NUTRITIVE VALUES OF DIFFERENT TYPES OF CORN-BASED ANIMAL FEED BASED ON SAMPLES FROM 2012 TO 2018

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ABSTRACT. The objective of this study is to determine the nutritive values and quality of different types of corn-based feed analysed by the Animal Feed Laboratory of the Malaysia Veterinary Institute from year 2012 to 2018. A total of 460 corn samples were received for routine quality analysis. The samples were analysed according to four categories: corn silage (126), fresh corn (176), ground corn (124) and coarse ground corn (34). Proximate analysis was carried out using AOAC method. The result for corn silage showed dry matter content of 33.11% (8.7-99.9), crude protein 10.25% (4.1-16.6), crude fibre 26.66% (4.4-46.6) and metabolisable energy of 9.09 MJ/kg (5.6-10.89). Dry matter content of fresh corn (whole plant) was 44.75% (14.8-71.2), crude protein 8.82 % (6.7-17.3), crude fat 2.51% (1.1-4.4) crude fibre 18.61% (7.1- 41.7), total ash 4.23% (1.2-23.) and metabolisable energy 11.60 MJ/kg (6.31-15.17). Ground corn showed dry matter content of 90.26% (84.9-97.4), crude protein 9.49% (7-13), crude fat 3.50% (0.4-10.8), crude fibre 4.03% (1.7- 21.8), total ash 2.24% (0.4-9.5) and metabolisable energy 11.64 MJ/kg (6.57-16.64). The proximate composition of coarse ground corn shows dry matter content of 89.98% (87.1- 95.8), crude protein 9.42% (7.4-12.1), crude fat 2.76% (1.0-6.4), crude fibre 3.34% (1.4-7.7), total ash 1.96% (0.7-5.0) and metabolisable energy of 11.77 MJ/kg (9.66-13.8). The results showed that there was a high variability in the nutrient content for corn silage, fresh corn, ground corn and coarse ground corn.

Keywords: fresh corn, silage, ground corn, coarse ground corn, proximate composition

INTRODUCTION

When analysing corn silage for chemical compositions, several quality factors have to be considered. Several dynamics come into play when determining the quality of corn silage, such as maturity, harvesting at proper moisture, chop length and packing at an adequate density. There are certain target parameters that corn silage must meet to ensure optimal forage quality and optimal animal performance. Target values are considered on a dry matter basis with analysis result indicating percentages of protein, fibre content, energy values, digestibility and mineral in the corn silage (Chahine *et al.,* 2017). Corn is the second most widely produced crop in the world. Much of this production is used for animal feed, especially in developed countries. Only a small proportion (10 to 15%) is consumed directly as food or processed to

by-products such as starch, flours, hominy, cornflakes, and syrups (Watson *et al.,* 1999). The nutritive value of fresh corn depends on environmental factors and agronomic practices such as fertilisation, nitrogen loses due to rain, weed competition or method of harvesting. Corn contributes approximately 65% of the metabolisable energy and 20% of the protein in a broiler starter diet and is by far the most commonly used cereal grain in the diets of intensively reared poultry. One reason for the widespread use of corn in the diet of farmed livestock is that there is a perception that corn is of a consistent and high nutritional value (Cowieson, 2005). High quality feed and farm management ensure good animal performance and health. According to Corson *et al. (*1999), nutrition is often limiting the productivity of ruminants selected for high genetic merit, whether it is expressed as milk production, multiple births, and growth rate or disease resistance. Malaysian farmers should be aware about the quality of the feed that they use to feed their livestock. By knowing the nutritive values of the feed, the best ration to meet the nutritional requirements of various classes of livestock can be formulated. The Animal Feed Laboratory, Veterinary Institute of Malaysia (IVM), is one of the laboratories of the Department of Veterinary Services (DVS) responsible for conducting analysis of animal feed in the southern region of Peninsular Malaysia. Samples of feed materials, feed additives, mineral mixtures and compound feeds are routinely tested to ensure that they contain the declared nutrients (protein, fat, and minerals), fibre and moisture content. The aim of animal feed analysis is to ensure that the feedstuff administered to the livestock are of good quality. The objective of this study is to analyse the nutritive values and quality of different types of corn-based feed: fresh corn, corn silage, ground corn and coarse ground corn, from feed samples in 2012 to 2018.

