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Nutrient profiling in goats raised by smallholders and institutional farms in Bachok and Pasir Puteh Districts, Kelantan, Peninsular Malaysia

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ABSTRACT

A study was conducted to investigate the nutrient profiling of growing Boer-crosses goats reared by smallholders in Bachok and Pasir Puteh Districts, Kelantan, Peninsular Malaysia. Daily rations, encompasing about 60% garss and 40% concentrate mixture, were analyzed for proximate and selected minerals (Ca, P, Mg, Na, K and Cu), while blood plasma of the animals were analyzed for minerals only. The results were compared with those managed under the institutional environments in the same locations, where improved feeding and management were practised. The results demonstrated large variations in the content of dry matter (DM), crude fibre (CF), crude protein (CP), ether extract (EE), ash, Ca, P, Mg, Na, K and Cu, both in smallholders and institutional (MARDI) farms. Daily intake of nutrients by the animals under the smallholders condition was estimated below requirement, causing reduced animal performances and body conformation as compared with those under institutional condition. However, the deficiencies and imbalances in the nutrients studied are marginal to induce definite clinical symptoms. In the latter case, improved feeding system can still result in inferior growth performance. Parasite infestation was identified as a factor contributing to this effect. Practical methods to enhancing goat productivity under smallholders environment are highlighted.

Keywords: **Goats,nutrient profile, plasma mineral,smallholders, institutional farms**

1. Introduction

Nutrient deficiencies and imbalances are amongs the main constraints severely inhibiting the ruminant industry in Malaysia. Issues related to energy, protein, mineral and vitamin deficiencies are common, particularly in ruminants reared by smallholders. Under the extensive management systems, most ruminants largely depend on native grasses, shrubs, crop residues and agro-industrial by-products which are poor in nutrition, particularly in protein and energy content. In some areas, improved grasses of higher nutritive values are utilised as feedstuffs by smallholders, mostly in the semi-intensive system. Nevertheless, in many cases, these grasses are harvested at longer age (i.e. > 6 weeks), resulting in lower nutritional content. Imbalances of nutrients are also attributed to poor selection and mixing of ingredients which could not fulfil the daily nutritional requirements of ruminants. A comprehensive study on the mineral status of indigenous swamp buffaloes and Kedah-Kelantan cattle in Peninsular Malaysia has been undertaken and reported (Wan Zahari and Devendra, 1985).

In Peninsular Malaysia, goat is widely reared by the smallholders; and Kelantan is one of the major states having higher population of the animal. There are approximately 38,000 goats in Kelantan alone (which is about10% of the goat population in Peninsular Malaysia), mainly distributed in the following districts – Bachok (5,310 heads), Pasir Puteh (4,303 heads), Kota Bharu (6,564 heads) and Pasir Mas (6,680 heads) (DVS, 2011). The Boer breed is the most common one reared by smallholders, apart from the Jamnapari, the local Katcang, Anglo-Nubian as well as their crosses. The interest in goat rearing is attributed partly due to the push and promotion by the Malaysian government in the pursuit of vastly increasing local goat and mutton production, which currently only meets less than 10% of national demand. The emphasis on ruminant production, including goat, also runs in tandem with the development of the Eastern Corridor of Economic Region (ECER) – which sets its agenda and thrust towards vitalising the income of farmers with low-income.

In most tropical countries, phosphorus (P) deficiency is indeed one of the most predominant problems of mineral imbalances in ruminant production, particularly those from extensive agricultural systems (Kebreab and Vitti, 2010). Apart from calcium (Ca), phosphorus is the most abundant mineral element in the body and is the diet's major cation (Kiarie and Nyachoti, 2010). Deficiencies of other elements may also occur, being more attributed to specific locations; which thus merit special investigation. Many factors come into play, including: breed difference, physiological status, breed tolerance, and environmental factors. Deficiencies and imbalances of nutrients will exist when daily requirements cannot be met. As a matter of principle, an essential nutrient mandates a necessary amount of dietary intake into the metabolism – to thus fulfill the specific physiological processes (Windisch and Ettle, 2008).

In relation to this, the present trial was conducted to study the nutrient profiling of growing goats reared by smallholders in two selected districts (i.e. Bachok and Pasir Puteh) with the objective of understanding the severity of nutrient deficiencies and imbalances based on common feeding practices. It was also the objective of the study to look into the benefits of improved rations, so that comparison and strategic intervention could be planned in farms suffering from inferior nutrition. For this reason, two institutional farms in the same districts which have been observed to have better management and dietary practices were chosen for this study.

