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MINERAL NUTRITION OF RUMINANT IN THAILAND

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แร่ธาตุกับสัตว์เคี้ยวเอื้องในประเทศไทย

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บทคัดย่อ : รายงานนี้ได้รวบรวมผลการศึกษาเกี่ยวกับปริมาณแร่ธาตุในพืชอาหารสัตว์ และซีรัมของสัตว์จากพื้นที่ต่างๆ ในประเทศไทย นอกจากนี้ยังได้วิเคราะห์ส่วนประกอบของแร่ธาตุที่มีขายทางการค้า และกล่าวถึงผลการเสริมแร่ธาตุซึ่งมีผู้ศึกษาไว้ แม้ว่าส่วนที่ศึกษาจะมีความแปรปรวนค่อนข้างมาก แต่พอที่จะเห็นได้ว่า แร่ธาตุที่สัตว์เคี้ยวเอื้องมักได้รับไม่พอกับความต้องการ ได้แก่ Na, Ca, P, Cu, Zn และ Se ปริมาณแร่ธาตุหลักในซีรัมของโค, กระบือ, และแกะ ตามที่นักวิจัยรายงานมักจะอยู่ในช่วงดังนี้ Ca: 9-13 มก. P: 4-6 มก. K: 9-12 มก. Na: 250-320 มก. Mg: 1.8-2.5 มก. ใน ซีรัม 100 มล. นักวิจัยบางท่านสรุปว่า แม้ธาตุ Ca และ P ในตัวอย่างหญ้าจะต่ำแต่ความเข้มข้นของแร่ธาตุหลัก และแร่ธาตุปลีกย่อยในซีรัมก็อยู่ในช่วงปกติ สภาพดินพรุทางภาคใต้จะมีธาตุ Mg, Cu และ Zn ต่ำ ส่วนทางภาคอีสานในดินมักขาด P, S, K, Cu และ Mo. ปริมาณแร่ธาตุในดิน และในซีรัมของโค และกระบือ ไม่มีความสัมพันธ์ต่อกัน แร่ธาตุที่ขายในรูปเกลือแร่ในรูปก้อนและผง มีความแตกต่างกันมาก ผลิตภัณฑ์บางชนิดมีธาตุหลักและธาตุรองในปริมาณพอสมควร แต่ก็มีผลิตภัณฑ์ที่มีเกลือเป็นหลัก.

การเสริมแร่ธาตุแก่สัตว์เคี้ยวเอื้อง โดยเฉพาะในช่วงฤดูแล้งมีผลดีต่อการเพิ่มน้ำหนักตัวและการสืบพันธุ์ อย่างไรก็ตาม การเสริมแร่ธาตุไม่มีผลต่อระดับของแร่ธาตุในซีรัม เมื่อเปรียบเทียบแหล่งของ Ca และ P มีรายงานว่าแหล่งจากกระดูกป่นดีกว่า Dicalcium phosphate ทั้งในการเพิ่มน้ำหนักตัว การสืบพันธุ์ และการสะสมแร่ธาตุของเนื้อเยื่อ

ผู้วิจัยได้ให้ข้อเสนอแนะ ให้สำรวจการขาดธาตุเพื่อการเกิดพิษเนื่องจากแร่ธาตุ ตลอดจนการแก้ไขปัญหานี้ในพื้นที่ที่มีลักษณะการเกิดประเด็นดังกล่าว.

ABSTRACT : The reports on mineral content of forages available in different parts of Thailand, as well as mineral concentration in animal serum and in soil were compiled. In addition, commercial mineral mixtures were analysed, while the studies on mineral supplement were reviewed.

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Although high fluctuation was found among reports, it seemed that Na, Ca, P, Cu, Zn and Se were insufficient to meet the requirement of ruminant animals. The concentration of major minerals in serum of cattle, buffaloes, and sheep reported by most authors were 9-13 mg Ca, 4-6 mg P, 9-12 mg K, 250-320 mg Na and 1.8-2.5 mg Mg in 100 ml serum. Some authors concluded that the concentration of major and trace minerals in serum was in a normal range although grass samples were low in Ca and P. Peat soil which is the major soil type in the South was low in Mg, Cu and Zn, while pasture soils of northeastern Thailand were deficient in P, S, K, Cu and Mo. No correlation between the mineral content in soil and in serum of cattle and buffaloes was found. Mineral mixtures, commercially supplied in block or powder form, varied widely in their concentration. Some products were composed of major and trace elements in considerable amounts, while others were mainly salt.

