UNIVERSITI PUTRA MALAYSIA

EFFECT OF SUPPLEMENTING MOLYBDENUM, MOLYBDENUM AND SULPHUR, AND ZINC ON MINERAL EXCRETION OF SHEEP FED WITH PALM KERNEL CAKE

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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DEDICATION

With appreciation and respect,
this thesis is dedicated

To the people of Yemen. I owe my country a great debt

To my parents,

who supported and inspired me with confidence and ambitions

To all my supervisors,

who ensured it all worthwhile.

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilments for the degree of Master of Science

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May 2004

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Feeding high levels of palm kernel cake (PKC) has been reported to cause copper (Cu) toxicity in sheep. The degree of Cu toxicity is generally dependent on type of sheep breed, the form of Cu in the diets, feeding duration and interaction of Cu with other nutrients. This study was specifically carried out to investigate the effect of molybdenum (Mo), sulphur (S) and zinc (Zn) supplementation on the balance of minerals and to relate the findings with the degree of toxicity in Santa Inês x Malin crossbred sheep.

Twenty male Santa Inês x Malin crossbred sheep from 8 months to 1 year of age were divided randomly into 4 groups. The animals were fed the following diets over the 6 months experimental period, PKC (86.2%); guinea grass hay (10%) supplemented with 30 ppm Mo (diet Mo), 20 ppm Mo +1000 ppm S (diet Mo+S), 500 ppm Zn (diet Zn) and the control without supplementation (diet Control).

Faecal and urine samples were collected during the digestibility trial for mineral analysis. Mineral contents were also analyzed in blood plasma samples throughout the experiment period as well as from liver, kidney, pancreas and bile collected at slaughter. Mo+S or Mo alone and Zn treatments were observed to reduce the Cu level in the liver, kidney, pancreas and bile of the sheep. But Mo+S is more effective in reducing Cu from those tissues, especially the liver. Plasma minerals results showed that both Zn and Mo+S treatments were more effective in reducing Cu, Fe and Mg levels over time.

Based on the results of this study, the hepatic Cu content was found to be higher in control group compared with other treatments. However, Mo+S treatment was found to be more effective in controlling and lowering Cu levels.

There were significant effect of dietary supplement of Mo+S, Mo and Zn in increasing the loss of endogenous Cu from the body via faeces and urine.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PENAMBAHAN MOLIBDENUM, MOLIBDENUM DICAMPUR SULFUR DAN ZINK KE ATAS KESEIMBANGAN MINERAL PADA BIRI-BIRI YANG DIBERI MAKAN HAMPAS ISIRONG KELAPA SAWIT

Oleh

RIYADH ABBAS AL-KIRSHI

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Pemberian PKC pada aras yang tinggi telah dilaporkan menyebabkan keracunan kuprum (Cu) pada biri-biri. Tahap keracunan Cu pada amnya bergantung kepada jenis baka bebiri, bentuk Cu dalam diet, jangka masa pemberian makanan dan interaksi antara Cu dengan nutrien-nutrien lain. Kajian berikut telah dijalankan khususnya untuk menyiasat kesan penambahan molibdenum (Mo), sulfur (S) dan zink (Zn) ke atas keseimbangan mineral dan untuk mengaitkan penemuan tersebut dengan paras keracunan pada biri-biri kacukan Santa Ines x Malin.

Sebanyak dua puluh ekor biri-biri kacukan Santa Inês x Malin berumur 8 bulan hingga setahun telah dibahagikan secara rawak kepada 4 kumpulan. Haiwan berkenaan telah diberi makan diet berikut sepanjang eksperimen selama 6 bulan. PKC (86.2%); hay rumput kuda (10%) ditambah dengan 30 ppm Mo (diet Mo), 20 ppm Mo+1000 ppm S (diet Mo+S), 500 ppm Zn (diet Zn) dan kawalan tanpa sebarang penambahan (diet Control).

Sampel-sampel tinja dan urin telah diambil semasa kajian pencernaan untuk analisa mineral. Kandungan mineral juga telah dianalisis daripada sampel darah sepanjang tempoh eksperimen, begitu juga dengan sampel hati, ginjal, pankreas dan hempedu yang telah diambil semasa penyembelihan. Rawatan Mo+S atau Mo dan Zn didapati menurunkan paras Cu di dalam hati, ginjal, pankreas dan hempedu biri-biri. Tetapi Mo+S adalah lebih efektif dalam mengurangkan Cu daripada tisu-tisu tersebut, terutamanya di dalam hati.

Keputusan untuk mineral plasma menunjukkan bahawa kedua-dua rawatan Zn dan Mo+S adalah lebih efektif dalam mengurangkan aras Cu, Fe dan Mg dengan peningkatan masa.

