Nutritional Support for Small Ruminant Development Based on Oil Palm By-products

(Dukungan Nutrisi dalam Pengembangan Ternak Ruminansia Berbasis Hasil Samping Kelapa Sawit)

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ABSTRACT

Biomass by-products or plant residues from the plantation system would play a crucial role in animal production since the utilization of forages from the underneath tree crops would be less or minimal when the palm oil crop mature. By-products generated from the palm oil system vary, but in relation to the animal production they could be generally categorized into the fibrous by-products and the non-fibrous (concentrate) by-products. Palm oil mill effluent (POME) and palm kernel cake (PKC) are concentrate by-products produced during the processing of palm oil extraction which have great potency to support sheep and goat production, although limiting factors such as contamination of shell and high copper level in PKC need to be considered in their utilization as feed. The fibrous palm oil by-products include oil palm fronds (OPF) and oil palm trunk (OPT) generated from the palm crop trees and oil palm empty fruit bunch (OPEFB) and palm pressed fiber (PPF) generated from processing of fresh fruits to yield crude oil. These fibrous by-products cannot meet the metabolisable energy required for high growth rate and for lactation of sheep and goats due to low DM digestibility, low crude protein content, low fermentable carbohydrate and low level of intake. Limited inclusion level in ration should be applied for those by-products to yield an acceptable production level of sheep and goats. Pretreatments (physical, chemical, and biological) gave some improvement in their nutritional qualities, however additional cost of pretreatments need to be considered. In the future, there would be a great challenge for the utilization of those fibrous by-products as animal feed since bioconversion of lignocellulosic materials to products such as chemicals (bioethanol, sugar, and bioplastic), fuels, and organic fertilizers are receiving greater interest. Some comparative advantages of these natural wastes are their relatively low cost, renewable and widespread in nature for used in an industrial operation.

Key words: Palm oil, by-products, nutrients, sheep, goat

ABSTRAK

Hasil samping biomassa atau limbah tanaman perkebunan berperan penting dalam produksi ternak mengingat akan berkurangnya penggunaan hijauan yang tumbuh di bawah pohon dengan bertambahnya umur tanaman kelapa sawit. Hasil samping yang dihasilkan dari minyak sawit bervariasi, tetapi jika dikaitkan dengan produksi ternak, hal itu dapat dikategorikan menjadi limbah berserat dan tidak berserat (konsentrat). *Palm oil mill effluent* (POME) atau limbah cair kelapa sawit dan bungkil inti sawit (BIS) merupakan konsentrat yang dihasilkan selama proses ekstraksi minyak sawit yang memiliki potensi besar dalam mendukung produksi kambing dan domba meskipun dengan adanya faktor pembatas seperti kontaminasi cangkang dan kandungan tembaga yang tinggi dalam BIS perlu diperhatikan pada penggunaannya sebagai pakan. Limbah minyak sawit berserat meliputi pelepah dan batang kelapa sawit yang diperoleh dari pohon sawit dan tandan kosong, serta serat perasan yang dihasilkan dari proses pemerasan minyak mentah dari buah sawit segar. Limbah berserat tersebut tidak mampu memenuhi energi metabolisme yang diperlukan domba dan kambing untuk laju pertumbuhan yang tinggi dan kebutuhan induk menyusui, karena rendahnya daya cerna bahan kering, kandungan protein kasar yang rendah, rendahnya karbohidrat yang dapat difermentasi, serta rendahnya tingkat konsumsi. Pembatasan penyertaan bahan tersebut dalam rasio pakan juga perlu diterapkan untuk menghasilkan tingkat produksi yang tepat bagi domba dan kambing. Pra-perlakuan (fisik, kimia dan biologis) secara teknis dapat meningkatkan kualitas nutrisi, namun perlu mempertimbangkan biaya produksi dan manfaat ekonomisnya. Ke depannya, akan muncul tantangan dalam upaya penggunaan bahan-bahan limbah berserat tersebut sebagai pakan ternak mengingat bahwa dengan biokonversi bahan lignoselulosa tersebut dapat juga dimanfaatkan untuk menghasilkan berbagai produk kimia (bioetanol, gula dan bioplastik), sebagai bahan bakar atau pupuk organik yang berpotensi menawarkan potensi manfaat yang lebih kompetitif. Beberapa keunggulan komparatif dari limbah tersebut antara lain adalah biaya yang relatif rendah, dapat diperbaharui dan tersebar luas untuk digunakan dalam operasional berskala industri.