2. Methodology

(I) Animals and Feeding

The study was conducted at Bachok and PasirPuteh – two districts popularly known for goat farming in Kelantan. Three smallholders from different villages were randomly selected from each district for the study. The number of goats reared differed between smallholders and ranged between 20 and 40 heads, primarily encompassing of crossbred Boers. The animals were between 6 and 18 months of age with estimated live weight (LW) averaging at 30 -32 kg. Each smallholder fed their animals with grass and concentrate mixture at the ratio of about 60:40, normally in the morning. The grass fed was predominantly of the Napier (*Pennisetumpurpureum)* species whilst the concentrate exclusively consisted of palm kernel expeller (PKE), soya bean waste and lower-grade rice bran. Apart from consuming the feed mixture, the animals were also allowed to graze freely, when possible, for 4 to 6 hours with *ad libitum* fresh water.

The study also incorporated groups of growing Boer goats from the Telong MARDI Station in Bachok; and the JeramPasu MARDI Station in PasirPuteh. In Telong, the animals were fed with 60% pelleted complete feed and 40% chopped *Brachiariahumidicola*; whereas in JeramPasu, the animals were allowed free grazing for approximately 4 hours on the same species of grass and also fed with 200g of pelleted complete feed daily. Irrespective of gender, the animals chosen for the study were between 6 to 18 months of age with mean live weights of 40 kg and 35kg from Telong and JeramPasu farms respectively. Both institutional farms were used as benchmark comparisons to the smallholders' farms with regard to the management and dietary practices. Numbers of animals from the respective treatment groups are shown in **Table 1.**

(I) Blood analysis

Samples of blood plasma were collected from the respective goats and analyzed for Ca, P, Mg, Na, K and Cu by using inductive coupled plasma (ICP) – optical emission spectrometry (Perkin Elmer, Model: Optima 5300 DV) against prepared concentration gradients of different mineral standards.

(II) Feed analysis

Samples of feed were collected from the respective farms and were immediately dried (at 70°C till a constant weight was attained) and milled through a 2 mm screen for proximate and mineral analysis. Analysis of dry matter, ash, crude protein (CP), ether extract (EE) and crude fiber (CF) were based on the method of AOAC (2000) and two replications were carried out for each sample.

Mineral analysis on feed samples is similar to those applied for blood plasma samples. The nutritive value of feed samples from each farm is shown in **Table 2** whereas the estimated feed and nutrient intake is shown in **Table 3.**

Table 1: Number of Animals, Body Condition Score (BSC) and Feeding Practices Between Four Farms.

Variables	Smallholders farms		Institutional farms	
	Bachok **(BF)**	PasirPuteh **(PF)**	MARDI TelongBachok **(BM)**	MARDI JeramPasu, PasirPuteh **(PM)**
No of Animals used for sampling purposes	28	19	22	15
Breed type	Boer crosses	Boer crosses	Boer	Boer
Type of diet	60% grass: 40% concentrate mixture	60% grass: 40% concentrate mixture	Intensively fed with complete feed (pellet) (60%) plus chopped *Brachiariahumidicola*(40%)	Free grazing on *Brachiariahumidicola* + 200 g complete feed per animal per day*
Mean live weight (kg)	30	32	40	35
Body Condition Score (BCS)[+]	3	4	4	2.5
Reported health condition	Reduced appetite, osteophagia (pica), skinny body	-	-	Parasite infection**, High mortality of kids

* Complete feed received: calculated about 0.6% of mean live weight of 35 kg.
**Mean of egg/ gram (EPG) = 2330
\+ Reference: Langston University Goat Research Extension

(III) Statistical analysis

The analysis of variance of the mineral contents in the plasma samples were analyzed by Snedecor and Cochran (1980). The least significance differences (LSD) were used to determine the differences among the means of treatment.

Table 2 : Nutritive value of feeds used in the four farms.

Nutrients	Bachok Farms (BF)		PasirPuteh Farms (PF)		MARDI Bachok (BM)+ MARDI PasirPuteh (PM)	
%	Grass mixture	Pellet	Grass mixture	PKE Pellet	Grass**	Pellet*
DM	40	87	38	90	19	91
CF	29.5	24.48	28.57	16.6	30.4	17.94
CP	11.05	14.43	12.53	15.65	10.2	14.50
EE	2.65	3.17	2.77	3.3	3.2	4.5
Ash	13.45	10.55	13.40	5.63	13.4	7.36
Ca	0.30	0.31	0.34	0.30	0.29	1.23
P	0.23	0.55	0.21	0.67	0.30	0.53
Mg	0.29	0.18	0.30	0.28		
Cu(ppm)	8.15	16.93	8.0	22.3		

*Developed by MARDI for commercial use (2010).
** Grass species: *Brachiariahumidicola*

Table 3: Estimation of nutrient intake and requirement (g/day), in goats in four farms.