Berdasarkan kepada keputusan kajian ini, biri-biri kacukan Santa Inês x Malin didapati ia lebih resistan kepada kesan toksik Cu terutamanya di dalam diet kawalan sepanjang 6 bulan kajian pemberian makanan. Kandungan Cu dalam hati didapati lebih tinggi berbanding dengan rawatan-rawatan lain. Walau bagaimanapun, rawatan Mo+S didapati lebih efektif dalam mengawal dan merendahkan aras Cu dan meningkatkan kehilangan Cu daripada badan melalui tinja dan urin.

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ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
ADF	Acid Detergent Fiber
ARC	Agricultural Research Center
CF	Crude Fiber
CP	Crude Protein
DM	Dry Matter
DMD	Dry Matter Digestibility
DMI	Dry Matter Intake
DVS	Department of Veterinary Services
EE	Ether Extract
FAO	Food and Agricultural Organization
GOT	Glutamate Oxaloacetate Transaminase
h	Hour
MARDI	Malaysian Agricultural Research and Development Institute
ME	Metabolizable Energy
MPOB	Malaysian Palm Oil Board
MT	Metallothionein
NDF	Neutral Detergent Fiber
NFE	Nitrogen Free Extract
OM	Organic Matter
OPF	Oil Palm Frond
PKC	Palm Kernel Cake

POME	Palm Oil Mill Effluent
POS	Palm Oil Sludge
PPF	Palm Press Fiber
ppm	Part Per Million
RM	Ringgit Malaysia
SD	Standard Deviation
SEM	Standard Error of Mean
TCA	Trichloroacetic acid
TDN	Total Digestibile Nutrient
TM	Thiomolybdate

CHAPTER I

INTRODUCTION

One viable approach in the production of red meat is to have a production system which utilizes existing feed resources at minimal cost to the producers. Feed cost must be kept low in beef, sheep and goat production, since the gestation period is long and progeny turn-over is low on a per production unit basis. Although, lacking in natural grasslands but has an abundant supply of feed resources in tree crop plantation; Malaysia is poised to be a major red meat producer when it can optimize the utilization of these feed resources for food production. One of major plant, which can produce substantial by-product feed resources, is the oil palm.

Since more than 20 years, Malaysia has been the world's leading producer of palm oil with the area expanding from 300,000 ha in 1970 to about 3.5 million ha in 2001 (MPOB, 2001). Concomitant with this tremendous increase in palm oil production has been a marked increase in the availability of oil palm by-products and crop residues, thus giving reason to hope that their utilization as feeds will help to enhance local ruminant production. The ruminant sector in Malaysia's livestock industry, however, is still far away from producing sufficient beef, milk and mutton to meet the domestic demand.

The four main by-products from the palm oil mill are palm press fiber (PPF), palm kernel cake (PKC), oil palm fronds (OPF) and palm oil mill effluent (POME). Among these, PKC has been the most successful by-product to be used as feed for ruminants and non-ruminants. It has a high nutritive value with 14-16% crude

protein (Mustafa Babjee, 1989) and 9.5-10.5 MJ/kg metabolizable energy (ME) (Jalaludin et al. 1991; Wong and Wan Zahari, 1997). However, the use of PKC in diets for small ruminants especially sheep is usually restricted to a maximum of 30% of the dietary dry matter intake (DMI) in rations (Zainur Alsmi 1991, Wong and Wan Zahari 1992). This is due to a high contents of copper (Cu) in PKC (containing about 27 ppm). Dietary inclusions of over 50% PKC may result in chronic Cu poisoning in sheep as early as 4 to 6 weeks after feeding (Abd.Rahman et al., 1989; Hair-Bejo and Alimon, 1992a).

Copper absorption and utilization in the animals can be markedly affected by several elements and other dietary factors. For example, it has been known that Mo can depress absorption of Cu in grazing ruminants. The adverse effect of increased dietary Mo and S on the utilization of Cu by ruminants has been largely attributed to the formation of thiomolybdates (TM) in the rumen (Dick et al., 1975; Suttle, 1974; Gooneratne et al., 1989). TM binds Cu in the rumen to form copper thiomolybdate (Cu-TM) which are insoluble and subsequently become unavailable for absorption.

In sheep, a diet high in Zn also reduces Cu toxicity and liver storage (Bremner et al., 1976). The existence of the antagonistic interaction between Cu and Zn, which is less toxic than Cu might be useful in the treatment of Cu poisoning (Hair-Bejo et al., 1991).

Furthermore, the phosphorus (P) content in PKC is above, and the calcium (Ca) content is below the dietary requirement for beef cattle (ARC, 1980). This imbalance may indicate the need of Ca supplementation in PKC based diets. Additionally, it may enhance the bioavailability of dietary Cu, as well as other macroelements, particularly Ca. Several studies have shown that supplements of Mo plus S and Zn are effective in controlling an outbreak of chronic Cu toxicity in sheep fed PKC (Hair-Bejo and Alimon A.R., 1992_b; Rusihan, et al., 1997; Li Juan, 1999). Meanwhile, to fully understand the Cu status in sheep fed PKC, it is necessary to investigate and determine other minerals in blood, liver, kidney, bile, pancreas and their excretion via faeces and urine because of the interactions among these minerals and Cu. In order to determine the actual assimilation of the minerals from the feed, allowance must be made for the content of endogenous minerals in the faeces and urine. These routes could be important in ruminants to play an important role in the homeostasis mechanism which regulate the absorption, plasma levels and body storage of minerals.

