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# Research Article
# Potential of Raw and Processed Kenaf (*Hibiscus cannabinus*) as Alternative Nutrient Sources in Ruminant Feed Production in Malaysia

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## Abstract

**Background and Objective:** Since the world population reaches nine billion by 2050, both humans and animals may experience further malnourishment and starvation. It is crucial to comprehend the current state of the alternative plant. The study was carried out to evaluate the potential of kenaf (*Hibiscus cannabinus*) as a rich source of fibre and nutritional benefit for high-quality ruminant feed production in Malaysia. **Materials and Methods:** The fibre content and nutritional elements of raw kenaf tree (3 months old) and two types of kenaf processed products (bast and core fibres) were evaluated using the standard procedure of proximate analysis. The nutritional elements (i.e., dry matter, crude protein, metabolizable energy, ether extract, crude fibre, acid detergent fibre, organic matter digestibility and total digestible nutrient) of different groups were assessed proximately using standard techniques. **Results:** The result revealed that nutrient elements such as dry matter, crude protein and total digestible nutrients were significantly ($p<0.05$) higher in the leaves of raw kenaf plants while metabolizable energy, ether extract and organic metabolizable energy differed insignificant ($p>0.05$) between leaves and stems and crude fibre and acid detergent fibre in stems were substantially higher ($p>0.05$). For the processed kenaf plants, nutrient elements such as dry matter, ether extract and total digestible nutrients varied significantly in both bast, 1st and 2nd processed cores, while nutrient elements including crude fibre, metabolizable energy, crude protein, acid detergent fibre and organic matter digestibility were insignificantly differentiated ($p>0.05$) from one another. The combination of kenaf samples both raw and processed products detected potential nutritional values for ruminants' consumption. Raw kenaf is good in nutritional values supply whereas, processed kenaf is good for its longer shelf life and fibre content. **Conclusion:** Therefore, the findings of this study suggested that raw and processed kenaf products have the potential to be formulated into high-quality animal feed.

Key words: Kenaf, fibre, feed, ruminant, production, nutrition, livestock

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The potential of kenaf as an animal feedstock is determined by its fibre content, which allows for a wide range of varieties to be grown[1,2], as kenaf contains more cellulose than other herbaceous energy crops when compared to other fibre plants[3,4]. Furthermore, ruminants preserve strong cellulolytic and hemicellulolytic bacteria that offer nutrients to the host through the degradation of the food in the digestive system and play an important role in the breaking down of uncontrolled hemicellulose biomass[5]. The energy content of kenaf ranges from 15 to 24%, which shows that kenaf is high in energy and may be suitable for animal diets as well[6]. The high cellulose content of kenaf suggests that it could be an appealing feedstock for ethanol production[7,8], because it encounters competition from alternative biomass feedstocks for ethanol or bioenergy of another type of plants[3,9]. Energy shortage is the most frequent problem restricting small ruminant nutrition, leading to lower production, reproductive failure, an increase in mortality cases and increased susceptibility to diseases and parasites[10]. Besides, sheep and goats are typically underfed as a result of poor pasture quality and roughages are the primary source of energy shortage[11]. Thus, substituting feed items that give appropriate energy is critical to resolving this issue.

The nutrient value of kenaf cannot be over emphasised for example, the fibre in kenaf is an important component of the diet, in some cases, it is made up of structural carbs which are cellulose, hemicellulose and lignin[12] and the crude fibre technique is useful in determining the nutritional value of forages, also essential for the non-ruminants[13,14], even though digestion rates are low, it is easily digested by ruminants and normally does not create any difficulties. According to research conducted by Akil *et al.*[15], dry weight basis, kenaf contains 45 to 57% cellulose, 21.5% hemicellulose and 8-13% lignin making it more nutritional cellulose than other fibre plants, such as herbaceous energy crops[3,4]. Wong *et al.*[16] reported that bast and core had the highest crude fibre range 53-54% CF, followed by stems at 40% CF and leaves only 16% CF, which corresponds to leaves ranges of 15-16%, stems: 34-37%, this fibre composition determines the potential of kenaf as a feedstock[17].