		Nutrients (g/day)++										
Farms		Fresh g / day	DM%	DM	CF	CP	EE	Ash	Ca	P	Mg	Cu
Bachok Farms	Grass mix	1050	40	420	123.9	46.41	11.13	56.49	1.26	0.097	1.22	0.34
	Pellet	250	87	218	53.37	31.46	6.91	23.0	0.68	1.20	0.39	0.37
	Total intake			638	177.27	77.87	18.04	79.49	1.94	1.30	0.51	0.71
	Req. g/day			1050 *	291.75	128.16	29.69	138.8	3.19	2.14	0.84	1.17
PasirPuteh Farms	Grass mix	1150	38	437	124.85	54.75	12.11	58.56	1.49	0.92	1.31	0.35
	Pellet	375	90	338	56.11	52.90	11.15	19.03	1.01	2.27	0.95	0.75
	Total intake			775	180.96	107.65	23.26	77.59	2.50	3.19	2.26	1.10
	Req. g/day			1120**	261.52	155.57	33.62	112.13	3.61	4.61	3.27	1.60
MARDI Bachok	Grass 40%	2421	19	460	139.84	46.92	14.72	61.64	1.33	1.38		
	Pellet 60%	758	91	690	123.79	100.05	31.05	50.78	8.49	3.66		
	Total intake			1150	263.63	146.97	45.77	112.42	10.22	5.04		

	Req. g/day			1400 ***	320.94	178.92	55.72	136.86	12.44	6.14		
MARDI PasirPuteh	Grass +	2196	19	417.24	126.84	42.56	13.35	55.91	5.13	2.21		
	Pellet	200	91	182	32.65	26.39	8.19	13.40	2.24	0.97		
	Total intake			599.24	159.49	68.95	21.54	69.31	7.37	3.18		
	Req. g/day			1225 ****	326.04	140.95	44.03	90.17	15.07	6.50		

*Based on 3.5% of mean live weight (30kg) ** (32kg) *** (40kg) ****(35kg)

+ Assuming that grass intake (DM) is about 40% of the total dry matter on offer

++ All estimation were based on DM basis

3. Results & Discussion

Mean live weight of MARDI farm in Bachok (BM) group (40kg) was higher than MARDI farm in PasirPuteh (PM) group (35kg) and BF and PF groups (30kg and 32kg respectively) **(Table 1**). The differences in mean live weights may be attributed mainly to the high level of feeding in the former group (1150 and 146.97g/day, for DMI and CP respectively) **(Table 3)**. These findings are in agreement with those of Hicks *et al*.,(1990) who reported that higher intake of a given diet resulted in greater live weight. The effects of different dietary levels on rate of growth of lambs have been reported (Wan Zahari*et al*, 1989; Hosseini*et al.,* 2008).

It is observed that the mean live weights of animals from both institutional farms are higher than those from smallholder farms. The difference is mainly attributed to better selection of the animals in the former groups as purchasing are based on certain specifications with more inclination towards higher blood line (pure breed). Animals owned by smallholders are often variable in body sizes. Most of the time, purchase depends on *in situ* availability thus limiting selection opportunities. Differences of mean live-weight between the two institutional farms are mainly attributed to the difference in feeding practices. BM group were intensively fed with complete feed (pellet) and chopped *Brachiariahumidicola*at the ratio of 60%: 40%, whereas the PM group were allowed free grazing on *Brachiariahumidicola* and supplementing with 200 g of complete feed per animal per day. In comparison to the BM group, the depression of mean live-weight of the PM group is seen to be caused by pronounced parasite infection with mean faecal egg count (FEC) of 2330. This was also reflected by impairment of appetite, voluntary feed intake, poor growth rate and subsequent poor body condition. It is likely that uncontrolled free-grazing is the main factor causing high parasitic load in the PM group, despite grass supply being abundantly available. However, the grasses are below the optimum age of maturity with crude protein (CP) content of 10.2%. Undoubtedly, higher humidity (>80 %) coupled with warmer environmental temperature (>30^{o}C) will encourage maximum parasitic activity, causing significant impairment in their overall body systems (Barger, 1999 and Chiejina*et al*., 2005). The effects of parasite on reduced feed intake, feed conversion efficiency (FCE) and live-weight have been well established (Knox and Wan Zahari, 1997; Beriajaya and Copeman 2006; Al-Khayat and Al-Jebory, 2012).