Furthermore, an antagonistic interactions among Cu, Zn, Mo, S, Fe and other nutrients has been demonstrated (Cousins, 1985; Hidiroglou et al., 1984). Hence it is possible that relevant mineral imbalance might have indirect effects in the development of PKC intoxication.

It is therefore important to obtain baseline data of mineral profile of PKC since this aspect may benefit the safe and efficient utilization of PKC in sheep.

Therefore, the objective of the following study was to investigate:

The effect of dietary Mo, Mo+S and Zn on liver. Kidney, pancreas, bile and plasma mineral concentrations and mineral excretion of sheep fed high level of PKC in diet.

CHAPTER II

LITERATURE REVIEW

Livestock Industry in Malaysia

Malaysia in the past decades has become a self sufficient in non-ruminant products such as poultry meat and eggs. The demand of red meat (beef, mutton and goat meat) and milk products on the other hand is far higher than the local production. For example the current annual demand for beef is 122,500 tones and 14,000 tones for mutton and goat meat, while local supply for these two products is only 21.7% and 7.4% respectively (Table 1).

Table 1: Production and Consumption of Livestock Products (2000)

Items	Local Production (m.t.)	Total Consumption (m.t.)	% Self Sufficiency	Per Capita Consumption (kg)
Beef	27,860	122,500	21.7	5.3
Mutton	1,040	14,000	7.4	0.6
Poultry	803,120	647,670	124	35.3
Pork	148,410	187,500	79.2	29
Eggs	428,480	390,160	110	16.8
Milk	35.1	732.8	4.8	33.2

Note: m.t.: metric tons; Source: DVS, Ministry of Agriculture, Malaysia; 2001

This poor growth of the ruminant industry has been attributed mainly to the unavailability of good quality feeds at reasonable cost (Alimon, 1993). An adequate supply of poultry and eggs for the domestic market and increase in production of fresh beef, mutton and eggs for the domestic and export markets are

the goals for the livestock industry in Malaysia. Small holder farming will be consolidated into larger and more efficient commercial operations with modern farming approach to encourage private sector participation. Livestock integration with plantation crops will be strengthened and Malaysia will also strive to become an international *halal* food hub MOSTE (1999).

Feedstuffs in Malaysia

The availability of local feed resources has remained as a major constraint for the livestock industry in Malaysia. The annual demand for animal feed is estimated about 4.4 million tones of which 70- 80% (worth about RM 1.4 billion) are currently imported, forming a major component of the national import bill. The animal feed which makes up a large proportion of the cost in animal production, is about 60-70% of the total cost of production MOSTE (1999).

With 5 million ha of Malaysia land under tree crops (3.5 million ha of oil palm, 1.7 million ha of rubber and 257,600 ha of fruits) there is a tremendous scope for increased production of red meat and milk in the tree crop environment to increase local supply of these products.

The oil palm industry offers a number of opportunities in terms of feed resources which can be utilized for animal production. These feed resources range from forages in the inter-rows to the by-products from the oil palm. Many of these by-products, e.g. PKC and oil palm fronds (OPF), are rich in certain nutrients especially the crude protein and have been proven to be suitable feeds for

ruminants. Integrating animals with oil palm plantations will ensure long-term profitability as well as sustainability of the agriculture industry in a very competitive environment.

Palm Oil By-Products

Palm oil is available in about 15 different grades, ranging from crude to semi-refined, refined, crude fractionated, refined fractionated oil and refinery by-products. Palm oil is currently the main fat source in feeds for monogastric animals, but it is not commonly fed to ruminants because it can result in rumen disorders, metabolic problems and reduced milk fat content (Palmquist, 1995). However, calcium soaps of palm oil origin, given to dairy cattle to increase energy intake, produced many positive effects of an energy supplement (Palmquist, 1995). This is attributed to the high level of unsaturated fatty acids (primarily oleic acid) which escape rumen degradation, leading to enhance digestibility. This makes calcium soaps of palm oil origin a good source of by-pass energy.

Oil Palm By-Products as Animal Feed Materials

The major by-products from palm oil industry that can be used as animal feed materials are as follows:

Palm Press Fiber (PPF), is a fibrous residue of oil palm fruits after oil extraction. The potential of using PPF for ruminant production is enormous but, due to its bulkiness and low feeding value, the amount consumed and digested is inadequate to support production at an economic level. Therefore, the use of PPF could be