Other than that, the crude protein content of the total plant varies from 6-23%, whereas the leaf protein content varies from 14-34%[18]. Beneficially, the young stems and leaves of kenaf have rich in nutrients and could be used as feed for animals[19,20]. In addition, the leaves of the kenaf are extremely important to the forage's nutritional value and to obtain a high protein and dry matter yield, a variety of mature harvest and correct cultivars is required[21-23]. The most basic technique for regulating nutrient diets in ruminant animals is to supply enough kenaf plants as a source by utilising 3 months old, due to their high nutrient content. This study utilised 3 months old kenaf plants, specifically, the parts that include leaves, stems, bast and processed cores, to investigate the richness and palatability, as well as cost-effectiveness for ruminant animals and Malaysian farmers and suggests to the Malaysian government the important mass production of animals using kenaf plants as ingredients that can boost ruminant animals' standard.

## MATERIALS AND METHODS

**Study site:** The feed analysis study is conducted at Pulau Pinang Malaysia duration (January to May, 2020). The climate in this study is characterised as equatorial, meaning that it is hot and humid all year. The average annual rainfall is 250 cm (98 inches) and the average temperature is 27°C. The climate of the peninsula is directly affected by wind from the mainland.

**Sample collection and preparation of processed kenaf:** The feed sampling study is conducted at Kelantan Malaysia on January, 2020. Approximately 500 g (3 months old) dry samples of the kenaf plants were randomly selected from different feed bags at Lembaga Kenaf dan Tembakau Negara (Pusat Pemprosesan Kenaf Insitu (PPKI) Air Tawar, Kampung Air Tawar Tok Bali, Kelantan). The collected samples were then oven-dried at less than 60°C until a constant weight was achieved, ground into small particles and poured into pill bottles, labelled and stored in a safe and cool place.

**Field sampling of raw kenaf:** The feed sampling study is conducted at Kelantan Malaysia on January, 2020. Approximately 500 g (3 months old) fresh kenaf plants were randomly selected in the farms located at Institut Latihan Kenaf dan Tembakau (Lembaga Kenaf dan Tembakau Negara Padang Pak Amat, 16800, Pasir Putih, Kelantan) and Ladang Kenaf Jeli, Kelantan. The samples were dried and ground into small particles and poured into pill bottles, labelled and stored in a safe and cool place.

**Proximate analysis of nutrient elements:** A total of 20 g of each group from each replicate were collected and subjected to proximate analysis. This analysis was conducted following standard procedures to identify the elements of the nutrient content in both processed and raw kenaf at the Feed Technology Laboratory, Technology Industry USM. The