The proximate and mineral analysis of feed used in the smallholder farms in Bachok (BF) and PasirPuteh (PF) and institutional farms (MARDI stations, BM and PM) are shown in **Table 2**. Large variations exist in the nutritive values of grasses used by the different farms, which could be attributed to environmental factors – notably of temperature, rainfall and soil conditions, as well as the genetic variations and the age when the grass was cut. All of these main contributing factors have been well highlighted by many authors (example Fatur and Khadiga, 2007 and Wood *et al.,* 1998). The *Brachiariahumidicola* in the BM and PM groups are consumed at early stage of growth (< 4 weeks) and this is linked to lower DM content (19%) as compared to 38 – 40% in the grass mixture of the BF and PF groups. Lean (1980) also reported lower DM and CP content when grasses are at early stage of growth.

Apart from formulations, differences were also evident in the type and quality of ingredients in the pellets used by different farms as have been reported (Dryden, 2008; NRC, 2001). If the intake of the diets are not limiting in the respective groups, the values can be considered meeting the requirements of 11-12%, as recommended by the NRC (1981) for moderate body weight gains of growing goats.

Dry matter intake (DMI) for each group are estimated based on 3.5% of mean live weight of goats as commonly been practiced in Malaysia. These values will then be used to calculate fresh intake based on moisture content of the diets. These will subsequently allow estimation of nutrient intake for the respective groups as shown in **Table 3.** Highest DMI was recorded by BM group (1150g), while the lowest was PM (599.24g). Intermediate DMI were observed in the PF and BF farms with the values of 775g and 638g DM respectively. Similar pattern of flow were observed in all nutrients. In particular, the demand for Ca is seen highest in BM group, possibly could not be fulfilled by the low Ca content in the grasses, moreover when Ca requirement is increased to suit the bigger body size and weight (40 kg) of the animals.

Similarly, based on 3.5% of mean live weight, **Table 4** shows the estimated additional DM required to meet the daily requirements for optimum performance. The demand is highest in the PM group (625.76g/day), followed by BF group (412g/day), PF group (345g/day) and BM group (250g/day). These values are equivalent to 1.7, 2.1, 2.4 and 2.9% of the mean live weight of the goats. However, the highest demand for DMI in this study (625.76g/day) was far less than those reported by Omojola*et al.* (2001) using West African dwarf goats. Compensatory growth can be considered as one of the factors contributing to the differences, apart from breeds, plant species and environmental factors. Interestingly, Phosphorus (P) in the BM is not following the same order, which can be explained by high inclusion of cereals in the pellets. In contrast to grass, cereal-based diets generally contain a significant proportion of P, even though in the form of phytates (NRC, 2001). These substances are highly available to ruminants, mainly due to the presence of phytases in the rumen (Morse *et al.,* 1992).

Table 4: Estimation of additional nutrient required for optimum performance* (g/day).

Farms	DM	CF	CP	EE	Ash	Ca	P	Mg	Cu
Bachok farm (BF)	412	114.48	50.29	11.65	51.33	1.25	0.84	0.33	0.46
PasirPuteh Farm (PF)	345	80.56	47.92	10.36	34.54	1.11	1.42	1.01	0.50
MARDI Bachok (BM)	250	57.31	31.95	9.95	24.44	2.22	1.10		
MARDI PasirPuteh (PM)	625.76	166.55	72.00	22.49	46.06	7.70	3.32		

*Targeted DM intake, based on 3.5% of mean live weight.

Hence, these results revealed the importance of balance feeding and adequate nutrition in ensuring optimum performances of the animals. In this regard, inadequacy of feeding, either in terms of DMI or lack of nutrients could affect animal body condition, and more importantly the general health of the animals and their ability to defense against diseases. These issues are more critical when animals are loaded with parasitic infections, which also involved important nutrients, particularly protein and minerals. The demand for these nutrients is high especially during rapid growth (Wan Zahari*et al.,* 1989). Therefore, the supply of proteins, lipids, carbohydrates, minerals and vitamins must be provided in optimal concentrations and according to requirements for specific production functions (Studzinski*et al*., 2006).

The mineral concentrations in blood plasma of the animals between farms merit some comments .Animals in PF group were found to have highest plasma Ca (14.98 mg/100 ml) ($P<0.05$) **(Fig.1).**whereas those in PM group were the lowest (8.47 mg/100ml). However, these values are within normal acceptable range and not an indicative of Ca deficiency (McDowell, 1976). In fact, the values are comparable to those in earlier study (Wan Zahari and Abdul Wahid, 1985). On the other hand, there were no significant differences between BF and BM groups.