The supplement of minerals to ruminants, especially in the dry season had positive effects on weight gain and reproductive performances. However, no effect of the supplement was found in mineral concentration of blood serum. When different sources of Ca and P were compared, it was reported that bone meal was superior to DCP in supporting higher weight gain, a better feed conversion ratio and the mineral retention of lambs.

The research priority suggested by authors was to survey the potential areas of mineral defficiency or toxicity, mineral availability and the alleviation of mineral deficiency or imbalance problems.

INTRODUCTION

Ruminant industry in Thailand has been boosted since the last decade, thus more attention is paid to the improvement of production efficiency. Mineral nutrition is one of the interesting aspects, due to its role in animal production. Its imbalance in feed resources is well accepted as one of the most important limitation to ruminant production. A certain amount of research work in Thailand was involved with both the general survey of mineral concentration in cattle and buffalo serum as well as its supplement to animals. This review intends to present the necessary information for the benefit of further study within the country as well as for neighbouring countries.

MINERAL NUTRITION STATUS

MINERAL CONTENT IN FORAGES AND FEEDSTUFFS

Holm (1971) published the composition and nutritive value of feedstuffs in northern Thailand, including the content of calcium (Ca), phosphorus (P), potassium (K) and sodium (Na). Grass species and season of the year had an influence on the mineral content of forages. The plants were fertilized and irrigated in the dry season.

Ca and P content was 10-20% higher in the dry season (Holm, 1973). *Panicum maximum* had a high Ca content while *Tripsacum laxum* was low in this mineral. On the other hand *Brachiaria mutica* and *Chloris gayana* had a 3-4 times higher Na content than other species. In the highland conditions of northern Thailand where *Imparata cylindrica* is the most common species, the average mineral content of native plants was 0.18% (0.09-0.47%) P and 0.10% Na (Falvey, 1980).

A later study in central part of the country by Tumwasorn (1981) found that native grass species had a low P (0.13-0.20%) and copper (Cu) content, while other minerals were just sufficient. Vichulata *et al.* (1983) measured the mineral content of forages in the dry and wet seasons and reported that only 25-35% of the samples were deficient in Na, P and Cu, while 73, 61, 58 and 77% of the remaining samples were at borderline to deficient in Ca, P, Cu and zinc (Zn) respectively.

Limpoka *et al.* (1982) determined the concentration of Ca, P, magnesium (Mg), manganese (Mn), Cu, Zn, Na and K in native forages in some provinces of the lower north and northeastern part of Thailand and found that grasses provided sufficient minerals for grazing cattle. Pichaicharnarong (1974) reported that the grasses grown in the Northeastern were deficient in Cu, cobolt (Co), Mn, sulfur (S) and showed a total lack of iodine (I) and selenium (Se). In a later report, Pichaicharnarong *et al.* (1988) concluded that Cu, Zn and Se content of some fresh grasses were 1.94-6.40, 19.83 and 0.04 ppm respectively, which were lower than the recommended requirement. In the survey study of Sakpuaram *et al.* (1986) there was a positive relationship between mineral content in blood serum of cattle and buffaloes and in grasses in some northeastern provinces. The levels of mineral concentration in grasses from different studies are shown in Table 1.

Falvey (1980, 1982) indicated that the forages selected by highland cattle apparently contained sufficient nitrogen (N) and P for higher liveweight gain than the average rate and one of the productivity limitation may be the low Na levels. Low forage Na concentration (0.01%) along with low Na levels in saliva, rumen fluid and faeces were noted. Overall production increased by 20% when Na was supplemented.

MINERAL CONTENT IN SERUM OF RUMINANTS

The survey studies on mineral concentration in serum of cattle, buffaloes and sheep in Thailand are summarized in Table 2 and 3. The concentration of major elements did not vary much, i.e. 9-13 mg Ca, 4-6 mg P, 9-21 mg K, 250-320 mg Na and 1.8-2.5 mg Mg in 100 ml serum. However, the concentration of Mg in serum of cattle and buffaloes (5.0-6.0 mg/100 ml serum) reported by Limpoka *et al.* (1982) was 2 times higher than the other reports.

Table 1. Concentration of major and minor elements in grasses.