MATERIALS AND METHOD

Corn silage, fresh corn, ground corn and coarse ground corn

A total of 460 corn samples were received from DVS farms, other agencies, feed millers, farmers and individuals from January 2012 to Disember 2018 for routine quality analysis at IVM. The corn received can be divided to corn silage (n=126), fresh corn consisting of corn stalk (n=64), cob (n =8), corn husk (n=11), corn fruits (n=37), whole plants (n=45), corn seeds (n=11). Ground corn (n=124) and coarse ground corn (n=34). Proximate analysis was carried out on all samples received as shown in Figure 1a and Figure 1b.

Proximate analysis

Proximate analysis was carried out on all corn samples for dry matter, crude protein, crude fat, crude fibre, total of ash and metabolisable energy to evaluate the quality of nutrition. The samples were analysed for crude protein content (N × 6.25) using the Kjeldahl method (FOSS, 2003) while crude fibre was measured using Fibertec methods (FOSS, 2010). Other parameters in proximate analysis were determined according to the Association of Official Analytical Chemists methods (AOAC, 2000). Finally,

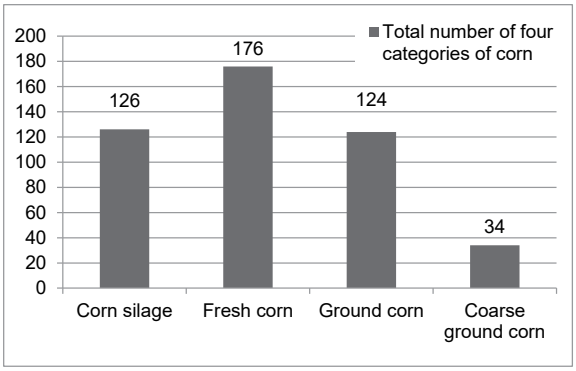

Figure 1a. Categories of corn samples analysed from year 2012 to 2018.

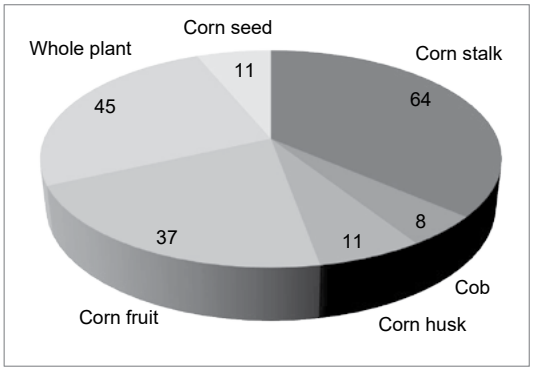

Figure 1b. Total number of fresh corn samples tested for proximate analysis.

the metabolisable energy for ruminant was calculated using Manke equation (1986).

RESULTS AND DISCUSSION

A total of 460 corn samples used in this study were analysed for dry matter, crude protein, crude fat, crude fibre, total ash and metabolisable energy to evaluate the quality of nutrition using Method of Test for Animal Feeds and Feedstuff (FAO, 2011). Nutrient content of the samples were calculated based on dry matter (%). The result of proximate composition of the corn silage, fresh corn (stalk, cob, husk, fruit, whole plant, seed), ground corn and coarse ground corn based on dry matter (%) are in Table 1.

The results showed that the mean of dry matter in the 126 samples of corn silage was 33.11% which is in the range of 30% to 40% of target value in dry matter (Chahine *et al.,* 2017). The percentage of crude protein was 10.25%. The range of crude protein in the corn silage is between 4.1% to 16.6%. The suitable value of crude protein in corn silage has been reported as 7% to 9% (Chahine *et al.,* 2017). Proximate composition showed that 126 samples of corn silage is within the range of nutrient content. Corn silage has potential as ruminant diet and it is good for performance and production of ruminants. Goats fed with 100% whole corn plant silage would most likely show the highest growth performance compared to a basal diet of Napier grass and other percentages of corn silage in the Napier diet (Khaing *et al.,* 2015). Dry matter intake of dairy cows fed 67% and 100% of corn silage (10.4 kg/day and 10.7 kg/day respectively) were higher than those fed with 100% grass silage (8.8kg/day) (O'Mara *et al.*, 1998). Dry matter intake of beef cattle fed with diet containing corn silage was higher than diet containing grass silage as sole forage (Kirkland *et al.*, 2006). Study by Navjot *et al.* (2016) showed that feeding corn silage to dairy cows increased milk yield with average from 24.8 kg/animal/day to 28.6 kg/animal/day. High protein content is desirable. Low protein content may be due to under-fertilisation, nitrogen loses due to rain, weed competition or improper harvesting (Chahien *et al.,* 2017). The result of crude fibre in the 126 samples of corn silage is 26.66%. The percentage of crude fibre is 4.4