Highest intake of Ca in the BM group (10.22 g/day) did not result in increased plasma Ca level. In fact, plasma Ca concentration is lowest (8.46 mg/100ml) in this group. This is likely to be linked to high intake of P in this group (3.66 g/day), and possibly has indirect effect on the availability of Ca (Studzinski*et al.,* 2006).

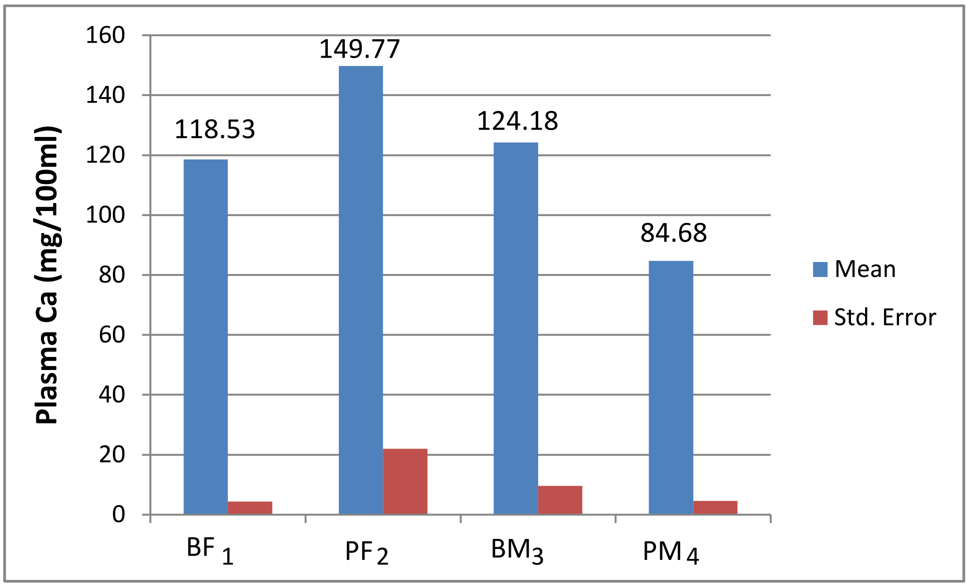

Figure 1: Mean plasmaCa concentration (mg/100ml) in the four groups.

There were statistical differences ($P<0.05$) between BF, PF and PM groups in plasma P concentrations with the mean of 10.81, 9.71 and 7.73 mg/100ml respectively **(Fig.2).** These values are slightly lower than the mean value of 12.18 mg/100ml as reported in the earlier study (Wan Zahari and Abdul Wahid, 1985) and even not suggestive of P deficiency. Deficiency of P usually occurs when level of plasma P is less than 4.5 mg/100 ml (McDowell, 1976). Lower level of plasma P in the PM group could be related to low intake of P which is associated with grazing activity. More so, if soil is limiting in available-P (McCosker and Winks, 1994). There were also no significant differences in plasma P between BM (10.05 mg/100 ml) and PF groups.

