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Characterization of nutrient composition in three different parts of sweet corn (*Zea mays* L. var. saccharata) residue as a potential for ruminant feed

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The corn residue or leftovers such as corn stalks, leaves and husk contain excellent nutritional values and are expected to give a beneficial effect on the ruminant. Thus, the objectives of this study are to characterize the nutrient composition of the stalk, leaves, and husk from sweet corn residue and to compare the nutrient composition of these three different parts of the sweet corn residue. This study was conducted at Besut, Terengganu. The sweet corn residues were collected from the Universiti Sultan Zainal Abidin (UniSZA), Tembila Farm, Besut, and were separated into three different parts before being transferred to the Plant Physiology Laboratory and Food Analysis Laboratory of UniSZA, Besut Campus. The sweet corn residue of each part was analyzed for the nutritive composition using the proximate analysis. The proximate analysis was measured based on the percentage of moisture content, ether extract, nitrogen-free extract, dry matter, crude protein, ash contents, and crude fibre. The results show that the leaves had the highest content of dry matter, ash, crude protein, and ether extract with 29.23%, 4.20%, 16.86% and 2.20%, respectively. Meanwhile, the stalk showed the highest content in crude fiber with 32.26%, and the husk had the highest energy with 288.32 kcal/g. The nutritive composition of the stalk, leaves, and husk of the sweet corn residue in this study shows significant differences $p < 0.05$. Therefore, it can be concluded that the residue of sweet corn, especially the leaves, could be used efficiently as livestock feed.

Keywords: Sweet corn (*Zea mays* L. var. saccharata), husk, leaves, stalk, proximate analysis

INTRODUCTION

Ruminant production is very significant in livestock production throughout the world, especially in developing countries (Adjorlolo et al. 2014). Despite their importance, ruminant production presents significant challenges, in particular an inadequate feed resource (Adjorlolo et al. 2014; Jamaludin, 2014). Corn is a large cereal plant and is globally popular as the queen of grains; it is the third largest commonly planted crop after wheat and rice (Jamaludin, 2014). Instead of being used for human food, corn residues can also be given to animals such as ruminants because of their excellent nutritional value which can enhance

the growth rate (Hasan, 2012). According to world agricultural production, world corn production has increased from 1,116.41 million tons to 1,133.89 million tons from the year 2020 to 2021 which represents an increase of 17.47 million tons or 1.57% around the world (World Agriculture Production, 2021).

In Malaysia, corn production increased from five thousand tons in 1971 to 60 thousand tons in 2020 growing at an average annual rate of 14.03% (Mundi, 2021). Sweet corn (*Zea mays* L. var. saccharata) is a corn that is genetically different by mutation at the sugary (su) locus. This sweet corn crop has been successful as an important commercial cash crop in many tropical and semi-tropical countries (Chavan, 2015). The use of such human-inedible parts or waste from agricultural products as animal feed will not only enhance food security for the livestock but also contribute to the alleviation of environmental problems associated with their waste disposal (Abdullah, 2016; Bakshi et al. 2017).

The feeding shortage has become a major constraint in the ruminant industry all over the world including in Malaysia. Higher feed costs are one of the major impediments to the growth of the livestock industry. In general, the cost of animal feed accounts for 25% of the total cost of production (Saadiah et al. 2019). The main factor that contributed to the higher cost of animal feed is the raw materials, which are imported from other countries.

Malaysia spends more than RM5.14 billion to import animal feed (Saadiah et al. 2019). The corn plant has a high potential to boost the economic level due to many useful benefits that can be produced from it and the residue can also be more useful rather than discarded (Saadiah et al. 2019). The corn residue that is leftovers which consists of corn stalks, leaves and husk contains excellent nutritional values and is expected to give a beneficial effect on ruminant health (Abdullah, 2016).