Unit	Ca	P	K	Na	Mg	References
mg%	0.28-0.31 (64)	0.22-0.53 (62)	- -	-	2.2-3.0 ppm (61)	Limpoka *et al.* (1982)
mg/100 g	119.27-324.05	39.69-87.64	0.69-0.96% DM	- -	- -	Senakas *et al.* (1984b)
%DM	0.16	0.12	-	-	0.17	Senakas *et al.* (1984a)
%DM	0.17-1.06	0.32-0.74	0.58-2.28	0.03-0.05	-	Holm (1973)
mg%	1713-3107		1.26-1.94	0.19-0.54	-	Sakpuaram *et al.* (1986)
%DM	0.31	0.20-0.36	0.99-2.49	0.01-0.0	0.09-0.19	Vijchulata *et al.* (1984)
%DM	0.28-0.37	0.07-0.18	1.51-2.53	-	0.16-0.23	Tumwasorn (1981)
	Cu	**Zn**	**Mn**	**Fe**	**Se**	
ppm	18.1-48.5 (32)	113.5-246.0 (49)	91.3-412.5 (54)	-	-	Limpoka *et al.* (1982)
ppm	13.9-19.6 (163)	72.5-96.4 (163)		- -	-	Sakpuaram *et al.* (1986)
(mg/kg)	8.56	29.1	-	1140	-	Senakas *et al.* (1984a)
mg/100 g	-	-	19.08-19.71	-	-	Senakas *et al.* (1984b)
ppm	1.94-6.40	19.83-50.61	-	-	0.04	Pichaicharnarong *et al.* (1988)
mcg/g	1.16-5.46	18.6-31.3	51.7-45.7	265-342	-	Vijchulata *et al.* (1984)
ppm	7-10	30-38	186-281	487-866	-	Tumwasorn (1981)

* Numbers in brankets are the amount of samples being analysed.

Table 2. Ca, P, K, Na and Mg concentration in ruminant serum.

Unit	Ca	P	K	Na	Mg	References
CATTLE						
mg%	10.2-13.3 (154)	4.8-7.0 (82)	17.5-21.4 (73)	252.0-320.0 (76)	51.7-56.6 ppm (138)	Limpoka *et al.* (1982)
mg%	8.5-8.7 (74)	5.6-5.8 (74)	-	-	2.1-2.2 (74)	Vadhanakul *et al.* (1984)
mg%	12.2-15.0 (312)	3.4-5.3 (312)	9.1-18.6 (312)	257-294 (312)	18.4-25.9 ppm (312)	Sakpuaram *et al.* (1986)
mg/dl	9.8	5.7	-	-	2.3	Senakas *et al.* (1984a)
mg/dl	8-10	4.6-7.0	-	-	2.1-3.0	Senakas *et al.* (1984c)
mg/dl	10.16 (429)	6.71 (429)	-	-	2.6 (429)	Senakas *et al.* (1989a)
BUFFALOES						
mg%	10.5-14.7 (87)	3.8-6.0 (49)	17.4-24.2 (49)	201-338 (45)	57.0-62.6 ppm (83)	Limpoka *et al.* (1982)
mg%	12.8-15.1 (436)	3.5-5.4 (436)	16.3-19.0 (436)	267-295 (436)	22.4-28.9 ppm (436)	Sakpuaram *et al.* (1986)
SHEEP						
mg/dl	10.1-11.2 (30)	6.0-6.5 (30)	-	-	2.6-3.2	Senakas *et al.* (1984b)

* See Table 1.

Table 3. Cu, Zn, Mn, Fe, and Se concentration in ruminant serum.

Animal	Cu	Zn	Mn	Fe	Se	References
CATTLE						
ppm	1.1-1.2 (149)	3.4-5.2 (148)	0.08 (144)	-	-	Limpoka *et al.* (1982)
mcg%	48.1-53.6 (74)	119-124 (74)	-	157.5-17.14 (74)	-	Vidhanakul *et al.* (1984)
ppm	0.3-0.5 (312)	1.4-2.4 (312)	-	-	-	Sakpuaram *et al.* (1986)
mcg/ml	0.52	1.19	-	1.65	-	Senakas *et al.* (1984a)
ppm		2.42-3.69	0.03-0.07			Limpoka *et al.* (1986)
ppm	0.7	1.38		0.13		Pichaicharnarong *et al.* (1988)
mcg/ml	0.16-0.65	1.10-1.95	-	1.23-2.45	21.2-42.4	Senakas *et al.* (1989)
BUFFALOES						
mcg/ml	0.9-1.1	-	-	-	0.01-0.07	Pichaicharnarong *et al.* (1983)
ppm	0.3-0.4 (436)	1.5-2.0 (436)				Sakpuaram *et al.* (1986)
ppm	0.9-1.2 (80)	4.9-5.4 (80)	0.06-0.08 (74)	-	-	Limpoka *et al.* (1982)
SHEEP						
mcg/ml	0.72-0.89 (30)	0.95-1.56 (30)	-	1.63-1.66 (30)		Senakas *et al.* (1984b)
mcg/ml	0.47 (421)	1.09 (421)	1.36 (421)			Senakas *et al.* (1989)