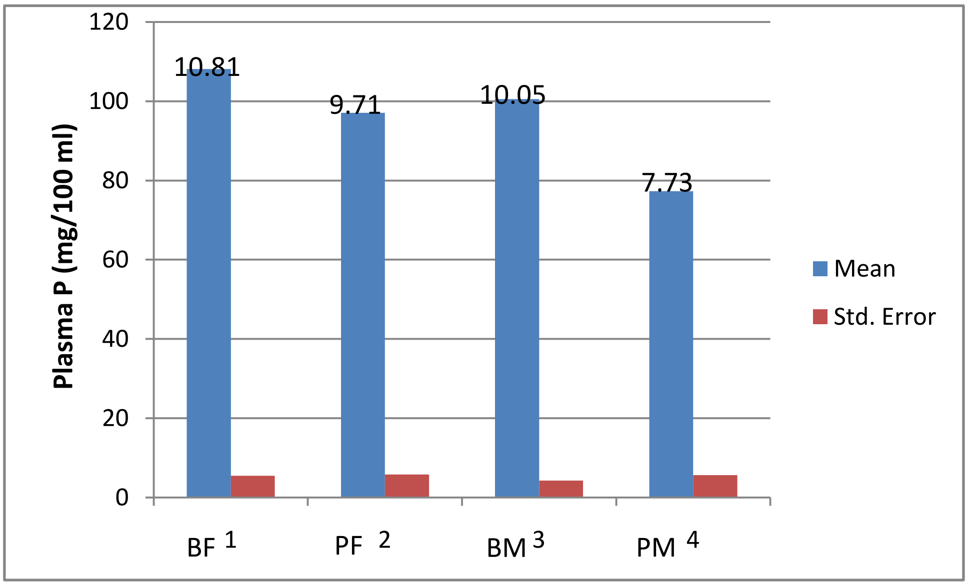

Figure 2: Mean plasma P concentration (mg/100ml) in the four groups

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Ca and P are often considered together in livestock nutrition as their metabolisms are very closely related (Kebreab and Vitti, 2010; Dryden, 2008). The results in this study generally indicated that there were no direct effects of Ca and P intakes on their levels in blood plasma in all of the groups. However, the inter-dependent of Ca and P in their metabolism is evident, affecting their absorption (Laroche, 2001). P availability is greatly depended on the ratio of Ca:P, apart from its chemical form in the diets (Dryden, 2008). Similarly, any disturbance in the absorbed Ca:P, for example with the presence of oxalate, will lead to reduced Ca absorption (Cheeke and Dierefeld, 2010).

There were no significant differences in plasma Mg concentrations between the BF and PF groups with the mean values of 28.58ppm and 29.63ppm respectively. Plasma Mg concentrations were markedly higher in both groups ($P<0.05$) as compared to other groups. PM group was found lowest (21.28ppm) in plasma Mg concentration. **Figure 3** shows the results of plasma Mg concentration between groups.

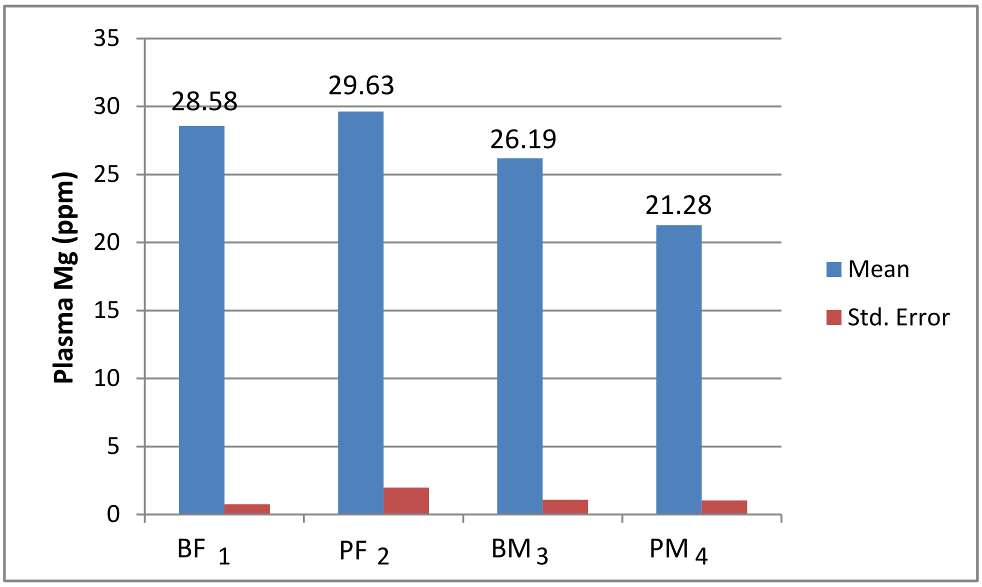

Figure 3: Mean plasma Mg concentration (ppm) in the four groups.

Plasma Na concentration in the BF group (2408.47ppm) was higher ($P<0.05$) than other groups **(Fig.4).** BM and PM groups were found to have lower Na plasma concentrations, with the means of 2290.31ppm and 2220.4ppm respectively. On the other hand, the Na plasma concentration was 2314.11 ppm in the PF group but the differences with other groups were not significant.