Table 1. Nutrient content of corn silage, fresh corn (stalk, cob, husk, fruit, whole plant, seed), ground corn and coarse ground corn based on dry matter (%)

Type Of Samples	Corn Silage	Corn Stalk	Cob	Corn Husk	Corn Fruit	Whole Plant	Corn Seed	Ground Corn	Coarse Ground Corn
Dry matter % Min-Max Mean (stdev)	8.7-99.9 33.11(±21.70)	19.5-93.6 37.40(±17.27)	20.8-98.8 47.51(±28.30)	15.5-99.8 67.62(±28.16)	22.9-75.8 53.71(±14.64)	14.8-71.2 44.75(±16.08)	70.2-93.4 82.85(±8.67)	84.9-97.4 90.26(±2.32)	87.1-95.8 89.98(±1.81)
Crude Protein % Min-Max Mean (stdev)	4.1-16.6 10.25(±2.13)	3-17.3 9.07(±2.96)	2.9-11.9 7.21(±3.74)	2.9-13.2 7.81(±3.43)	6.5-10.5 8.64(±0.97)	6.7-17.3 8.82(±2.14)	7.6-17.8 10.63(±2.58)	7-13 9.49(±1.15)	7.4-12.1 9.42(±1.22)
Crude fat % Min-Max Mean (stdev)	0.5-8.5 2.09(±1.05)	0.2-3.7 1.34(±0.79)	0.3-3.6 1.25(±1.13)	0.5-3.4 1.31(±1.13)	1.2-5.6 2.62(±0.96)	1.1-4.4 2.51(±0.82)	2-12.3 4.73(±)2.75	0.4-10.8 3.50(±1.80)	1.0-6.4 2.76(±1.19)
Crude fibre % Min-Max Mean (stdev)	4.4-46.5 26.66(±6.35)	5.9-41.2 29.62(±7.16)	13.4-69.6 31.09(±19.27)	9-33.6 25.55(±10.06)	4.9-16.4 9.86(±2.80)	7.1-41.7 18.61(±7.09)	2.3-22.3 4.83(±5.85)	1.7-21.8 4.03(±3.13)	1.4-7.7 3.34(±1.58)
Total of ash % Min-Max Mean (stdev)	0.7-32 7.09(±4.07)	2-17 5.75(±2.79)	0.6-6.7 3.34(±1.97)	2.1-5.4 3.25(±1.03)	1.3-4.5 2.39(±0.86)	1.2-23.9 4.23(±3.88)	1.1-4.5 2.29(±1.18)	0.4-9.5 2.24(±1.44)	0.7-5.0 1.96(±0.83)
Energy MJ/kg Min- Max Mean (stdev)	5.6-10.89 9.09(±1.03)	7.02-13.8 9.04(±1.39)	7.08-11.4 8.83(±3.39)	7.34-14.13 8.93(±2.14)	10.88-15.2 12.84(±1.04)	6.31-15.17 11.60(±2.08)	10.26-17.14 11.99(±2.12)	6.57-16.64 11.64(±1.45)	9.66-13.89 11.77(±1.08)

* stdev (standard average deviation in the bracket)

to 46.5. Low and high percentages in crude fibre may be caused by improper harvesting where low percentage in crude fibre showed that the age of fresh corn used to make the silage was too young and a high percentage of crude fibre may be caused by the usage of old corn in making the silage. The mean metabolisable energy in 126 samples of corn silage is 9.90 MJ/kg. Corn (also known as maize) is a suitable crop for ensiling. It is considered an ideal forage because it grows quickly, produces high yields, palatable, rich in nutrients and helps to increase body weight and milk in cattle (Sattar *et al.,* 1994). The quality of corn silage depends on harvesting. Moisture content of corn at harvest is the most important factor. It should be harvest at 30% to 40% dry matter content. Excessive or inadequate moisture content can cause spoilage and decrease the quality of the silage. Too dry is usually associated with a reduced digestibility and energy content (Chahien *et al.,* 2017)

