Chemical and Physical Analyses of Goat Feed Pellets with Oil Palm By-products Inclusion

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INTRODUCTION

The Malaysian oil palm industry generates huge amounts of by-products annually. Most of these by-products have great potential to be utilised as components in compound feeds. However, some of these by-products need further processing before they can be used effectively in livestock rations (Mohamed *et al.*, 2012).

The most common processing method in animal feed production is the pelletising process, which involves mechanical action, in combination with moisture, pressure and temperature elements, to agglomerate particles of ingredients (Muramatsu *et al.*, 2015) into a pellet form. Pelleted feed is not only convenient for feed handling, but also improves feeding efficiency in animals (Fahrenholz, 2012; Vakili *et al.*, 2015).

Pellet quality can be determined by the ability of the pellets to remain intact during handling without breaking up, and to reach the animal without producing a high proportion of fines (Briggs *et al.*, 1999; Amerah *et al.*, 2007). Feed quality is a critical issue in feed pellet production. Good quality pellets are required to withstand repeated handling processes and mechanical actions during transportation, and so remain capable of achieving the benefits of feeding with pellets. Pellets with low durability will generate additional fines during transportation and handling.

Apart from the feed pellet quality, the cost of raw materials is another concern to feed producers. Considering the importance of good feed pellet quality and the possible alternative of using new raw materials from the biomass of the oil palm industry, a study was conducted to compare the chemical and physical properties of goat feed pellets with oil palm by-products (OPB) inclusion to commercial feed pellets (COM). Feed pellets formulated without oil palm by-products inclusion (CNT) was also used as the control.

MATERIALS AND METHODS

Materials

COM pellets and all raw materials such as corn, soyabean meal, rice bran, palm kernel cake (PKC), empty fruit bunches (EFB), palm fatty acid distillates (PFAD), rice straw and other additives for OPB and CNT production were purchased from local suppliers. The supply of oil palm fronds (OPF) was from the MPOB Keratong Oil Palm Research Station, Pahang, Malaysia.

Methods

The study was conducted at the Energy and Protein Centre (EPC), MPOB Keratong Research Station, Pahang, Malaysia. Both OPB and CNT rations were formulated using the FORMAT software to be isonitrogenic and isocaloric with COM. All three treatments met the maintenance requirements for goats in accordance to guidelines on nutrient requirements of small ruminants (NRC, 1981). Pellet production for OPB and CNT was carried out using the Animal Feed Pilot Plant at EPC.

Samples of OPB and CNT were collected randomly after pellet production and were subjected to chemical analyses for total moisture, total ash, crude fat, crude protein (CP) and gross energy content using the procedures of AOAC (1990), whereas crude fibre (CF) content was determined using the procedure of Van Soest (1991). Similarly, the COM pellet sample was also collected randomly from different feed bags for chemical analysis.

The feed samples also underwent physical analyses which included fines percentage, pellet durability index (PDI) and pellet hardness. Fines percentage was analysed using a mesh sieve of 3.35 mm diameter (ASTM). Fines were calculated as a percentage of the difference in weight of the pellets that remained on the mesh sieve and the initial weight of the pellets over the initial weight of the pellets. PDI was measured using a pellet

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durability tester (New Holmen, NHP100). The 100 g of pellets, from which the fines had been removed, were tumbled through the tester continuously for 60 s. PDI was calculated as the percentage of the weight of the remaining pellets over the initial weight of the pellets. The hardness test was carried out using a digital tablet hardness tester (Model HT – 30/50). The measurement was done using five randomly selected pellets. The hardness value was expressed as the force (in Newtons) needed to crack the pellet.

Data obtained from the physical analyses were analysed using the one-way ANOVA Statistical package 9.1 (SAS Institute, 2003). The Duncan multiple range test was used to further compare means at $P<0.05$ for significant differences.

RESULTS AND DISCUSSION

Results from the chemical analyses of all the treatment groups are shown in *Table 1*. The major nutritional components that are considered during feed formulation are total moisture, total ash, crude fat, CP, CF and gross energy content. Total moisture of the pellets from all the treatment groups as shown in *Table 1* is below 13%, which is within the recommended value for pelleted feeds. Moisture content reflects the water content in the feed samples. A moisture content that is higher than the stipulated limit will increase the possibility of mould growth, thus reducing pellet quality during storage.

CNT had the highest content for total ash at 10.72%, followed by OPB and COM at 7.74% and 6.90%, respectively. Ash content represents the mineral content of the feed that remains after the feed samples are ignited at a very high temperature. The ash may contain major elements such as calcium, phosphorus and potassium, as well as trace elements such as iron, zinc and copper (McDonald, 2002). Although such minerals exist only in small quantities in the feed, they play an important role in terms of physiological and metabolic roles in animals.

Ether extract is an analysis to determine the amount of crude fat, which includes oils, fats and fat-soluble components, in feeds. Diets with oil and fat inclusion increase the calorie content because oil and fat contain 2.25 times more energy per unit weight than carbohydrates (Bajjalieh, 2004). Apart from that, oils and fats also provide essential fatty acids and, to a certain extent, they improve palatability and consequently increase feed intake by the animals. CNT had the highest amount of crude fat at 5.59%, followed by OPB and COM at 4.36% and 4.00%, respectively.