Kata kunci: Kelapa sawit, hasil samping, nutrisi, domba, kambing

INTRODUCTION

It has long been recognized that the integration of ruminants with oil palm plantation is a promising alternative production system to encourage the ruminant production. In addition to developing a sustainable plantation industry or smallholders, the integration of plantation crops and ruminants is in accordance with the Indonesian government's policy to increase the national food production and to minimize imports including meat and other foods. The core concept of this type of agricultural production system has been based on the land and/or biomass by-products that are potentially available from the plantation system in supporting ruminant production in a mutualistic pathway. In the context of this paper, the nutritional support of by-products of oil palm plantation system will be discussed as these are the most abundant and various by-products. In this type of animal production system the biomass by-products or plant residues from the plantation system would play a crucial role since the utilization of forages from the underneath tree crops would be less or minimal as the palm oil crop mature.

Massive quantities and various by-product biomass are generated from the tree crops management and the process of extracting oil from the seed of palm oil fruits. Abdullah et al. (2011) reported that about 50-70 tonnes of biomass residues could be generated from one hectare of oil palm plantation. These by-product biomass are potential bases for developing a ruminant production system integrated with the palm oil plantation system. Except for palm kernel cake, all other by-products from oil palm extraction process and crop plantation residues are classified as non-conventional feed because they are generally not used in the ration of small ruminant either by smallholder or semi commercial enterprises. This paper presented and discussed the nutritional potentials, constraints and challenge of various by-products from the palm oil plantation system as feed for small ruminant production.

FEED INGREDIENTS FROM OIL PALM PLANTATION

The type of by-products generated from palm oil system is various, but in relation to the animal production they could be generally categorized into the fibrous by-products and the non-fibrous by-products. Quantitatively, the fibrous materials are the largest originating from the crop trees as crop residues and from the extracting process of palm oil fruits into crude palm oil. Although available in huge quantities, nutritionally they have limitation in supporting the nutrient and energy requirement of ruminants. In contrast, the non-fibrous by-products are available in

much less amount, but have greater nutritional capacity per unit biomass in supporting the animal requirements for energy and major nutrients such as protein, calcium, and phosphor to achieve an acceptable production level.

Fibrous by-products

Oil palm by-products or residues are mostly of fibrous materials rich in cellulose, hemicellulose, and lignin. The complex structures of the lignocellulosic materials make them very difficult to be degraded in the animal digestive tract system. These lignocellulose biomass include oil palm fronds (OPF) and oil palm trunk (OPT) generated from the palm crop trees and oil palm empty fruit bunch (OPEFB), and palm pressed fibre (PPF) generated from processing of fresh fruits to yield crude oil.

The standard management of oil palm plantation required that OPF is pruned during harvesting of fresh fruit bunches or when it senescences. Oil palm frond has complex structure containing leaves, rachis, and petiole. The petiole contains a large amount of sugars (Zahari et al. 2012) and relatively palatable. The production of OPF is approximately 550 kg/ha/year (Ebrahimi et al. 2015). Rahutomo et al. (2012) estimated that the weight of OPF could range from 3.19 to 15.07 kg linearly related to the age of the oil palm trees. Sudaryanto (2017) reported that oil palm fronds could be used as alternative green feed for ruminants. Palm fronds could be fed as it was or chopped without affected to rate of cattle consumption. Sudaryanto (2017) calculated that each tree produces 22 palm fronds/year with its weight of 7 kg/plant that is estimated equally to 20 tons fresh palm fronds per year. Each palm frond yields 0.5 kg of leaves or equal to 658 kg dry matter/ha/year. Based on this estimation, each hectare of oil palm provides 5,872 kg green feed resources. These residues are left in the field between the rows of the palm trees, and thus can represent an alternative source of roughages for ruminants on daily basis. However, in the long term the OPFs left in the field will benefit the oil palm plantation, as the composted OPF could conserve and control soil erosion as well as recycling nutrients to the palm oil trees. It is, therefore, not recommended to remove all OPF from the palm oil plantation to be used as animal feed. Rahutomo et al. (2012) suggested that optimum balance should be achieved when approximately 50% of the OPF is left in the field and the rest could be used as animal feed.