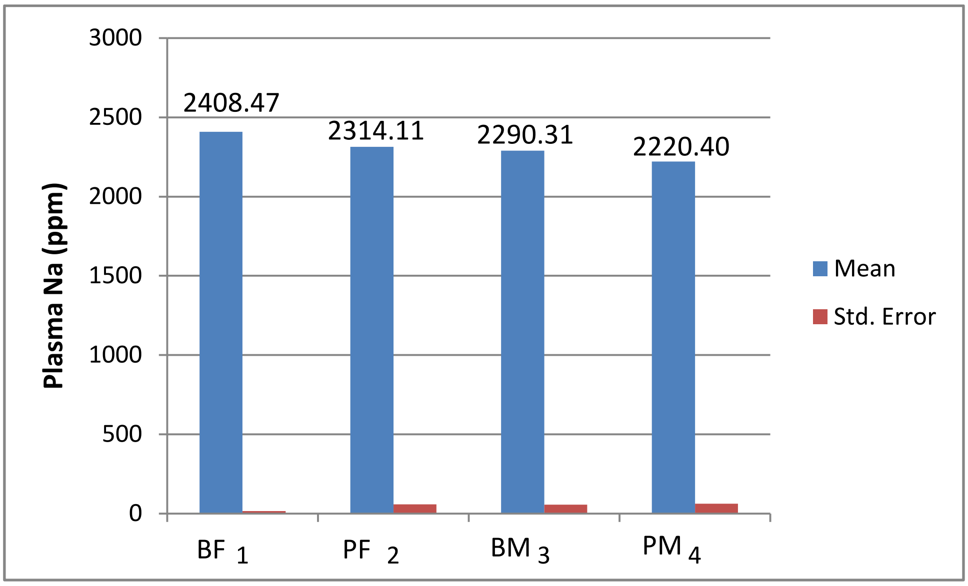

Figure 4: Mean plasma Na concentration (ppm) in the four groups.

Figure 5 shows the plasma K concentrations in the four groups. BM group recorded highest (990.28ppm) ($P<0.05$) as compared with other groups. PF group recorded the lowest (351.31ppm). There were no significant differences in plasma K concentrations between BF group (431.4ppm) and PM group (425.64ppm

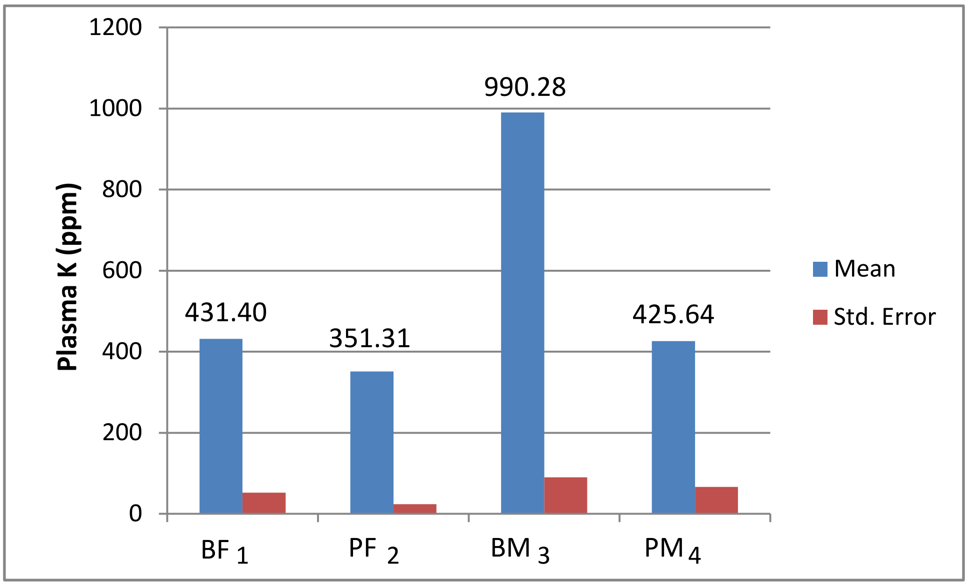

Figure 5: Mean plasma K concentration (ppm) in the four groups.

Plasma Mg levels in the animals from the institutional farms are lower than those in the smallholders farms (BF and PF groups) even though the estimated Mg intakes are very much lower in the former groups. Low Mg and high K levels in the grass (*Brachiariahumidicola*) used in the institutional farms could be the main factor attributing to their lower plasma Mg level. Furthermore, the mixture of grasses used by the smallholders will provide more conducive levels of minerals which subsequently translated into better animal performance. As in the case of the institutional farms, heavy fertilized pastures with high N and K will result in an extremely low availability of Mg (NRC, 2001; Studzinski*et al*., 2006). Low Mg intake associated with grazing young and lush grasses could be the causal factor attributing to low plasma Mg level in the PM group.

Plasma K and Na levels varied greatly between groups. It is also observed that the plasma Na is constantly higher than plasma K in all groups with the Na: K ratio of 5.58: 1, 6.59: 1, 2.31:1 and 5.22:1 in the BF, PF, BM, and PM groups respectively. These ratios are lower than 8.66: 1 for goats as reported previously (Wan Zahari and Abdul Wahid, 1985). The lowest Na:K ratio was recorded in the PM group and this could be associated partly to high Na intake from grass mixture, consisting varieties of grass species (Dryden, 2008).