However, corn residues were traditionally applied for fertilisation or disposed of by combustion, which affected air pollution by the release of unpleasant odours and gases into the atmosphere. Sometimes, they were even thrown into the rivers and streams thereby endangering aquatic life (Akinfemi et al. 2009). Recycling this crop waste to be used as animal feed helps food processors to save money and reduce environmental pollution.

Corn residues are major crop residues that remained in the field after harvest. There are about 21 million tons of plant by-products produced annually and about 13,600 thousand tons of them are from corn (Akinfemi et al. 2009; Elkholy et al. 2009). However, no detailed studies were investigated regarding the nutritional value of *Zea mays* L. var. saccharata residues.

Therefore, the purpose of this study is to measure the nutritional composition of corn residues, which includes comparing the nutritional value of different parts of corn residues. The study will support the corn industry in managing the remaining portion of corn production that is no longer wasted. It may also contribute to the improvement of nutritional feeds, particularly ruminant consumption. In addition, it also helps Malaysian farmers to overcome the problem of obtaining ruminant feed and improve the nutritional value of the feed. This study can also help educate farmers to apply best management practices for corn waste to increase farmers' income production.

MATERIALS AND METHODS

Plant sample collection

Sweet corn residue samples were collected from Tembila Farm (5˚45’00’’N, 102˚37’59’’E) Universiti of Sultan Zainal Abidin (UniSZA), Besut Campus, Terengganu. Figure 1 shows the location and sample of sweet corn from this study. The collected samples were separated into three different parts which were stalks, leaves and husks before being placed into different plastic bags and transported to the Plant Physiological Laboratory Universiti of Sultan Zainal Abidin (UniSZA), Campus of Besut for further analysis. Figure 2 shows the collected different parts of sweet corn residue samples which consist of husk, leaves, and stalk.

Figure 1. Location of sweet corn plantation in the Universiti of Sultan Zainal Abidin (UniSZA) Besut Campus, Terengganu.

(a) (b) (c)

Figure 2. Different parts of sweet corn residues which consisted of (a) husk (b) leaves and (c) stalk

Plant sample preparation

Sweet corn residue samples were properly washed under tap water for 30 seconds to remove debris and remaining soil. The samples were then dried in an oven at 65 ºC for 72 hours (Association Official Analytical Chemists, 2005). The samples were grounded by using a Waring Commercial Laboratory Blender (Model 8010S/G Made in United State) into fine size to obtain homogenous powder for subsequent analysis.

The samples were then stored in a zip-lock plastic bag to keep them fresh with a label and stored under cool, dry conditions at room temperature.

Proximate composition analysis

Proximate analysis was performed to determine the quantitative measurement of moisture content (dry matter), total solids, ether extract, crude fibres, total ash, protein, nitrogen-free extract, and energy of the sweet corn residues. All samples were analysed in triplicate according to the standard methods of the Official Association of Official Analytical Chemists (AOAC) 18th edition (AOAC, 2005). The detailed procedures for each parameter were as follows:

Moisture analysis

Moisture refers to the quantity of water in the feed, while dry matter refers to the remaining material once the water is removed (AOAC, 2005). Fresh samples were used in this study and the analysis was carried out using the oven-drying method. First, the dry crucible with a lid was heated to 105 ºC for 4 hours (w_1).

Then, 3 grams of homogenised samples were weighed on an analytical scale and placed in the crucible (w_2). Subsequently, the crucible sample was heated at 105 ºC for 6 hours. Then, it was cooled in a desiccator, weighed (w_3), and removed after attaining room temperature. Below was the formulation for moisture and dry matter:

$$\%\, Moisture = (w2\,/w3)\,/(w3 - w1) \quad \textbf{Eqn. 1}$$

Where,

$w_1 = Weight\ of\ empty\ crucible\ (g)$

$w_2 = Weight\ of\ crucible(g) + weight\ of\ wet\ sample\ (g)$

$w_3 = Weight\ of\ crucible\ (g) + weight\ of\ dry\ sample\ (g)$

$$\%\ \text{Dry Matter} = 100 - \%\ \text{Moisture}$$

Ash analysis

Ash is an inorganic residue that remains after water and organic matter have been combusted (AOAC, 2005). First, the crucibles were dried with the lid in an oven at 105 ºC for four hours. The crucibles were then cooled in a desiccator and weighed after they reached room temperature (w_1). The samples were then weighed (w_2) and placed into the crucible. Samples with high moisture retained were dried in an oven for a day. The samples were placed in a muffle furnace and heated to 550 °C for an overnight period. The dried samples were then cooled in a desiccator before being weighed once they had reached room temperature (w_3). The formula below was used to estimate the ash percentage:

$$\%\, Ash = (w_3 - w_1)\,/w_2 \times 100 \quad \textbf{Eqn. 2}$$

Where,

$w_1 = Weight\ of\ empty\ crucible\ (g)$

$w_2 = Weight\ sample(g)$

$w_3 = Weight\ of\ crucible\ (g) + Ash\ (g)$

Crude protein analysis

Crude protein was analysed using the Kjeldahl method which consisted of three processes: digestion, dilution, and titration. During the digestion process, sulphuric acid (H_2SO_4) digests proteins and other organic compounds in the presence of catalysts with organic nitrogen and is converted to ammonium sulphate. 1 g of sample was placed in a digestion tube, followed by the addition of the Kjeltabs Cu 3.5 catalyst. Subsequently, H_2SO_4 concentrate was added to the digestive tube and gently agitated to blend the sample with the acid. The rack loaded with the exhaust system into a digester block was then attached to the digester tubes in the rack. The temperature was set to 420 ºC. Samples were digested for 60-90 minutes until they turned clear with a green/blue solution.

During the distillation process, the digested samples in the digestion tube were placed in the

distillation unit. The receiver solution consisting of 25 ml of 2% boric acid with 10 drops of indicator solution was filled into a conical flask and placed in the distillation unit before the analysis. Then, 70 ml of distilled water and 50 ml of 32% of sodium hydroxide (NaOH) were added to the digestion tube automatically. This process took around 4 minutes. The receiver solution in the distillate flask was then changed to green colour due to the presence of an alkali (ammonia). In the titration process, the distilled sample was titrated with standard hydrochloric acid (HCl) 0.1 N. This process takes place until it is switched to pink or red. The volume of HCl used was recorded. The percentage of protein was calculated by using the formula below:

$$\%\ Nitrogen = [A\ X\ (T - B)\ X\ 14.007\ X \frac{100}{weight\ of\ sample} X100$$ **Eqn. 3**

$$Percentage\ of\ crude\ protein = \%\ Nitrogen\ X\ F$$

Where,
$T = Volume\ of\ acid\ for\ sample\ (ml)$
$B = Volume\ of\ acid\ for\ blank\ (ml)$
$A = Normality\ of\ HCL$
$F = Protein\ factor, 6.25$

Firstly, the extraction cups were pre-dried in the oven at 105 ºC for six hours and cooled in a desiccator one day before the experiment. Then, the pre-dried extraction cups were held with a holder for weighing (w_2). Next, the three grams of samples were weight (w_1) and wrapped with filter paper before being placed into the extraction thimble. 150 ml petroleum ether was measured using a volumetric cylinder and poured into the extraction cup.

Then, the extraction thimble was inserted into the thimble holder and has been put into the extraction cup. The extracted cup containing a sample and 150 ml of petroleum ether was placed into the Automated Soxhlet Fat Extractor system (Model Gerhardt Analytical Soxtherm 6, Made in Germany). The extraction process took about 2 hours. After the extraction finished, the extracted cups containing petroleum were transferred into the oven at 105˚C for 2 hours. Then, extraction cups were transferred into a desiccator for the cooling process. Lastly, the extracted cups were weighed using an analytical weighing scale (w_3). The following formula was used to determine the fat percentage:

$$\%\ Lipid\ =\ (w_3\ -w_2\ )\ /w_1 \times\ 100$$ **Eqn. 4**

Where,
$w_1\ =\ Weight\ of\ sample\ (g)$
$w_2\ =\ Weight\ of\ extraction\ cup\ (g)$
$w_3\ =\ Weight\ of extraction\ cup\ +fat\ (g)$