Oil palm empty fruit bunch are generated after oil extraction and account for approximately 20-25% of the fresh fruit weight. It is used internally by many oil palm mills as solid fuels for steam boiler, but a large portion is put in the field to be biodegraded into

compost or is burned in the incinerators to clear the field. It has bulk density of 112 kg/m³ (Olisa & Kotingo 2014). Information on its utilization for animal feed is very limited.

Oil palm trunk is a raw material generated from rejuvenation palm oil plantation after termination of the palm oil growing period whose life span is usually of 25 years. There is an opposite polysaccharide composition between the upper (above the half height point) and the lower parts of the OPT. The upper part contains less lignocellulose (35%) and more starch (65%), while the lower part has 68% lignocellulose and 32% starch (Munir & Goenadi 1999). The major lignocellulosic component of the OPT are lignin (25%), hemicellulose (24%), and cellulose (33%). It was reported that the lignocellulose fiber of OPT is covered by silica bodies that are present in greater amount in lower part of the trunk. Meanwhile, the physico-chemical properties of OPT starch is generally similar to those of sago and tapioca starch (Ridwansyah et al. 2007). These characteristics indicate that upper part of the OPT should offer a greater promising source of feed. Palm pressed fibre or mesocarp is a fibrous residue generated from oil palm extraction of the oil palm fruits that approximately accounts for 13-15% of the fresh fruit bunch. It has indigestible fraction due to high lignin contents, and usually used as solid fuel by many palm oil mills.

Non-fibrous by-products

Palm oil mill effluent and palm kernel cake are non-fibrous by-products produced during the processing of palm oil extraction. Purification of the crude palm oil yield palm oil mill effluent (POME) which include various liquid, residual oil, suspended solid and other contaminant such as dirt. The suspended solid are typically cellulosic material generated from the palm oil fruits. More than 500 kg of liquid wastes, mainly in the form of POME, are discharged during the processing of 1.0 ton of fresh fruit bunches. Palm oil mill effluent has high nutrient contents and large oil palm plantation prefer to use it directly as fertilizer. Decanter that reduce the solids in the waste water before discharging into the ponds has been adopted by many palm oil mills and yield a pasty solid by-product as decanter cake.

Palm kernel cake is obtained after extraction process of palm kernel oil from the kernel of oil palm fruit either by mechanical process using expeller or by chemical extraction using solvent. Approximately 55-60 kg palm kernel cake are produced per tonne of oil palm fresh fruit bunches processed. It is classified as non-fibrous feed mainly due to its relatively high energy content with a moderate level of protein concentration.

NUTRITIONAL QUALITIES AND SUPPORT FOR SMALL RUMINANTS

Feeding value in ruminants is determined by the efficiency of feed utilization to meet the amount and balance of nutrients required by rumen microbes to digest and ferment the feed and the amount and balance of nutrients absorbed by the animals (Leng 1990). Thus, the feeding value is the result of complex interaction among the crude chemical composition and digestibility of a feed and the intake and metabolism of the animal.

Fibrous component

The composition of the fibrous component of fibrous palm oil by-products are shown in Table 1. This composition could significantly vary due to factors such as area of origin, growing condition and age of palm oil trees. The cellulose are the most abundant in all by-products followed by the hemicellulose. These two components are reinforced in a lignin matrix (Khalil et al. 2012) which make them difficult to be degraded by rumen microbial enzymes.

Macro and microminerals

In general, the two macrominerals that have greater significant effect on the animal production when they are deficient in the diet are calcium (Ca) and phosphorus (P). The Ca and P requirement of growing goats of 20 kg body weight and gain at 100 g/day are about 3 and 2.1 g/day, respectively (NRC 1981). When these requirement recommendations are used as a reference, it is clear that the availabilities of these two elements from all of the fibrous palm oil by-products do impose restriction in meeting the requirements, due to the low intake of these by-products (Table 2).

