum*, *Morinda citrifolia* and *Ocimum basilicum* have less than 0.8. *Premna cordifolia* has the least amount of digestibility disappearance at 120 h than the other 10 plants.

The extent of DM digestibility is not necessarily determined by the lignin contents in the plants. Plants with the lowest DM digested at 120 h i.e. *Morinda citrofolia*, *Premna cordifolia* and *Sapium baccatum* contain lignin at 7.38 %, 9.57% and 6.97 % respectively.

According to Bogdan (1977), the higher CP in the forage, the higher is its digestibility. However, as seen in Table 5.10, the plants with higher CP did not show a higher digestibility than those other plants with low CP (e.g. *Dipalazium esculentum* and *Premna cordifolia*). *Pluchea indica* with 26.40 % of CP shows a higher digestibility at 24 h and 96 h than the other 10 plants. *Pennisetum purpureum* show the highest in digestibility in 48 h and 72 h, while *Sesbania grandiflora* at 120 h with 95.95 %. The CP level in *Sesbania grandiflora* and *Pennisetum purpureum* are 21.13%.

Other factors (e.g. ANF contents) in these plants are thought to influence the extent of DM digestibility *in vitro*. The information obtained from the RUSITEC system may not necessarily reflects those which occurred *in vivo*. Plants with low DM digestibility *in vitro* may have higher DM digestibility *in vivo*. Studies in goats and cattle consuming tannin –rich browse showed marked reduction of tannin contents in extrusa samples collected from esophagus (Provenza and Malachek, 1984; Burrit et al, 1987). This suggests the involvement of a salivary defence mechanism in ruminants which was also reported in the saliva mule deer (*Odoncoileus heminous heminous*) which contains more protein, including a prolin – rich protein and has a greater tannin – binding capacity than sheep and cow saliva (Austin et al, 1989; Robbins et al., 1991).

		Dry matter digestibility (%)				
Plants Innoculation (h)	CP (%)	24 h	48 h	72 h	96 h	120 h
Artocarpus integra	22.62	40.00	63.27	67.27	73.28	87.93
Dipalazium esculentum	29.94	23.71	36.04	40.61	61.76	79.81
Ficus hispida	14.64	17.76	38.79	56.90	64.51	74.79
Fragraea fragrans	11.30	31.31	47.43	57.15	64.30	88.22
Morinda citrofolia	18.23	31.79	38.19	40.00	52.51	60.45
Ocimum basilicum	7.89	31.85	45.54	54.26	59.48	80.30
Pennisetum purpureum	21.13	56.77	65.07	69.66	71.15	73.96
Pluchea indica	26.40	58.95	61.24	65.34	72.17	83.22
Premna cordifolia	26.80	29.54	48.11	56.45	60.01	66.69
Sapium baccatum	8.69	34.19	45.60	50.59	62.05	68.46
Sesbania grandiflora	21.13	27.15	36.83	45.82	70.54	95.95

Table 6.2 : Comparison between CP content and *in vitro* DMD (RUSITEC) in 11 selected plants

6.4 Anti-nutritional Factors (ANF)

A major factor limiting the wider use of browse plant and tree legumes is the ubiquitous distribution of a diverse array of natural compounds which are capable of precipitating adverse effects in animals (D'Mello, 1992). These compounds include tannin (condensed and hydrolysable, essential oils and aromatics compound and are collectively termed as anti – nutritional factors (ANF). These ANF may constitute to low palatability and nutrient digestibility of many tree leaves even though they are similar to good quality fodder in chemical composition (Kumar and Vaithiyanathan, 1990). The total intake of ANF must be minimized (Nout, 1993). Otherwise toxic effects due to damage in the liver, kidneys and the epitelium of the digestive tract could take place (Kumar and Sigh, 1984; Reed, 1995). Hydrolysable tannin for instance can be degraded in the digestive tract to phenols and sugar. Subsequent absorption of phenols causes toxic effects (McLeod, 1974). The distribution of several ANF in a single plants species causes difficulties with detoxification, particularly if the deleterious compounds are heat stables. Forage selection is entirely reduced to plant protected by secondary compounds.