Laboratory analysis showed that nutrient content in fresh corn and other parts of the fresh corn is not consistent. Fresh corn received and analysis by the Animal Feed Laboratory consisted of the whole plant of the corn and the part of the fresh corn which was the stalk, cob, husk, corn fruit and corn seed. Proximate composition of the whole plant of the corn showed that the range of dry matter content was 14.8% to 71.2%, crude protein 6.7% to 17.3%, crude fat 1.1% to 4.4%, crude fibre 7.1% to 41.7%, total ash 1.2% to 23.9% and energy 6.31 to 15.17 MJ/kg respectively.

The inconsistency of nutritional value in 45 samples of fresh corn (whole plants) is as shown in Figure 2. The difference of nutritional value in corn stalk, husk and corn seed can be seen in Table 1, from the minimum and maximum values of dry matter, crude protein, crude fibre, total ash and energy. Inconsistency of nutritional value of the fresh corn and the part of the corn may be caused by environmental factors and agronomic practices such as fertilisation, nitrogen loses due to rain, weed competition or improper harvesting (Subedi *et al.,* 2009)

Figure 3 shows the highest percentage of dry matter in corn seed is 82.85% compared to other parts of the corn. The highest percentage of crude protein in corn seed is 10.63% compared to the stalk, husk, fruit and the whole plant (plant and fruit). The results also showed that the highest percentage of fibre in the corn cob (Abu Bakar *et al.,* 2016) is 31.09 compared to the stalk, husk, whole plant, fruit and corn seed. From the result, the highest value of energy, 12.84 MJ/kg, was found in the corn fruit.

Using proximate composition analysis for 8 samples of corn cob, the mean and range of dry matter content was 47.51 (20.8-98.8%), crude protein was 7.21(2.9-11.9%), crude fat was 1.25 (0.3-3.6%) crude fibre was 31.09 (13.4-69.6%), total ash was 3.34 (0.6-6.7%) and energy was 8.83 (7.08-11.4 MJ/kg) respectively. The inconsistencies in nutritional value in corn cob is shown in Figure 4.

The inconsistencies of nutritional values in 37 samples in corn fruits is as shown in Figure 5. Inconsistencies of nutritional values in corn stalk, husk and corn seed in Table 1 were of minimum and maximum values of dry matter, crude protein, crude fibre, total ash and metabolisable energy.

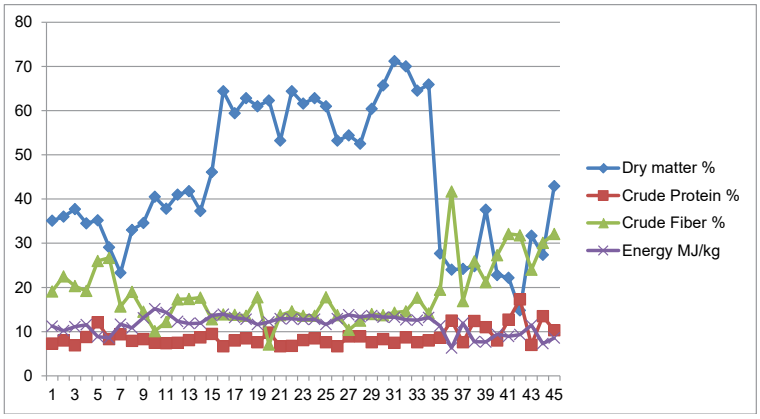

Figure 2. Percentage of dry matter, crude protein, crude fibre and metabolisable energy in fresh corn (whole plants) base on dry matter.