* See Table 1.

Among trace elements Cu and Zn were quite interesting (Table 3). Sanakas *et al.* (1984a) found that Cu concentration in cattle serum was 0.52 mcg/ml or 0.52 ppm, similar to Vadhanakul *et al.* (1984) and Sakpuaram *et al.* (1986). While the first authors reported that these animals tended to show deficiency signs, i.e. rough and discoloration of hair due to the low Cu but high Fe in grass samples (8.5 ppm

Cu and 1084 ppm Fe), the latter authors did not found any deficiency indication in their cattle.

The survey study in sheep by Senakas *et al.* (1984b) reported that the concentration of major and trace minerals in serum was in a normal range although grass samples were low in Ca and P.

MINERAL CONTENT IN SOIL

A study in the south by Senakas *et al.* (1984a) reported that peat soil, the major soil type covered large grazing area in the south, composed of exchangeable Ca, Mg, Na and K at 1.67, 1.30, 0.38 and 0.25 meq/100 g of soil respectively. Trace element concentration, Cu and Zn, were 0.31 and 0.99 ppm. They concluded that this type of soil contained low Mg, Cu and Zn.

Table 4. Concentration of mineral in soil.

Unit	Ca	P	K	Mg	Na	References
mg%	83.8-127.0 (65)	6.3-9.2 (65)	-	112.5-247.0 ppm (65)	-	Limpoka *et al.* (1982)
mg%	98-175 (125)	-	0.003-0.006 (125)	22.0-56.6 ppm (125)	0.38-0.48 (125)	Sakpuarm *et al.* (1986)
	Cu	**Zn**	**Mn**	**Se**		
ppm	1.25-0.95 (65)	5.0-11.3 (65)	82.7-59.8 (65)	- -		Limpoka *et al.* (1982)
ppm	0.3-0.5 (105)	3.03-5.83 (125)	-	-		Sakpuaram *et al.* (1986)
ppm	20.7	45.5	-	0.25-0.98		Pichaicharnarong *et al.* (1988)

Shelton *et al.* (1979) studied pasture soil nutrients of northeastern Thailand. The results from a series of nutrient omission pot trials on acid sandy upland soils and soil analyses confirmed that the soil was deficient in P, S, K, Cu, and molybdenum (Mo). Limpoka *et al.* (1982) found no relationship between mineral content in soil and in serum of cattle and buffaloes. The authors reported that mineral content of soil in the study area was 84 - 127 mg% Ca, 6.3-9.2 mg% P,

113-247 ppm Mg, 0.95-1.25 ppm Cu, 5.0-10.3 ppm Zn and 82.7-59.8 ppm Mn respectively.

COMMERCIAL MINERAL MIXTURES

Mineral mixtures, commercially available as ruminant feed in Thailand are in the form of either powder or lick block. The powder is recommended to use in concentrate mixture or directly supplemented to roughages, while a lick block is given as a free choice. The products are either produced in the country or imported. The price is considerably high especially for those imported products. Their components are vary widely, as shown in Table 5.

The formula of some of these mineral mixtures were calculated according to the information indicated on the tag (Table 6).

It is noticable that some products composed of major and trace elements in considerable amount, while in other products the major element is mainly salt. Some contained high amount of vitamins, while the others have no Ca and/or P. The amount of minerals obtained from commercial supplement when 10 kg feed dry matter intake (300 - 400 kg beef cattle with 0.2 - 0.6 kg daily gain) was assumed is shown in Table 7. The Value were compared to the requirement of animals.

Table 5. Mineral content of commercial mineral mixture.