TABLE 1. NUTRITIONAL ANALYSES OF CONTROL, COMMERCIAL AND OIL PALM BY-PRODUCTS BASED PELLETS

Chemical analysis	CNT	COM	OPB
Total moisture (%DM)	12.11 ± 0.18	12.63 ± 0.25	9.42 ± 0.45
Total ash (%DM)	10.72 ± 0.02	6.90 ± 0.01	7.74 ± 0.06
Crude fat (%DM)	5.59 ± 0.10	4.00 ± 0.15	4.36 ± 0.09
Crude protein (%DM)	16.16 ± 0.11	15.98 ± 0.22	15.58 ± 0.32
Crude fibre (%DM)	16.76 ± 0.09	13.56 ± 0.59	21.66 ± 0.92
Gross energy (cal g^{-1})	3 858 ± 15.21	3 933 ± 25.42	3 954 ± 5.75

Note: COM - commercial pellets, CNT - control pellets (without oil palm by-product inclusion), OPB - oil palm by-product based formulated pellets, DM - dry matter, cal - calories.

CP content is one of the most important nutritional components in feeds, and its shortage has a direct effect on animal growth and production. Due to this fact, it is the major cost in feed production (Vakili *et al.,* 2015). CNT contained 16.16% CP, while COM and OPB had 15.98% and 15.58% CP, respectively. It is interesting to note that the goat feed formulation using OPB as the main ingredients did not compromise the CP content in the complete ration despite the fact that the OPB contain only moderate levels of CP.

CF is the non-starch carbohydrate element in a feed. It consists of plant cell wall structures, primarily cellulose, hemicellulose and lignin (McDonald, 2002). Ruminant diets usually have high fibre content to support the rumen microbial population growth requirements. OPB contained the highest level of CF (21.66%), followed by CNT (16.76%) and COM (13.56%). This shows the difference of OPB in terms of dietary benefits as compared with feed sources from corn or soyabean. According to Hungate (1966), the rumen microbial population will degrade the fibre component in feed materials into volatile fatty acids, which become an energy source to the animal.

Energy can be described as the capacity to perform work. In animals, energy is required to perform the necessary activities such as muscle movement as well as for production purposes, for instance, milk production (McDonald, 2002). Thus, providing an adequate level of energy in feeds based on the animal's requirements is vital to avoid energy deprivation without conceding the maintenance and production activities. In this study, all treatment groups were isocaloric with gross energy of 3954, 3933 and 3858 cal g^{-1} for OPB, COM and CNT, respectively.

Table 2 shows results of the physical analyses of CNT, COM and OPB feed pellet samples.

There was no significant difference (P>0.05) among all the treatments in fines percentage. Fines are produced from pellets that have disintegrated due to low quality, or because of mechanical abrasion. In the processing mill, the acceptable fines percentage for good quality pellets is below 5% (Milanovic, 2017). In this study, all treatments showed fines percentages falling within the accepted value.

CNT had significantly higher (P<0.05) PDI percentage at 97.30% than COM and OPB at 96.40% and 96.53%, respectively. PDI is one of the significant analyses to define pellet quality, as it indicates the percentage of pellets that remain intact after being submitted to mechanical forces. Pellets are introduced to impact, friction and pressure during storage and transportation from the feed mill to the farms (Briggs *et al.*, 1999; Löwe, 2005). Thus, pellets with good durability are important to avoid a high proportion of broken pellets.

The hardness value of CNT (132.22 N) was significantly higher (P<0.05) than that of OPB (126.50 N) and COM (37.00 N), while the recommended value for hardness is more than 100 N. The results show that both CNT and OPB needed a higher force to fragmentise the pellets; thus, they met the desired hardness of a feed pellet that is able to withstand rough handling of the feed, especially during transportation.

TABLE 2. PHYSICAL ANALYSES OF CONTROL, COMMERCIAL AND OIL PALM BY-PRODUCTS BASED PELLETS

Physical analysis	CNT	COM	OPB
Fines test (%)	0.90 ± 0.11	0.60 ± 0.32	0.90 ± 0.55
PDI (%)	97.30^{a} ± 0.26	96.40^{b} ± 0.17	96.53^{b} ± 0.35
Hardness (N)	132.22^{a} ± 1.36	37.00^{c} ± 0.54	126.50^{b} ± 3.99

Note: PDI - pellet durability index, COM - commercial pellets, CNT - control pellets (without oil palm by-product inclusion), OPB - oil palm by-product based formulated pellets.

$^{a-c}$ Means in the same row with different superscripts are statistically different (P<0.05).

CONCLUSION

The OPB feed pellets that were formulated at the EPC, MPOB Keratong Research Station, Pahang were shown to contain adequate nutritional value for a goat diet in accordance to the goat's nutrient specifications, and were comparable to the commercial feed pellets. A plus point is that OPB is also a pelleted feed with good physical qualities in terms of fines percentage, PDI and pellet hardness. As this study focussed only on the chemical and physical analyses of the feed pellets, future research should focus on the effects of the pellets on the goat's performance and carcass quality, as well as on cost analysis, to gain more comprehensive information on the goat feed pellets with CNT.

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