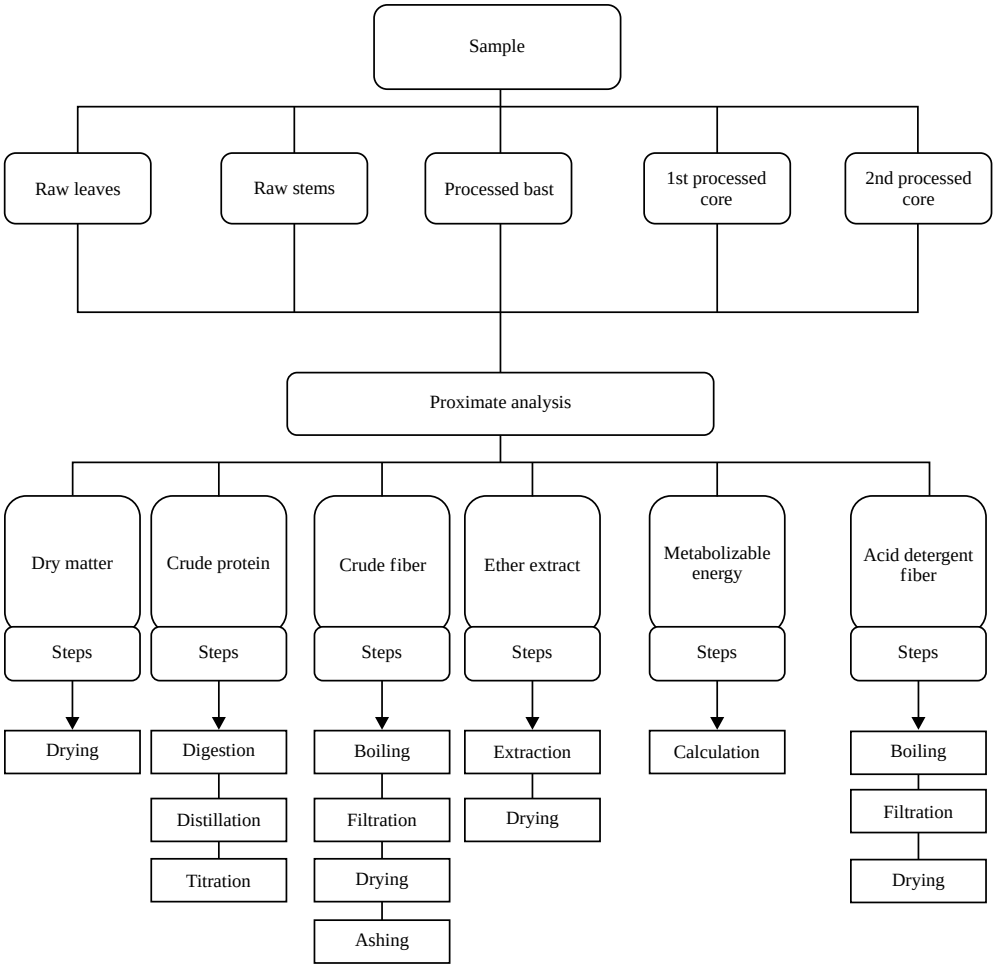


Fig. 1: Flow chart of kenaf samples and proximate analysis by Zaklouta *et al.*[13]

nutrient elements such as dry matter (DM), crude proteins (CP), metabolizable energy (ME), ether extract (EE), crude fibre (CF), acid detergent fibre (ADF), organic matter digestibility (OMD) and total digestible nutrient (TDN) were subjected in proximate analysis. The flow of analysis was referred in Fig. 1.

**Analysis to investigate the dry matter (DM):** The initial weight of about 5 g of feed sample was weighed and transferred in a drying oven at 105°C for at least 12 hrs. The sample was allowed to cool in a dryer then weighed again and finally broken down into small pieces with a grinder. The procedure of this experiment was repeated three times to reduce errors and allowed the generation of accurate data. The method by Zaklouta *et al.*[13].

**Calculation:**

$$\text{Moisture content (\%)} = \frac{(c-b)\times 100}{b-a}$$

$$\text{Dry matter (\%)} = 100\ \% - \text{Moisture content (\%)}$$

a = Weight of the empty crucible
b = Weight of crucible+sample before drying process
c = Weight of crucible+sample after drying process

**Analysis to investigate crude protein (CP):** Crude protein identification was conducted by following the method adopted by Zaklouta *et al.*[13]. There are three main processes in crude protein investigation that include digestion, distillation and titration. The procedure of this experiment was repeated three times to reduce errors and allowed the generation of accurate data.

**Digestion process:** The feed was digested using Kjeldahl's (Velp-Scientifica, Heating Digester) because it can evaluate the total nitrogen content of the sample after it has been digested in sulphuric acid with a catalyst. As 0.5 g feed samples were approximately weighed and transferred into a Kjeldahl flask

and 1 tablet of catalyst was poured into the flask, followed by the additional 10 mL concentrated Sulphuric Acid ($H_2SO_4$) solution. As 3 mL Hydrogen Peroxide ($H_2O_2$) solution was added to the preparation in the flask. The samples were let to digest until the content became clear colour. The samples were allowed to stand for 3-10 hrs to thorough the process, then heated at low temperature for complete reaction in the flask and finally allowed to cool.