Crude fibre analysis

Crude fibre (CF) measures the indigestible parts of the feed content which consist of lignin, chitin, pentosan and cellulose. First, the empty fibre bags were weighed (w_1) using an analytical scale. Then,1 g of the sample was inserted into the fibre bag and weighed using the analytical scale (w_2). Then, glass spacers were inserted into the fibre bags, which were then placed in a carousel. Samples containing higher than 10% of fat were defatted by immersing the carousel three times in 100 ml of 40/60 (boiling range) petroleum ether. The samples were defatted by turning it moving up and down. The fibre bags were then left to dry for around two minutes. The carousel was inserted into the axis carousel before being placed inside the glass container. Next, the carousel was placed into the glass container which was in the previewed position of the hotplate before the machine ran. Then, the fibre bags were removed from the carousel and placed into the crucible after completing the analysis. The fibre bags and crucible, then were dried for 4 hours at 105 ˚C, then cooled in a desiccator for 30 minutes. Next, the crucible and dried fibre bag were weighed using the analytical scale (w_3). The crucible that contains the fibre bag is placed in a furnace at a temperature at 550 ˚C and burned for four hours.

After that, crucibles that contained ash were cooled in a desiccator after it reached room temperature and weighed using an analytical scale (w_4). The empty crucible was weighed using the analytical scale (w_6). The ash and crucible of the empty fibre bag were then weighed (w_7). The blank value of the empty fibre bag (w_5) could be got from the value of ash and crucible of the empty fibre bag (w_7) minus the value of the empty crucible (w_6). The percentage of crude fibre was measured using the formulation below:

$$\%\ Crude\ fibre = \frac{[(w_3 - w_1) - (w_4 - w_5)]}{w_2} \times\ 100$$ **Eqn. 5**

Blank value (w_5) = $w_7\ -\ w_6$

Where,
$w_1 = Weight\ of fiber\ bag\ (g)$
$w_2 = Weight\ of\ sample\ (g)$
$w_3 = Weight\ of\ crucible\ (g) + fiber\ bag\ after\ digestion(g)$
$w_4 = Weight\ of\ crucible + ash\ (g)$
$w_5 = Weight\ of\ blank\ value\ of\ the\ empty\ fibre\ bag(g)$
$w_6 = Weight\ of\ crucible\ (g)$
$w_7 = Weight\ of\ crucible + ash\ of\ the\ empty\ fibre\ bag(g)$

Nitrogen-free extract

Nitrogen-free extract (NFE) was estimated by the difference analysis of all nutrient values in the proximate analysis. Nitrogen-free extract fraction is a heterogeneous mixture of all the unspecified components that are not analysed through proximate analysis. NFE is used to represent soluble carbohydrates in feed such as starch and sugar. This fraction may also consist of the solubilization of hemicellulose and lignin.

Energy

The energy values of the corn residue were calculated in kilocalories per hundred grams (kcal/100g) by multiplying the factors of crude protein, carbohydrate, and lipid/fat, respectively by 4, 4 and 9% according to the AOAC method (AOAC, 2005). The calculation for energy is determined as follows:

$$Energy\ content\ \left(\frac{kcal}{g}\right) = (Crude\ protein \times 4) + (Carbohydrate \times 4) + (Lipid \times 9) \quad \textbf{Eqn. 6}$$

Statistical analysis

Data were analysed for differences in the mean value in different parts of sweet corn residues by one-way ANOVA analysis using Minitab version 17.0 and Ms Excel version 2013 software. The *p* value ($p < 0.05$) is considered a significant difference.