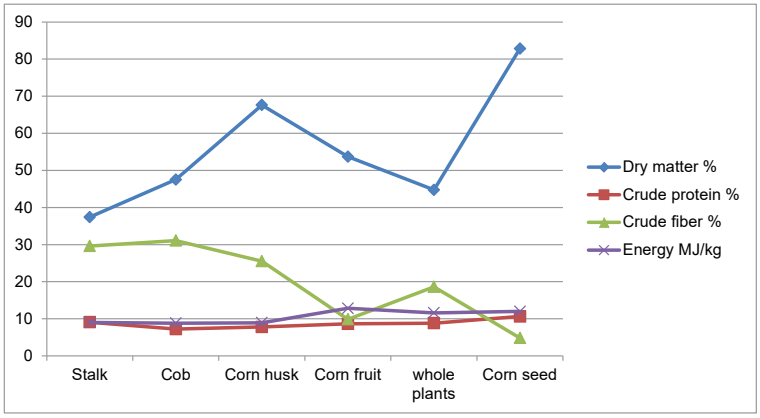

Figure 3. Percentage of dry matter, crude protein, crude fibre and metabolisable energy in corn stalk, cob, husk, fruit, whole plant and seed based on dry matter.

Inconsistencies with a wide range of nutritional values was observed in corn stalk, cob, husk, fruits and corn seed. Inconsistencies of nutritional values of the fresh corn and the part of the corn may be caused by environmental factors and agronomic practices such as fertilisation, nitrogen loses due to rain, weed competition or improper harvesting.

The proximate composition of 124 samples in ground corn is shown in Figure 6. Proximate composition of ground corn analysed showed that the mean and range of dry matter were 90.26 (84.9-97.4%), crude protein 9.49 (7-13%), crude fat 3.50 (0.4-10.8%), crude fibre 4.03 (1.7- 21.8%), total ash 2.24 (0.4-9.5%) and metabolisable energy 11.64 (6.57-16.64 MJ/kg). In the Malaysian Standard for Animal Feeding Stuffs – cereal Grains (Maize and Wheat)- Specification (Department of Standards Malaysia, 2005), the percentage of the crude protein must not

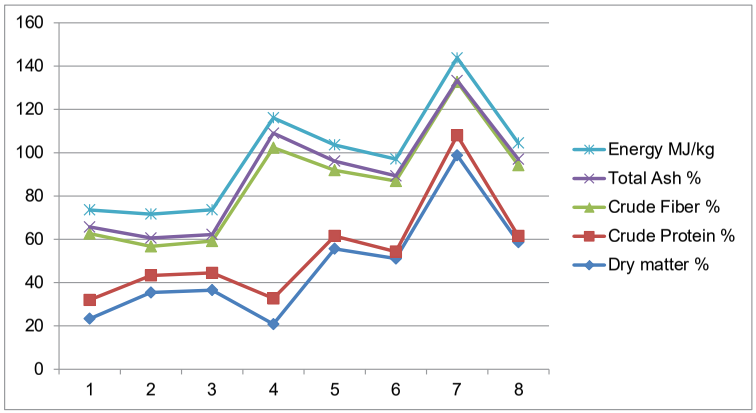

Figure 4. Percentage of dry matter, crude protein, crude fibre, total ash and energy in corn cob.

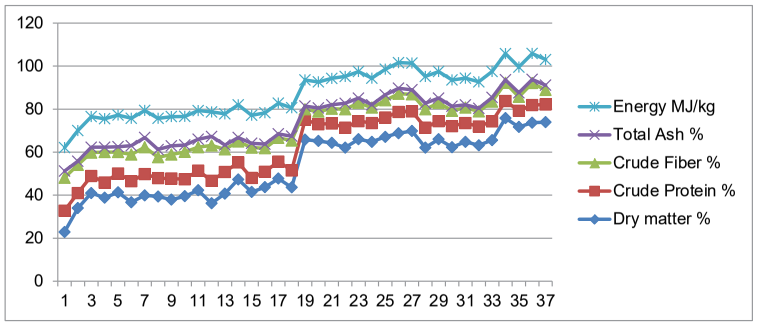

Figure 5. Percentage of dry matter, crude protein, crude fibre, total ash and energy in corn fruits