**Distillation process:** As 25 mL of 4% $H_3BO_3$ boric acid and 35 mL of 35% NaOH sodium hydroxide solutions were transferred into a distillation tube that was connected to a distillation machine (Protein Distillation Unit Velp Scientifica, UDK 127, ID 141395). The distillation process took about 3-5 min until the colour changed to blue (endpoint) after reacting with ammonia gas (i.e., the boric acid solution turned blue due to reaction with ammonia gas).

**Titration process:** The distilled solution obtained was titrated with 0.01 M Sulphuric Acid ($H_2SO_4$) solution up until the colour changed from blue to red as the endpoint. The calculation was stated by Zaklouta *et al.*[13].

**Calculation:**

$$\text{Crude protein (\%)} = \frac{P \times M \times L \times Fc \times Fp \times 100}{W \times DM\ (\%)}$$

W = Feed sample (g)
P = g nitrogen equivalence to 1 mL acid 1 M sulphuric (0.028)
M = Molarity for standard acid use for titration (0.01 M)
L = Milliliter titration after minus the control sample titration
Fc = Dilution factor (250/5)
Fp = Nitrogen changing factor to crude protein (6.25)
DM (%) = Dry matter at 2.2.1

**Experiment to investigate crude lipids/ether extracts (EE):** For the ether extract experiment, 3 g feed samples were approximately weighed in a pre-weighed extraction thimble. The thimble was transferred into the Soxhlet apparatus (M-Top Soxhlet Extraction Mantles 6 Races, Model MS-EAM Series (with temperature controller), MTOPs-KOREA). As 200 mL petroleum ether extract was then poured into a round bottom flask of the Soxhlet and the condenser was allowed to run water as cooling effects in the fume chamber (Labline General Purpose Fume cupboard), which was heated at a low temperature of about 40-60°C for 8-10 hrs. The round bottom flask was then detached from the Soxhlet apparatus to drain out the solvent. The moist ether extract in the round bottom flask was placed in the oven (Memmert) and dried at 100°C for 24 hrs, it was then allowed to cool in the desiccator and lastly, the weight (Mettler Toledo, JB1603-L-C, 2009) as described by Zaklouta *et al.*[13]. The procedure of this experiment was repeated three times to reduce errors and allowed the generation of accurate data.

**Calculation:**

$$\text{Ether extract (\%)} = \frac{(d-c) \times 100}{(b-a) \times DM\ (\%)}$$

a = Weight of empty thimble
b = Weight of thimble+sample
c = Weight of the empty round bottom flask
d = Weight of round bottom flask+extracted lipid (after drying)
DM (%) = Dry matter at 2.2.1

**Analysis to investigate crude fibre (CF):** For the crude fibre, nutrient investigation, 2.0 g of dried and defatted sample was weighed and transferred into a round bottom flask, 150 mL (5%) Sulphuric Acid ($H_2SO_4$) solution was then added and boiled for 30 min (initially at low temperature and later increased to boiling point 40-60°C) by using extractor M-Top Extraction Mantles 6 Races, Model MS-EAM Series (with temperature controller) MTOPs-KOREA, 5 mL of NaOH was transferred and the excess acids were neutralized by using 40 % NaOH (Litmus blue paper) as an indicator. As 10 mL 25% of NaOH was put in by the addition of 2 drops of antiform was added and refluxed for 30 min. The hot mixture was filtered and the precipitate was rinsed away by using 1% HCl followed by hot water to remove the acids. Phenolphthalein was applied as an indicator to identify the e-endpoint. The residual samples on the filter paper were rinsed with methyl spirit, positioned inside the crucible and dried in an oven at 105°C until a constant weight was gotten (overnight). The dried filter paper was then moved inside the desiccator to cool down and weighed. The crucible was placed to ash in a muffle furnace (Thermolyne SYBRON, Type 6000 Furnace) and heated at 450°C until the black spot vanished. The crucible was left to cool and the final weight was noted down. The procedure of this experiment was repeated three times to reduce errors and allowed the generation of accurate data.