RESULTS

Proximate composition

The results of the proximate composition of three different parts of the corn waste are presented in Table 1. The results of husk, leaf and stalk show significantly different ($p < 0.05$) values for all the proximate analyses conducted. Based on the results, the dry matter, crude protein, ash and ether extract were highest in the leaf with 29.23 ± 0.27%, 16.86 ± 0.02%, 4.20 ± 0.03%, 2.20 ± 0.07%, respectively. While crude fibre was highest in the stalk with 32.26 ± 0.95%. The Nitrogen-free extract was found highest in the husk with 71.65% compared to stalk (60.41%) and leaf (54.04%). For energy in every 100 grams of sample, it was highest in the husk with 288.32 kcal followed by leaf and stalk with 284.33 kcal and 243.02 kcal, respectively.

Table 1. Proximate composition of three different parts from sweet corn residues

Parameter (%)	Husk	Leaf	Stalk
Dry matter	28.86 ± 0.32^{b}	29.23 ± 0.27^{a}	28.55 ± 0.33^{c}
Ash	2.07 ± 0.06^{b}	4.20 ± 0.05^{a}	1.80 ± 0.02^{c}
Crude protein	5.04 ± 0.10^{c}	16.86 ± 0.04^{a}	5.32 ± 0.12^{b}
Ether extract	0.24 ± 0.24^{b}	2.20 ± 0.13^{a}	0.21 ± 0.16^{c}
Crude fiber	21.0 ± 0.61^{c}	22.70 ± 0.53^{b}	32.26 ± 0.95^{a}
Nitrogen-free extract	71.65	54.04	60.41
Energy (kcal/kg)	288.32	284.33	243.02

Note: Values are Mean ± SD. $^{a-c}$ Mean values within the same row sharing no common superscript are significantly different ($p < 0.05$).

DISCUSSION

Dry matter

Dry matter contents refer to the materials remaining after the removal of water (AOAC, 2005). According to the results of this study, the leaves have the highest proportion of dry matter with 29.23%, followed by husk and stalk, which are 28.86% and 28.55%, respectively. There was significant variation among the means of the dry matter contents of the sweet corn residues at $p < 0.05$. According to Dayek (2019), the higher dry matter accumulation in the leaves part due to the greater photosynthesis process than respiration which sustains the plant growth and development. The dry matter values obtained in this study are comparable with the previous study values which are 19.8% to 29.9% of dry matter (Jaster and Murphy, 1983; Dayek, 2019). However, the result from the study by Ayaşan et al. (2020) found that the husk contains the highest amount of dry matter content which is 95.13% and is inconsistent with the present study. Where the husk contains a lower percentage of dry matter than the leaf. The differences might be due to the differences in genotype, variety, total precipitation and

temperature during the harvest time, vegetation and ecological conditions of the place where the study was carried out (Vaswani et al. 2016). Animals need to consume a certain amount of dry matter according to their needs to maintain production and health (Samad 2019; Wilkins, 2000). Commonly, the amount of dry matter given to ruminant animals is between 1–3% of their body weight, but it depends on several other factors including the stage of production such as lactating, pregnancy, and others (Samad, 2019; Wilkins, 2000).

Crude protein

In terms of crude protein contents, the leaf recorded the highest percentage of crude protein which is 16.86%, followed by a stalk with 5.32% and the husk with 5.04%. The result was significantly different at $p < 0.05$. The crude protein value in the leaf of this study is comparable with the value of the previous study which found that the leaf has the highest crude protein content of 12.41% followed by the stalk at 4.37% and husk at 4.3% (Ayasan et al. 2020). The crude protein contents were higher in the leaves which were directly related to the dynamic of the dry matter accumulation (Newman et al. 2010; Popoviv et al. 2001). According to Newman et al. (2010); Popoviv et al. (2001); Kamaruddin et al. (2019); Kamaruddin et al. (2020), crude protein is often used as an indicator of forage quality. The leaf is a more palatable and more digestible part of the ruminant (Fuller, 2004). In general, crude protein is one of the main essential elements of ruminant nutrition. Crude protein includes true protein and nonprotein compounds (AOAC, 2005). The deficiency of crude protein in animals leads to improper function of vital organs and systems of animals. In general, more than 7% of crude protein is needed by small ruminants (Cappellozza, 2014) while 16% of crude protein is needed by large ruminants in purpose for maximal growth and activity of ruminal microorganisms (Ondarza, 2004). However, the requirements of crude protein varied with production stages (Cappellozza, 2014).