Palm oil mill effluent contained sufficient amount of Ca and P to meet the requirement for growth, but the Ca/P seems to be too low so that diet based on the POME should be supplemented with calcium to correct this Ca/P ratio to approximately 1.2-2.0. The content of Zn is within the acceptable range, but again due to the low intake of this fibrous by-products supplementation of Zn might be required. Zn is not stored in the tissue of the animal so that it must be available on the daily basis. Supplementation of Zn at 35 ppm in diet composed of 30% (DM) OPF and was the sole roughage in the diet improved the DM intake and daily gain of growing goats (Ginting et al. 2017a). The content of copper (Cu) in PPF and palm kernel cake (PKC) is high, but due to the limited intake of PPF, this high level of Cu might not be harmful. The case is

Table 1. Compositions of fibrous component of several palm oil by-products

Component	Fiber compositions					
	Fibrous by-products				Non-fibrous by-products	
	OPF ^a	OPT ^a	PPF ^b	EFB ^a	POME ^{ce}	PKC ^{df}
Cellulose	40-50	29-37	21.3	43-65	39.56	35.7
Hemicellulose	34-38	12-17	31.9	17-33	23.33	30.3
Lignin	20-21	18-23	26.9	13-37	25.06	15.6
NDF					40,1	62-64
ADF	-	-	-	-	44	31,6

Source: ^aKhalil et al. (2012); ^bHock et al. (2009); ^cHandayani et al. (1987); ^{cd}Sinurat (2003); ^dGinting et al. (1987); ^eMun et al. (2008); ^fSaka et al. (2008)

Table 2. Macro and micromineral compositions of some fibrous and non-fibrous by-products of palm oil plantation

Elements	Fibrous by-products				Non-fibrous by-products	
	OPF ^a	OPT ^a	PPF ^b	EFB ^a	POME	PKC ^c
Ca (%)	0.17	0.15	0.20-0.32	0.17	0.02-0.09	0.20-0.42
P (%)	0.08	0.05	0.10-0.27	0.11	1.08.-2.33	0.42-0.74
Mg (%)	0.12	0.13	0.10	0.13	0.11-0.23	0.21-0.39
K (%)	1.63	1.46	0.50	2.06	2.00	0.33-0.92
Zn (ppm)	38	94	9.80	37	157	3-413
Cu (ppm)	9	13	27.10	8	-	20-55
Fe (ppm)	1090	951	-	1076	-	356-755
Mn (ppm)	47	39	n.d	42	n.d	24-313
Pb (ppm)	7.37	5.33	0.50	7.67	0.50	-
Cd (ppm)	1.33	0.56	n.d	1.30	n.d	-

OPF: Oil palm fronds; OPT: Oil palm trunk; PPF: Palm pressed fibre; OPEFB: Oil palm empty fruit brunch; POME: Palm oil mill effluent; PKC: Palm kernel cake

Source: ^aKala et al. (2009); ^bHock et al. (2009); ^cHeuzé et al. (2016)

different for PKC with high potential intake by the small ruminants. When PKC are offered in large amount during long period of time in particular for sheep, it can cause Cu toxicity to sheep which is more sensitive than goats. Copper toxicity in sheep could occur when dietary concentration at about 30 ppm, while in goats, Cu toxicity might occur at Cu concentration of Cu >60 ppm (Grace 1991).

Caloric and protein values

The average energy values were relatively low in most of the fibrous by-products ranging from 960 to 1450 Kcal ME/Kg DM (Table 3). The values varied due to the different process applied to generate these products. As expected, the non-fibrous by-products contained greater metabolisable energy. The total fat content of OPF is relatively low, but its fat has high unsaturated fatty acids (Hassim et al. 2007). The ether extract contents were relatively high in POME and

PKC. Thus, utilization of fibrous by-products as roughage in diet supplemented with high level of POME might give detrimental effect on the fiber digestion by rumen microorganism due to the high level of ether extract in the diet.

Table 3. Average nutrient content of palm oil by-products

By-products	ME (Kcal/kg DM)	CP (%)	Ether extract (%)
OPF	1400	4.69	1.20
OPT	1450	4.81	1.10
PPF	960	5.90	5.80
EFB	-	3.70	3.20
POME	2002	13.50	12.30
PKC (solvent extracted)	2506	16.50	7.50

Source: Hassan et al. (1994); Idris et al. (1998); Dahlan (2000); Kala et al. (2009)

The protein content of the fibrous palm oil by-products are relatively low ranging from 3.7 to 5.9%. These low level of crude protein contents suggested additional basic nutritional constraint of those materials in supporting the crude protein requirement of the small ruminants. It is clear that crude protein content is less than or in the border line of crude protein level (6-7%) required to enhance rumen microbial fermentation and feed intake.