**Calculation:**

$$\text{Crude fibre (\%)} = \frac{(c-d)\times 100}{a\times DM\,(\%)}$$

a = Weight of feed sample
b = Weight of the crucible
c = Weight of crucible+filtered residue (after drying)
d = Weight of crucible+ash
DM (%) = Dry matter at 2.2.1

**Experiment to investigate acid detergent fibre (ADF):** Acid detergent fibre nutrient investigation was conducted with 1 g of sample weighed and transferred into the round bottom flask. As 100 mL acid detergent solution was transferred into the flask and then heated to boil for 60 min. The sample was then filtered and weighed and allowed to dry by using a vacuum pump (Pump Vacuum GAST, Model DOA-P504-BN, ID 0410603709, Mich, USA). The precipitate was washed away with hot distilled water and wetted with acetone and allowed the crucible to dry out in the oven at 105°C for 24 hrs and the final weight was recorded. The procedure of this experiment was repeated three times to reduce errors and allowed the generation of accurate data.

**Calculation:**

$$\text{Acid detergent fibre (\%)} = \frac{(c-b)\times 100}{a}$$

a = Weight of feed sample
b = Weight of the crucible
c = Weight of crucible+filtered residue (after drying)

**Calculation of metabolizable energy (ME):** Metabolizable energy calculation was performed by following method[13].

**Calculation:**

$$\text{Organic matter digestibility (\%)} = 99.41-(1.17\%\ ADF)$$

$$\text{Metabolizable energy (MJ kg}^{-1}) = 0.16\times\text{Organic matter digestibility (\%)}$$

$$\text{Total digestible nutrient (\%)} = 96.35-(ADF\ (\%)\times 1.15)$$

Where:
ADF (%) = Acid detergent fibre at 2.2.5

**Statistical analysis:** Detailed data were evaluated using SPSS Statistic (Ver. 17 for Windows, SPSS Inc. Chicago, Illinois). To test significant differences, before analysis, all data were examined with the Shapiro Wilk test for normal distribution. The p-values are more than 0.05, thus it rejected the alternative hypothesis and determine that the data comes from a normal distribution to compare data gathered on various groups, a one-way analysis of variance was conducted. For mean separation ($p<0.05$) across samples tests, Tukey-Honestly Kramer's Significant Difference multiple comparisons test was used where there were significant differences.

## RESULTS AND DISCUSSION

**Chemical compositions of nutrient elements of raw kenaf plants (*Hibiscus cannabinus*):** The result of the chemical compositions of nutrient elements viz, (dry matter (DM), crude proteins (CP), metabolizable energy (ME), ether extract (EE), crude fibre (CF), acid detergent fibre (CDF), organic matter digestibility (OMD) and total digestible nutrients (TDN) of the raw kenaf plants was presented in Table 1. The result revealed that nutrient elements such as DM, CP and TDN were significantly ($p<0.05$) higher in the leaves of raw kenaf plants than the stems of the same plants with respective values of 27.04, 22.96 and 66.03%. For the elements such as ME, EE and OMD, the records revealed insignificant differences ($p>0.05$) between obtainable values of leaves and stem of the same plants, while, CF and ADF in stems were substantially higher ($p>0.05$) than leaves of same raw kenaf plants with values (40.92 and 47.00%), respectively.

**Chemical compositions of nutrient elements of processed kenaf plants (*Hibiscus cannabinus*):** The result of the chemical compositions of nutrient elements viz, (DM, CP, EE, CF, ADF, OMD and TDN) of the processed kenaf plants was detailed in (Table 2). Significant variations occurred in the composition of nutrient elements such as DM, EE and TDN and both bast, 1st and 2nd processed cores of the processed kenaf plants, with higher values of DM in bast (100%) and EE in bast (0.61%), these values substantially differentiated from the recorded values recorded in 1st and 2nd processed cores, nevertheless, there is no significant different ($p>0.05$) in EE between 1st and 2nd processed cores of the same kenaf plants. For the TDN, 1st processed core recorded a significantly higher value (25.67%), this value differed significantly ($p<0.05$) from the TND of bast and 2nd processed core of the same kenaf plants. In both sections (Bast and processed cores) of the same plants, compositions of the nutrient elements such as CF, ME, CP, ADF and OMD were insignificantly differentiated from one another.