Crude fibre

Crude fibre is made up of a variety of insoluble carbohydrates that are found in plant cell walls and are resistant to digestive enzymes. Besides, crude fibre is made up of plant cell structural components, including hemicellulose, cellulose, pectin, and lignin (Newman et al. 2010) Crude fibre is essential in the diets of ruminant animals, which can ferment a large portion of fibre (Newman et al. 2010). Comparing the crude fibre content, the stalk shows the highest percentage of crude fibre, which is 32.26%, followed by leaf (22.70%) and husk (21.01%) and there was a significant difference at $p < 0.05$. These data are similar to the previous study by Ayasan et al. (2010) which found that the stalk has the highest crude fibre which is 32.63%. This is because the stalk contains a high amount of hemicellulose known as the natural fibres in the plant (Ibrahim et al. 2019). A previous study reported that the fibre in the corn plant was highest in the stalk which contained about 60.3% of hemicellulose (Ibrahim et al. 2019). Hemicellulose is a carbohydrate polymer that acts as a constituent for fibre structure and plant strength (Ibrahim et al. 2019). Crude fibre is significant for estimating the indigestible percentage of feed, as well as the portions of feed that are digested by bacteria in the hindgut (Wilkins, 2000)

Ether extract

The ether extract is an organic compound that is non-soluble in water, but soluble in organic solvents. It is also known as crude fat, which consists of triglycerides that are commonly essential in animal nutrition (Jones et al. 1991). The ether extract is vital in a low level of fat content for proper rumen feeding to avoid off-feed problems of ruminants (Jones et al. 1991). The results of this study show that the leaf has the highest percentage of ether extract which is 2.20%, followed by husk and stalk which contain 0.24% and 0.21%, respectively. There was significant variation among the means of the ether extract contents of the sweet corn residues at $p < 0.05$. The result obtained in this study is comparable to the previous study which found that the leaf contains a high amount of ether extract which is 1.03%, stalks 0.29% (Ayasan et al. 2020) and husk 0.5% (Sabariah et al. 2019). It could be due to a high lipid content that is higher in the leaf which is known as glyceroglycolipids. The glyceroglycolipids are primarily found in chloroplast membranes which are concentrated, particularly in the parenchyma cells of the leaf mesophyll (Esmail, 2021). An excessive amount of ether extract in ruminant diets is detrimental which causes unpalatable and causes a loss in rumen microbes (Jones et al. 1991). The minimum requirement of ether extract in ruminants was between 2% – 3% of ether extract (Esmail, 2021). This requirement varies with the production stage. However, the amount of ether extract cannot be more than 7% of diet dry matter if it is given to ruminants because of its ability to cause negative side effects such as

metabolic problems which can cause damage to the rumen's health (Anitha et al. 2016).

Ash

Ash component of the feed describes the inorganic content of the feed and is mainly minerals. These are critical nutrients required in specific amounts in the ruminant's diets for stronger bone, blood clotting, enzyme activation and muscle contraction (Anitha et al. 2016). The leaf shows the highest percentage of ash, which is 4.20%, followed by husk and stalk with 2.07% and 1.80%, respectively. The result was significantly different at $p < 0.05$. A previous study found that the leaf contains the highest amount of ash which is 7.91% (Anitha et al. 2016). The high amount of ash in the leaf shows that it contains a high amount of minerals whereby ash analysis helps to determine the amount and type of mineral in the sample. The large differences in ash content in leaves might be because ash content is generally affected by hybrid variety, soil type, fertilisation practices and maturity (Anitha et al. 2016).