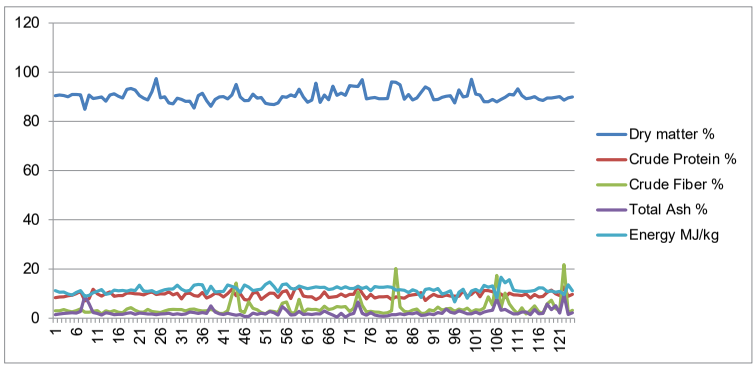

Figure 6. Percentage of dry matter, crude protein, crude fibre, total ash and energy in ground corn.

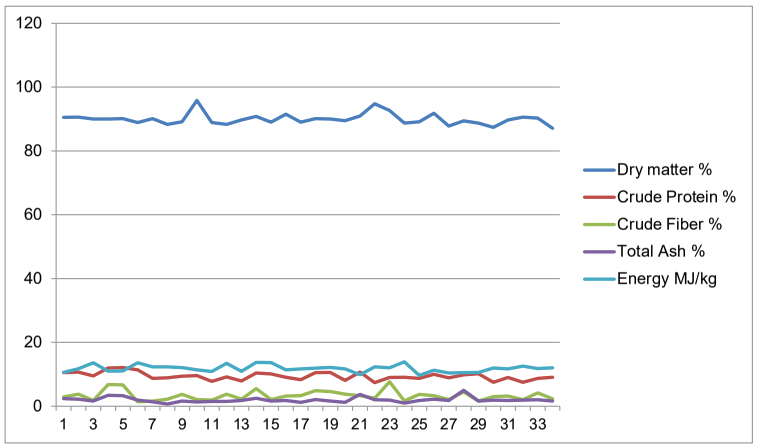

Figure 7. Percentage of dry matter, crude protein, crude fibre, total ash and energy in coarse ground corn

be less than 7.5%. Proximate composition of ground corn analysed showed consistency. Only three samples from 124 samples of ground corn were observed to have lower than 7.5% of crude protein. The mean of crude protein from 124 samples of ground corn was 9.49%.

The proximate composition of 34 samples in coarse ground corn is as shown in Figure 7. The figure showed that the percentage of dry matter, crude protein, crude fibre, total ash and metabolisable energy in coarse ground corn is consistent for all 34 samples tested. Proximate composition of coarse ground corn analysed showed mean and range of dry matter to be 89.98 (87.1% to 95.8%), crude protein 9.42 (7.4% to 12.1%), crude fat 2.76 (1.0% to 6.4%) crude fibre 3.34 (1.4% to 7.7%), total ash 1.96 (0.7% to 5.0%) and metabolisable energy 11.77 (9.66% to 13.89MJ/kg), respectively. One of the 34 samples of coarse ground corn had crude protein percentage of less than 7.5%.

CONCLUSION

Evaluation of nutritive values in corn silage, fresh corn, ground corn and coarse ground corn analysed at the Animal Feed Laboratory of IVM from year 2012 to 2018 showed that there is high variability in the nutrient content. Proximate composition analysis showed that 126 samples of corn silage is in the range of nutrient content. The result showed that the mean of dry matter of corn silage was 33.11% which is in the range of 30% to 40% of target value in dry matter (Chahine *et al.*, 2017). Corn silage has the potential as a suitable ruminant diet for good performance and production. The results showed that inconsistencies in the nutritional value of whole fresh corn plant and other parts of the corn may be due to environmental factors and agronomic practices such as the use of fertilisers, nitrogen losses due to rain, weed competition or improper harvesting. From this study, it was found that the nutrient content of ground corn and coarse ground corn is more consistent. The percentage of dry matter, crude protein, crude fibre, total ash and metabolisable energy in ground corn is consistent for all 124 samples tested. Only three of the 124 samples of ground corn had less than 7.5% crude protein. The percentage of dry matter, crude protein, crude fibre, total ash and metabolisable energy in coarse ground corn is consistent for all 34 samples tested. Only one out of the 34 samples of coarse ground corn had less than 7.5% crude protein. This study found that the nutrient content of corn silage, ground corn and coarse ground corn is more consistent compared to fresh corn.

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