The protein content of PKC depends on the extraction process applied. The solvent-extracted PKC has 2-3% lower ether extract content than the expeller-pressed PKC, resulting in greater protein content. PKC is considered to be cheap protein meal as animal feed with relatively high in methionine but low in lysine and threonine content (Carvalho et al. 2006).

Digestibilities

The lignocellulosic materials of the fibrous by-products typically have very low digestibility due to the high content of cellulose, hemicellulose and lignin. Lignin is the most resistant to degradation, while cellulose is more resistant to degradation than hemicellulose due to its highly crystalline structure. Xylan, a sugar polymer made of pentose sugar xylose also contained in these materials in high concentration, and is more susceptible to hydrolysis due to its amorphous structure compared to cellulose. *In vitro* study (Hassim et al. 2010) indicated a lower digestibility of oil palm frond (OPF) when included at higher level in the substrates, although the effects of inclusion level diminished when the rumen fluid used in the *in vitro* study have been previously adapted to the OPF. This indicated the potential adaptation of microbial population to the diet.

In vitro DM digestibility of PPF was reported to be very low ranging from 16.6 to 21.5% (Obese et al. 2001) resulting in low caloric value of approximately 1007 Kcal ME/kg DM. High contents of cellulose, hemicellulose, and lignin might account for this low digestibility level. A part from being resistant to microbial degradation, lignin prevented other nutrients from being degraded by ruminal microbes. The digestibility of cellulose and hemicellulose in PPF might even be interfered by its high ether extract content. Obese et al. (2001) reported the PPF ether extract content of 26.9 to 35% and defatted PPF has higher DM digestibility (34.5%) compared to undefatted PPF (16.6%). In this experiment, the ether extract content was too high which disturbed rumen digestion. Care must be taken when fed PPF without any process.

Delignification of PPF with White-rot fungi decreased the lignin content by as much as 35% and increased *in vitro* biodegradability by 21% (Tong et al.

1993). Previous study in goats (Ho et al. 1996) showed that time required for the establishment of rumen bacteria and fungi colonization of PPF was similar to other several fibrous crop residues including oil palm trunk shavings, but the degradation of PPF was slow. High content of fat in PPF (5-8%) may interfere the digestion of fibre in ruminants.

Intake

The feed intake is influenced by both the animal status (age, physiological status, and sex of the animal) and the feed characteristics (chemical composition and physical characteristic), with the animal seemed to affect more and the intake of those fibrous palm oil by-products is generally restricted by the physical constraints that closely related to the rate and extend of degradation and the rate of rumen outflow. For typical of feed ingredients, the size of the soluble and the insoluble fractions are the most important factor that will determine the intake (Ørskov 1991). Thus, from the feed characteristic, poor fermentation rate, low disappearance rate and passage through the rumen would lower feed intake. Unfortunately, the solubility of those fibrous oil palm by-products is limited. The fibre from oil palm by-products have relatively low specific gravity (1.25-1.50 g/cm³) (Khalil et al. 2012) which is indicator of their voluminous matter that would limit the rate of feed intake. The non-fibrous by-products particularly as PKC actually have good palatability so that intake should not be a limiting factor (Chanjula et al 2010).

Energy support of palm oil by-products

The nutrients and energy obtained by consuming feed is used mainly for maintenance and production. The nutrient and energy requirements for these both activities widely vary due to many factors such as body composition, physiological status, breed as well as environmental factors. To evaluate the nutritional support of feed to animal production, it requires a data base on nutrient requirements of the animal. In the case of goat nutrient requirements, some publication are available that could be used as references (Sahlu et al. 2004). The metabolizable energy (ME) requirement for growing goat of 15 kg body weight and gain at 100 g/day is predicted at 1377 Kcal/day (Sahlu et al. 2004). The average ME requirement for entire pregnancy period (BW 40 kg; 1.5 kid) and for lactation 1 milk/day calculated from Sahlu et al. (2004) to be 1100 and 414 Kcal/day, respectively. The predicted ME contribution relative to ME requirement of several palm oil by-products when fed as sole diet to growing goats, pregnant and lactating does are presented in Figure 1, 2, and 3. It is shown that none of the palm oil