Like most other elements, plasma Cu level usually influenced by dietary Cu and the relationship between Cu and other dietary components (WanZahari and Abdul Wahid, 1985).The absorption of Cu is governed by many factors as has been reviewed (Studzinski*et al.*, 2006; McFarlane *et al.*, 1990). **Figure 6** illustrates the plasma Cu level between groups and by comparison, plasma Cu levels recorded in this study are very much higher than those in the previous study (0.29ppm) (Wan Zahari and Abdul Wahid, 1985).There were no significant differences in the plasma Cu level between BF and BM groups, with the mean of 1.09ppm and 1.10 ppm respectively. However, significant differences ($P<0.05$) were observed between PF and PM groups whereby the former group recorded the highest (1.21 ppm) whereas the latter group the lowest (0.72ppm). Marked depression of plasma Cu in the PM group is understandable, possibly due to heavy parasitic infection as has been reported previously (Knox and Wan Zahari, 1997).

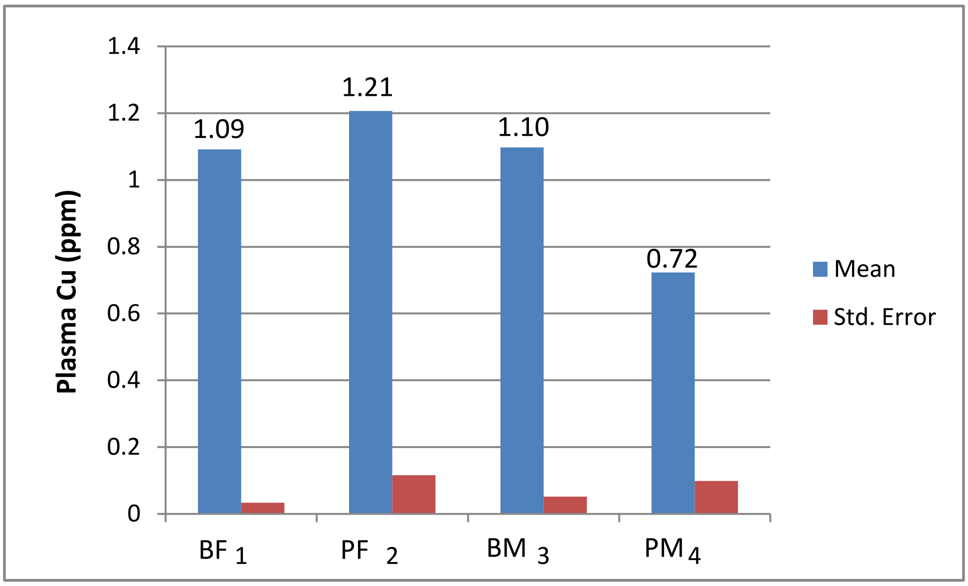

Figure 6: Mean plasma Cu concentration (ppm) in the four groups.

It is important to note that palm kernel expeller (PKE) is widely used by the smallholders in Kelantan as a main ingredient or as a concentrate supplement in goat feeding. PKE is observed to be more easily available in PasirPuteh as compare to other districts, partly due to larger number of feed suppliers and accessibility to a local feed mill. Thus, high Cu and low Ca level in the PF group could be linked to the heavy use of PKE by the smallholders. It is a known fact that PKC is high in Cu and limiting in Ca (Chooi*et al.*, 1988; Wan Zahari and Alimon, 2003).

Sub-optimum production of the animals under smallholder condition can be further enhanced by enriching their understanding on general goat nutrition. These should include information on how to find and utilize good quality feedstuffs (including pastures), better feeding protocols and simple formulations. This knowledge are also important for our smallholders in developing more practical and cost-effective feeds for smallholders. In this regard, local forages, tree fodders, crop residues and agro-industrial by-products available should be maximized for animal feeding. Nitrogen (N) fixing fodder trees of importance to be further introduced in the smallholders community include *Gliricidiasepium, Sesbaniagrandifolia, Flemingiacongesta* and commonly available, *Leucaenaleucocephala*(Wan Zahari*et al.,* 2009).

4. Conclusion

The present study demonstrated large variations of nutrient status in the goats raised under smallholder conditions as well as those under improved feeding conditions. As reflected in both smallholder farms (BF and PF), nutrient deficiencies and imbalances are not as severe as what have been originally thought. Though daily intake of nutrients is estimated below the daily requirements, there were no definite evidences to suggest specific nutrient deficiencies and imbalances, particularly with regard to mineral nutrition. Under those situation, nutrient imbalances might be marginal, but enough to cause impairments in growth rate and body condition. Productivity of goats can be improved through strategic feeding and proper nutrient supplementation which will be initiated in targeted farming areas. This objective will be realized by the UMK-ECER Research & Development Excellent Research Center for the smallholders in the ECER Region.

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