Table 1: Chemical compositions of nutrient elements of raw kenaf plants

| Parameter | Leaves | Stem |
|---|---|---|
| DM | 27.04±0.86[b] | 16.18±0.23[a] |
| CF | 16.1±0.33[a] | 40.92±0.34[b] |
| ME | 15.86±0.04[a] | 15.84±0.02[a] |
| EE | 2.58±0.04[a] | 1.63±0.08[a] |
| CP | 22.96±0.88[b] | 7.85±0.18[a] |
| ADF | 26.37±1.85[a] | 47.00±1.33[b] |
| OMD | 99.10±0.02[a] | 99.01±0.13[a] |
| TDN | 66.03±2.12[b] | 41.87±1.53[a] |

Values are Means±SE of mean replicates, Values followed by the same superscript(s) along the row are not significantly different (p<0.05). DM: Dry matter, CP: Crude protein, ME: Metabolizable energy, EE: Ether extract, CF: Crude fibre, ADF: Acid detergent fibre, OMD: Organic matter digestibility and TDN: Total digestible nutrients

Table 2: Chemical compositions of nutrient elements of processed kenaf plants

| Parameter | Processed bast | 1st processed core | 2nd processed core |
|---|---|---|---|
| DM | 100.00±0.00[c] | 86.97±0.01[a] | 90.94±0.03[b] |
| CF | 53.65±0.37[a] | 53.01±1.83[a] | 54.32±0.53[a] |
| ME | 15.78±0.02[a] | 15.79±0.00[a] | 15.78±0.03[a] |
| EE | 0.61±0.03[b] | 0.27±0.04[a] | 0.29±0.02[a] |
| CP | 2.10±0.21[a] | 1.38±0.04[a] | 1.53±0.01[a] |
| ADF | 64.57±1.07[a] | 61.47±0.77[a] | 66.00±0.86[a] |
| OMD | 98.65±0.01[a] | 98.69±0.01[a] | 98.63±0.01[a] |
| TDN | 22.10±1.23[b] | 25.67±0.89[c] | 19.88±0.99[a] |

Values are Means±SE of mean replicates, Values followed by the same superscript(s) along the row are not significantly different (p<0.05), DM: Dry matter, CP: Crude protein, ME: Metabolizable energy, EE: Ether extract, CF: Crude fibre, ADF: Acid detergent fibre, OMD: Organic matter digestibility and TDN: Total digestible nutrients

The use of kenaf is the need to reduce the cost of animal feed production controlled to the use of local feed sources such as palm kernel cake (PKC) and Napier, which serve as common concentrates and raw plants in Malaysia. The effort of the utilisation of kenaf plants can help animals grow and develop while also producing at a high quantity. Kenaf as a plant is widely used in the beef and goat industries in countries such as China, Thailand, Indonesia and others, however, it has not yet been fully implemented in Malaysia[24-26]. Despite the importance of kenaf plants and their nutrient benefits as ruminant feed in the tropics, there is currently a lack of information on the chemical nutritive components of kenaf [21-29]. This is because it usually exposes in the fibre industry and is not widely exposed in livestock sectors in Malaysia yet.