Figure 1. Estimated ME contribution/ME requirement of palm oil by-products when fed as sole diet to growing goat 15 kg BW, ADG of 100 g/day and feed intake at 3.5% BW (DM)

Figure 2. Estimated ME contribution/ME requirement of palm oil by-products when fed as sole diet to pregnant does of 40 kg with feed intake of 3.5% BW (DM)

Figure 3. Estimated ME contribution/ME requirement of palm oil by-products when fed as sole diet to 40 kg lactating does producing 1 l milk/day with 3.5% fat content

by-products could meet the ME requirement for growing goats that are expected to gain at the rate of 100 g/day. The contribution of the metabolisable energy might be even lower when the real intake of those fibrous by-products is most probably lower than that assumed in this calculation.

Utilization of plantation by-products as feed for small ruminants

The fibrous by-products as feed ingredients for ruminants have typical problems that must be addressed i.e. transportation to the animal farm (logistic aspect), the amount of the biomasses that should be retained in the field for nutrient recycling for the benefit of the palm oil trees, and their significant nutritional constraints. Due to their nutritional limitation almost all of the fibrous palm oil by-products could be used only as the sources of roughages that would contribute some metabolizable energy required by the animals. As roughage, they may also be important in supporting optimum physiological digestive function of the reticulo-rumen. Therefore, to achieve a high level of production, they should not be used as a sole feed in ruminants.

Inclusion of OPF at 25% in total mixed ration did not affect the intake and ADG in sheep and cause the reduction of carcass fat content and total subcutaneous fat. However, increasing the inclusion rate to 50% resulted in poorer ADG, decreased total carcass yield and subcutaneous fat but increased the amount of the n-3 PUFA in the body tissue of goats (Ebrahimi et al. 2013). Similar effects on carcass fat was detected in sheep offered high level of OPF (Goh 2002; Mahgoub et al. 2007). *In vitro* studies (Hassim et al. 2010) showed that increasing the level of OPF inclusion in diets linearly decreased total SCFA, increased the acetate and decreased propionate molar proportion and increased biohydrogenation of fatty acid and CH₄ production. Zain et al. (2008) found that feed intake, fermentation rate and ADG in sheep were less when elephant grass was replaced by ammoniated PPF at 50% inclusion rate in total mixed ration. This indicated that the optimum level of ammoniated PPF in the diet should be less than 50% on DM basis.

Due to complex structure of the lignocellulosic biomass cell wall, pretreatment is required to alter their structural and chemical compositions and to facilitate rapid and efficient hydrolysis of carbohydrates to fermentable sugars. Combination of physical, chemical, and thermal pretreatments to increase the enzymatic hydrolysis of oil palm empty fruit bunch (OPEFB) in the ruminant could be a promising method to increase its values as animal feed. This is indicated in the study of Ariffin et al. (2008) showing that the production of reducing sugars from enzymatic saccharification of

chemically and thermal pretreated OPEFB was nine times higher than untreated OPEFB. Although technically the method could be feasible for large scale feed production, the economic feasibility needs to be considered. The recommended optimal inclusion level of palm oil by-products is presented in Table 4. Among all by-products from oil palm plantation, PKC was the most widely studied and has been used in animal production. Although the fiber content of PKC could be relatively high especially when contaminated by nut shell, basically this by-products could be classified as non-fibrous feed ingredient. Thus, in addition of the level of nut shell contamination, the concentration of fat and Cu may limit the rate of utilization as feed for ruminants, particularly sheep. The Cu content of PKC is between 20-55 ppm. In long term feeding, high level of PKC inclusion in diet can cause Cu toxicity in sheep.