Nitrogen-free extract

In terms of nitrogen-free extract (NFE) typically consists of readily digestible carbohydrates. The percentage of NFE was influenced by the values of crude protein, crude fibre, total ash, and ether extract (Anitha et al. 2016). Results of this study showed there was a significant difference at $p < 0.05$ for the mean values of the NFE component. Husk shows the highest percentage of nitrogen-free extract which is 66.50%, followed by the stalk (54.95%) and leaf (49.28%). A previous study found that nitrogen-free extract in husk was the highest which is 51.69 %, followed by a stalk (48.25%) and leaf 42.4% (Ayaşan et al. 2020). This can be assumed that the husk contains high amounts of sugar and starches (Greenfield and Southgate, 2003). The NFE may be able to be an energy source for body processes in ruminants.

Energy

The energy content was the highest in the husk which is 288.32 kcal/g compared to the leaf which contains 284.33 kcal/g and stalks with 243.02 kcal/g. The previous study reported the highest energy content in the husk (231.07 kcal/g) followed by the stalk (219.82 kcal/g) and leaf (216.07 kcal/g) (Ayaşan et al. 2020). The most important nutrients for ruminants are proteins and energy. These nutrients support rumen microbes that consequently break down the forage. True proteins account for about 60% to 80% of the total plant nitrogen (N), with soluble protein and a small portion of nitrogen bound in fibre accounting for the rest (Sabariah et al. 2019).

CONCLUSION

This study showed that the different parts of sweet corn residues have different nutrient contents. The mean nutrient contents of the three different parts which are the leaf, husk and stalk were significantly different. In addition, crude protein (CP), dry matter (DM), and crude fibre content in the leaf were higher compared to the husk and stalk. Meanwhile, the stalk shows the highest content of crude fibre and the husk contains the highest amount of nitrogen-free extract and energy. Therefore, it can be concluded that the residue of sweet corn, especially the leaves, could be used efficiently as livestock feed. As a recommendation, this study could be enhanced by performing mineral analysis for leaf, husk, and stalk.

CONFLICT OF INTEREST

The authors have declared that the present study was performed in the absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

NAK devised the project, the main conceptual ideas, manuscript preparation and proof outline. NYMY was involved in the field sampling and lab analysis. All authors read and approved the final version.

REFERENCES

Abdullah NFN, 2016. In vitro, in sacco, in vivo digestibility of ruminants feed supplemented with herbs. Ph.D. thesis, University of Malaya, Malaysia.

Adjorlolo LK, Bessa TA, Kwarteng KA, Ahunu BK, 2014. Effect of season on the quality of forages selected by sheep in citrus plantations in Ghana. J. Trop. Grass. Forag. Trop. 2: 271–277.

Akinfemi A, Babayemi OJ, Jonathan SG, 2009. Bioconversion of maize husk into value added ruminant feed by using white-rot fungus. J. Revis. UDO. Agri. 9(4): 972–978.

Anitha KC, Rajeshwari YB, Prasanna SB, Shree SJ, 2016. Nutritive evaluation of azolla as livestock feed. J. Exp. Bio. Agri. Sc. 4(6): 671–674.

AOAC, 2005. Official methods of analysis 18th ed. Association of Official Analytical Chemists, Virginia, USA.

Ayaşan T, Cetinkaya N, Aykanat S, Celik C, 2020. Nutrient contents and in-vitro digestibility of different parts of corn plant. J. Ani. Sci. 50(2): 302–309.

Bakshi MPS, Wadhwa M, Balwinder K, 2017. Nutritional evaluation of baby corn fodder and conventional maize fodder in buffaloes. Liv. Res. Rural Dev. 29(7): 80–85.

Cappellozza BI, Cooke RF, Ries MM, Moriel P, Keisler DH, 2014. Effects of protein supplementation frequency on physiological responses associated with reproduction in beef cow. J. Ani. Sc. 92: 25–34.