The 3 months old kenaf plants were chosen for this study because their nutritional levels are at their peak at that age, allowing the plants to provide proper nutrient meals for the animals' growth and development. The choice of 3 months old was correlated to that of Erickson and Kalscheur[30], as found kenaf plants to have the best nutritional quality and quantity. However, this contradicts the findings of Kujoana *et al.*[28], who in their separate research employed kenaf plants that were 6-8 and 6-10 weeks old during harvest, respectively. In this research, DM was found to be high in processed cores and bast, followed by raw kenaf. This observation was accepted because the plants were at an age of fertility of this DM which serves as a determinant for the actual quantity of feed without moisture content. In this study, it was discovered that the stems of kenaf yielded more nutrients than the leaves in terms of receiving many of the elements. This related to the observation by researchers[21,22], which revealed that the bigger the DM production value of a kenaf plant, the more mature it is, so mature harvest and cultivar are important to obtain dry matter yield. Nevertheless, the other nutrient content will decrease. The DM in the leaves is higher than in the stems, resulting in increased population density in the plants. The main important element in ruminant feed is fibre.

Crude fibre (CF) is a type of carbohydrate in the food that is referred to as a non-soluble carbohydrate and serves as a vital ingredient for ruminant intake[30]. The greater the CF, the greater the yield. The current research revealed that the highest crude fibre content was found in the bast and core at 53-54%, followed by the stem at 40% and the least in the leaves at 16%, according to this study. These findings were supported by the research work of Wong *et al.*[16], who found the range values for leaves and stems are 15-16% CF and 34-37% CF, respectively. According to Bourguignon *et al.*[17] and Saba *et al.*[31], the fibre composition of kenaf may influence its viability as a feedstock. The findings contradict the research works of Jaimes *et al.*[32], who revealed that CF is in a range of 27.27-32.90%. These range values were lower in stem and processed kenaf plants but greater in leaves. The current study also revealed that crude fibre in leaves was low in quantity compared to the other sections of the kenaf plant, this low rate is beneficial to kenaf plant output, proving that the kenaf is a viable fibre source due to its fibre content and higher cellulose content than other herbaceous energy crops[3,4]. The nutrient element acid detergent fibre (ADF) distinguishes the types of fibres in the plant, which include cellulose, hemicellulose and lignin[32]. Thus, when ADF is high, it implies that it includes a lot of cellulose and lignin and when it is low, it signifies it has a lot of hemicelluloses. The ADF in kenaf is easily digestible by ruminants, except for lignin, which is not toxic to the ruminant and is simply expelled as waste[13]. These qualities of kenaf, when fed to ruminants as a diet, can help them produce more. According to Akil *et al.*[15] on a dry weight basis, kenaf appears to contain 45-57% cellulose, 21.5% hemicellulose and 8-13% lignin, making it a rich source of

nutrition for ruminant animals. The ADF's function is to avoid high lignin content in the feed, according to previous research undertaken to assess its functionality in animal diets. For example, the research work of Zaklouta *et al.*[13]. In this work, processed kenaf plants have a higher concentration of ADF than raw kenaf plants, because of the cellulose and less lignin, this high ADF content is ideal for animal feed. This agrees with researchers[33,34], who claimed lignin would result in unpredictably low digestibility. The results of this study differed in ADF from those reported by Noori *et al.*[35], as in their work, ADF content in the leaf and stem varies between 16-24 and 50-58%, with the average leaf and stem ADF being 20 and 54%, respectively, which is outside the range of current data. Other than fibre energy also is important for ruminant growth.

The metabolizable energy (ME) content in all groups for this current research is roughly the same, at 15% and this result was discovered to be an excellent source of energy in the diet of ruminants. Kenaf has a high energy content and may be good for animal consumption[10], reported that kenaf plants with high nutrient content and the ability to produce calories of energy during digestion by animals can be beneficial to ruminant animals' diets. The ADF values. On the other hand, are connected to digestion, therefore plants with a low ADF level have a higher energy content[36]. While, the amount of crude protein (CP) in different parts of the kenaf exhibited different results in each group, related to the research works of researcher[21,37], who reported that the CP content of the leaf is higher than that of the stem. In addition, Webber[18] reported, 14-34% for the leaves and 2-12% for the stem were also presented. Disproves, however, researchers[31,38], separately stated that crude protein (CP) kenaf plants have a crude protein content of 23.4% and a stalk content of 10-12%. Both protein and non-protein nitrogen are included in nitrogen protein-nitrogen combinations[13] and fortunately, ruminants can consume both types of protein[14].