Rusa deer (*Cervus timorensis*) and other species of deer appeared not to be deterred absolutely from eating available browse plants in the confinement despite the present of ANF in majority of plants analysed. This could be attributed to several behavioural and physiological adaptations including selective feeding and / or generation of more prolin – rich protein in the saliva to enable enhanced ANF – binding capacity (Robbins et al. 1987; Austin et al. 1989). The toxic effect of several of these ANF can be harmless by biodegradation in the rumen with appropriate microrganism actions. Tannic acid can be neutralized in goats as a result of higher activity of tannase of microbial origin in their rumen mucosa (Norton, 1982). These anti-nutritive contituents do not affect all herbivores equally (Robbins et al., 1987; Silanikove et al, 1996). Deer (Prior, 1968) and goats (Silanikove et al, 1996) have comparatively large liver and may be able to tolerate poisoning of ANF to this organ, of a degree which prove to be fatal to cattle (Gary et.al, 1992).

These ANF compound in browse plants are often implicated in reduced palatability and low rate of evacuation of digesta out of the rumen. They function as defensive role that ensures survival of the plants (Rosenthal and Janzen, 1979;

Coley et al., 1985). Small quantities of harmful secondary compound can be tolerated by domesticated livestock especially where the offending plant is not used as the sole diet (Mehansho et al., 1987). In general, tropical plants contain a higher level of allelopathic (secondary compound) than those in temperate region.

Leuceana leucocephala is a nutritious and highly palatable shrub legumes that contain between 1% - 12% of non - protein acid amino mimosine, which is toxic to both ruminants and monogastric (Jones, 1979). Peerzada et al. (1990) reported that although *Morinda citrifolia* can be used as nutritious feed resources based on PA composition, this plant gave a strong test for the presence of terpenes. *Premna cordifolia.* also showed a distribution of various terpenoid compounds (Reddy and Radhakrishna, 1990), some of which may exert antimicrobial activities (Habtemariam et al,1993).

Certain ANF including saponin, cynide and nitrite may extend their unpalatable characteristics to the level of being poisonous. Some of the ANF in *Melastoma malabathricum* have good potential in treating various illness (Yoshida et al., 1992; Mohandoss and Ravindran, 1993). *Moringa oleifera* and *Hibiscus rosa-sinensis* were commonly used by as Indian abortifacient plants but recent report (Nath et al., 1992) indicated that *Hibiscus rosa-sinensis* flower lacked the acclaimed teratologic potentials. While according to Fleisher and Fleisher (1992), *Ocimum basilicum* are traditionally used as a condiment in gastrodisorder treatment and antibacterial studies (Caceres et al., 1993). Other plants also have medicinal value such as *Morinda citrifolia* (Mala-Srivastava et al., 1993; Aalbersberg et al, 1993; Dittmar, 1993) and *Solanum nigrum* (Aruna-Krishnakuma et al., 1991).

Analysis with HPLC of extract from *Saudropus andogynus* and *Moringa oleifera* (Tee and Lim, 1992), showed the existence of saponin which cause losses in certain nutritional quality in plants. Edible *Barringtonia sp.* may also contain saponin especially in the bark and seed which were considered as poison (Jebb, 1992). Alex et al. (1992) and Tungtrakanoung and Rhienpanish (1992) found that *Mimosa invisa* can be poisonous to animals such as buffaloes and heifer because of it toxic cyanide and nitrite contents.

Aikaloid depresses relative acceptability of plants in term of choice between alternative or of absolute intake or may even act as delecterious agents to the animals' health and productivity. Some are toxic, others appear not to be directly toxic to animals but depress intake while other alter the extend and site of digestion and harmless direct consequences for intake and metabolism (Lechner - Doll et al. 1995).