Chavan UD, 2015. Nutritional value and health benefit from fruits, vegetables, nuts and spices. Daya Publishing House, New Delhi, India.

Dayek P, 2009. Sweet corn waste: forage quality and fermentation characteristics. Focus on Forage. 11(1): 1–4.

Elkholy MEH, Hassanein EI, Edrees N, Eleraky W, Elgamel MFA, Ibraheim D, 2009. Nutritional aspects of recycling plants by-products and crop residues (corn stalk) in sheep. J. Pakistan Nutri. 8: 1834–1841.

Esmail SH, 2021. Fats in cattle feed: What to consider. Misset. USDA.

Fuller MF, 2004. The encyclopedia of farm animal nutrition. CABI Pub, Oxon, England.

Greenfield H, Southgate DAT, 2003. Food composition data. Food and Agriculture Organization of the United Nations. Springer, Boston, MA.

Hasan F, 2012. Contract farming of corn production in Terengganu. Bachelor thesis, University Sultan Zainal Abidin, Malaysia.

Ibrahim MIJ, Sapuan SM, Zainudin ES, Zuhri M YM, 2019. Extraction chemical composition, and characterization of potential lignocellulosic biomasses and polymers from corn plant parts. BioRes.14(3): 6485–6500.

Jamaludin R, 2014. The effects of a different combination of organic and inorganic fertilizer on growth yield, and root biomass of corn. Bachelor thesis, University Sultan Zainal Abidin, Malaysia.

Jaster EH, Murphy MR, 1983. Effects of varying particle size of forage on digestion and chewing behavior of dairy heifers. J. Dairy Sci. 66(4): 802–810.

Jones JR, Wolf JBB, Mills HA, 1991. Plant analysis handbook. Micro-Macro Publishing Inc. Athens.

Kamaruddin NA, Ahmad N, Zulkifli AN, Zakaria J, Yusuf MAM, 2019. Characterization of chemical composition in five different Napier cultivars at different cutting ages. Biosci. Res. 16: 168–173.

Kamaruddin NA, Kamarudin MS, Ahmad N, Rahman NZA, 2020. Comparative Study on nutritional quality of napier grass (Pennisetum purpureum) cultivars. Biosci. Res. 17: 126–133.

Mundi I, 2021. Malaysia corn imports by year. United States.

Newman YC, Lambert B, Muir JP, 2010. Defining forage quality. pp. 1–5. Forages and pastures livestock. Texas Cooperative Operation System, Texas.

Ondarza MBD, 2004. Interpreting and implementing starch digestibility information in the field. J. Ani. Sci. 87: 275–294.

Popoviv S, Stejaponic M, Grljusic S, Cupic, T, Tucak M, 2002. Protein and fiber contents in alfalfa leaves and stems. pp. 215–218. In Ciheam-iamz, Spain.

Saadiah J, Predith M, Azizah A, Shamuganvellu S, 2019. Formulation and evaluation tool of dairy cattle rations for smallholders. Mal. J. Vet. Res 10: 1–12.

Sabariah B, Norlindawati AP, Samijah J, Supie N, Rosmawati NMN, Zul WE, 2019. Chemical composition of weeds as potential forage in integrated farming. Malay. J. Vet. 10: 39–47.

Samad A, 2019. A six-decade review: research on cattle production, management, and dairy products in Bangladesh. J. Vet. Med. OH Res. 2(2): 183–404.

Vaswani S, Kumar R, Kumar V, Roy D, Kumar M, 2016. Nutritional and mineral composition of different varieties of normal and high-quality

protein maize fodder at post- cob stage. Int. J. Sci. Env. Tech. 5(5): 2719–2725.

Wilkins RJ, 2000. Forage and evaluation in ruminant nutrition, pp. 1-14, Forages and their role in animal system. CABI Publishing, Wallingfog, United Kingdom.

WAP (World Agriculture Production), 2021. World corn production 2020-2021.USDA, Beltsville, MD.