Kenaf's tender stems and leaves have high palatability and can be fed to cattle and poultry as well[20]. Aside from that, kenaf leaves and the entire plant, including the bast and core, might be used as animal feed[39] and the nutritional value of kenaf can be compared to corn silage[40]. Kenaf can be supplied raw, but it can also be ensiled[22], which is favourable in Asia[41] but not yet widely exposed in Malaysia's livestock industry. On the negative side, the level of crude protein in the whole plant, its leaves and its stem declines with age[21]. Because the crude protein content is around 15%, it is recommended that it be collected between 10 and 12 weeks of age[37]. In other words, the kenaf sample used in this study is three months old, so it possesses all of the benefits listed above. The rapid increase of fibrous components is primarily responsible for the decline in crude protein content between ages[21,42]. However, when there is a shortage of high-quality feeders, such as the challenges created by the Napier, kenaf could be employed as an element in ruminant feed[21]. If a farmer wants to reduce the cost of animal feed sources compared to newly processed kenaf (core) is the best option. However, it is high in fibre content but low other in nutritional value. However, it can potentially be supplied as a high-fibre source unconventional plant with the other essential ingredients.

On the other hand, fat is the most energy-dense of all the nutrients, containing 2.5-2.25 times the energy content of carbohydrates[43-45]. Unsuitably, most of the farmers feed their cattle with concentrated carbohydrates, which increases acid production and leads to low rumen pH and the development of acidosis, one of the most important effects of ether extract (fat) is to prevent acidosis[46]. When starch and sugar constituents in the rumen ferment at opposite rates, producing acid and fat is not fermented in the rumen, the scenario arises. As a result, it does not affect acid production and a sufficient amount of fat, i.e., ether extract (EE), must be included in the feed to suit the needs of the animals, as it is a critical and irreplaceable nutrient that provides benefits not found in other nutrient elements such as fibre and starch. The ether extracts normal range has been determined to be 2-5% lipids. However, in the present study, the range of the EE obtained was 0.27-2.58% in processed and raw kenaf, with the raw kenaf being the most significant and good in the diet supply, despite being slightly higher than the normal range. This finding corroborated the outcome of Zaklouta *et al.*[13], who stated that lipid was widely found in ruminant diets since it is present in tiny amounts of 2-5% in most plant food sources and the range was supported by the current study. However, the findings of the study contradicted the findings of Emery and Herdt[46], who reported ether extract (fat), with a fat content of 3.5%, contradicted the work of Jie *et al.*[23], who stated ether extract at the range of 4-7%.

These findings revealed that nutritive parameters of a wide range of nutritional content types in kenaf plants are good suppliers of fibre in all of its portions. Although the leaves have the highest CP content, their economic worth is negligible due to their high dry matter content. Aside from that, there isn't much ether extract in any of the sections. Above all, the different portions of kenaf have almost the same amount of energy, 15% ME, which is high for feed production.

## CONCLUSION

Kenaf's high nutritional value makes it a great non-grain-based protein-rich feed option. Despite the high CP content, the DM yield in these areas is poor in the young plant. This implies that stubble height and harvest timing should be enhanced further, 3 months old kenaf is ripe and great for producing the proper combination. Fundamentally, the widespread kenaf plantation in Malaysia may fully help us by allowing us to develop a complete mixed ration diet for sustainable ruminant feed from unconventional sources in this current animal feed crisis.

## SIGNIFICANCE STATEMENT

Kenaf is a local plant which contain high nutritional values and make a specific contribution from unconventional sources to be produced as animal feed. The purpose of the work is it will contribute to the advancement of knowledge in feed analysis and investigation of the potential sustainability of ruminant feed from the alternative source. This is because the widespread kenaf plantation in Malaysia may fully help us by allowing us to develop a complete mixed ration diet for sustainable ruminant feed. Thus, the full use of the local source can contribute to both benefits for the agriculture and livestock sectors.

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