Table 4. Suggested level of inclusion of palm oil by-products for reasonable production level of goats

Item	Levels of inclusion in diets (% DM)			
	Growing ^a	Mature ^a	Pregnant ^b	Lactating ^b
OPF	20-30	30	20	10
OPT	20	50	-	-
PPF	10	20	-	-
EFB	-	-	-	-
POME	10-15	40	20	15
PKC	10-15	30-50	30	30

OPF: Oil palm frond; OPT: Oil palm trunk; PPF: Palm pressed fiber; EFB: Empty Fruit Bunch; POME: Palm oil mill effluent; PKC: Palm kernel cake

Source: Alimon (2004); Chanjula et al. (2010); Hassim et al. (2010); ^aGinting et al. (2017a); Ebrahimi et al. (2013); ^bIndonesia Goat Research Institute (2017)

Chanjula et al. (2010) observed in goats that inclusion levels of PKC in diet from 15 to 55% had no effect on feed intake, but found that significant decreases in apparent digestibility of DM, OM, CP, NDF, and ADF occurred at the inclusion level of 45 or 55%. At those inclusion levels, it was also reported that the rumen protozoal population was significantly reduced. Thus, this study concluded that the optimum level of PKC inclusion in goat diet should range from 15-35%. Others, however, reported that goats are less sensitive than sheep to the high Cu content of PKC, so that the inclusion level in diets could be at wider ranges. Another limitation of PKC utilization as feed, in particular for young animals are its potential contamination by the nut shell. Observation in the weaned goat flock at the Indonesia Goat Research Institute (Figure 4) showed the intact nut shell

remained in the digestive tract of weaned goat fed concentrate feed containing PKC. This figure indicated that the nut shell have not been digested at all. The maximum utilization of PKC should be achieved for all class of sheep and goats if the nut shell contamination could be minimized.

Ginting et al. (2017b) has used OPF as the sole source of roughage in a total mixed ration with crude protein level of 16-18% and metabolizable energy level of 2650-2850 Kcal/kg DM for growing Boerka goats (Boer × Kacang crossed) and found that inclusion of OPT at 30% (DM) resulted in good daily gain (97-110 g/day).

Figure 4. Intact nut shell remained in the digestive tract of weaned goat offered concentrate feed containing PKC

Source: Indonesia Goat Research Institute (2017)

FUTURE CHALLENGES AND OPPORTUNITY

Pretreatments (physical, chemical, and biological methods) have been suggested as means for improving the nutritive qualities of ligno-cellulosic materials. The ultimate goal of such procedures is to increase the digestible organic matter intake of those materials so that the supply of nutrient for fermentation process in the rumen and absorption and utilization by the animal tissues are optimal. The effects of pretreatments on the degradation and digestibility of oil palm fibrous by products and intake and performances of ruminants varied as they are affected by many factors and the application is limited. It might be concerned that direct use of most of the oil palm by-products has some serious limitation for practical application either for smallholders or commercial livestock operations. Although physical, chemical, thermal, biological treatments, or combination of these treatments have

proven to increase their DM digestibility, their application vary from low to moderate levels. The physical characteristics (fiber length, diameter, lumen with, density, and fibril angel) and mechanical characteristics (tensile strength, elongation at break) of fiber found in oil palm biomass residues vary greatly (Khalil et al. 2012). How these characteristics could be manipulated for optimal used as animal feed by increasing digestibility, lag time before the start of fermentation, a shift of a portion of its organic matter portion from slowly digested to the rapidly digested pool and increasing rate of digestion of the slowly digested pool is challenging. The adoption of the pretreatment technologies thus might be limited to large scale animal operations only. Although increased digestible organic matter intake from these materials could be expected by performing pretreatments, but the economic and technical feasibility should be serious concern. A wider adoption of those methods might be expected if there is a greater economic value of animal products that could be generated from such a feeding system. In this case, commercial small ruminant operations that focused on the exporting live animals might be prospective.

CONCLUSION

The capacity of nutritional support of palm oil residues and by-products on small ruminant production are various. Those feed ingredients categorized as fibrous feed seemed to be unable to fulfill the metabolizable energy requirement for high growth rate, and lactation, but they were adequate for pregnancy. In the concentrate feed, only palm kernel cake has the capacity in supporting the requirement of metabolizable energy for lactating, and both palm kernel cake (PKC) and palm oil mill effluent (POME) are insufficient to support the ME requirement for high growth rate of small ruminant. The crude protein contents of those fibrous feed ingredients seemed to be sufficient for maintaining the rumen function at best, but the crude protein content of PKC and POME are greater in supporting higher production rate. Palm oil mill effluent and PKC contained sufficient amount of Ca and P to meet the requirement for growth, but the Ca/P seems to be too low so that diet based on POME should be supplemented with Ca to correct this Ca/P ratio to approximately 1.2-2.0.

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