	Lick Block			Powder			
	Cubeco[1]	A-one[1]	Special T[2]	Supermix3	Supmix[3]	CB-RAL[4]	Ramical[5]
Amount (%)							
Ash	65	-	-	-	-	-	-
Ca	12	-	-	15.75	-	5	13
P	12	-	-	10.9	6.4	-	5
Na	4	38*	98*	30*	10.6	3.93	-
Cl	-	-	-	-	-	6.07	-
K	-	-	-	-	0.02	0.002	-
Mg	3	0.45	0.5	0.6	-	0.010	0.05
(ppm)							
Mn	1500	210	210	6700	7020	-	500
Zn	1500	280	320	-	-	756	1040
Fe	750	1650	1600	7000	7200	620	450
Cu	20	250	300	1400	1900	525	200
Co	15	55	45	60	38	155	12
I	40	125	125	370	730	74.2	16
Se	3	10	12	4	-	5	
Vit A (IU/kg)	60,000	-	-	-	2,250,000	-	200,000
Vit D_3 (IU/kg)	12,000	-	-	-	450,000	-	40,000
Vit E mg/kg	60	-	-	-	200		
Filler,%	-	-	-	-	>50	>50	-
Mixing direction (per 100 kg feed)				500 g	500 g	500 g	5 kg

[1] AIP. Co. Ltd.
[2] Special T Feeds Ltd. (Kana Co. Ltd.)
[3] Advance Pharma Co. Ltd.
[4] Wellab International Co. Ltd.
[5] Ramical Siam Industry, Co. Ltd.
* Salt

Table 6. Calculated mineral sources contained in mineral mixture.

	Supermix (powder)		DLD[1] (block)		Cubeco (block)
(g/100 g)					
DCP	55.3		17		64.7
NaCl (%)	31.5		70		10.3
$MgSO_4.7H_2O$	6.1		0.004	MgO	5.6
S	-		2		-
(mg/100 g)					
$MnSO_4.H_2O$	2060		250	MnO	288.5
ZnO	-		350		326.1
$FeSO_4.7H_2O$	3480	Fe_2O_3	600	$FeSO_4.7H_2O$	375.0
$CuSO_4.5H_2O$	550		400		8.0
$CoCl_2.6H_2O$	24		40		7.1
KI	480		3		5.8
NaSe	-		2		0.7
Filler (g)	0.5	Cement	10		-

[1] Promma *et al.* (1988), Department of livestock development.

Table 7. Minerals required by beef cattle and the amount supplied by commercial mineral mixtures.

		Lick block[3]			Powder[4]			
	Req[2]	Cubeco	A-one	Special T	Supermix	Supmix	CB-RAL	Ramical
(g/day)								
Ca[1]	14-22	6	-	-	7.88	-	2.5	65
P[1]	12-17	6	-	-	5.45	3.2	-	25
Na	6-10	2	7.2*	18.6*	5.7*	5.3	2.0	-
K	50-70	-	-	-	-	0.01	0.001	-
Mg	5-25	1.5	0.22	0.25	0.3	-	0.005	0.25
S	8-15	-	-	-	-	-	-	-
(mg/day)								
Mn	200-500	75	10.5	10.5	335	351	-	250
Zn	200-400	75	14	16	-	-	37.8	520
Fe	500-1000	37.5	82.5	80	350	360	31	225
Cu	40-100	1	12.5	15	70	95	26.25	100
Co	0.7-1.1	0.75	2.75	2.25	3	1.9	7.75	6
I	2-20	2	6.25	6.25	18.5	36.5	3.71	8
Se	0.5-3	0.15	0.5	0.6	0.2	-	-	2.5

1 Ca and P required by 300-400 kg BW growing and finishing cattle (medium frame steer calves) with 0.2-0.6 kg daily gain (NRC, 1984).
2 Requirement of beef cattle suggested by NRC (1984).
3 Assumed quantity of the block being licked is 50 g/d.
4 500 g or 5 kg mineral mixture was suggested for 100 kg feed (see Table 2). Estimated feed consumption for 300-400 kg cattle is 10 kg dry matter.
* Salt contains 38% Na.

STUDY ON MINERAL SUPPLEMENT

Falvey (1980) studied the supplementation of Na and P under Thai highland conditions. In the experiment lasting 39 months 2 groups of native cattle, each of nine heads, grazed on a native range. The first group was drenched with an aqueous solution of sodium dihydrogen orthophosphate at 30 g/h/d, while the other group did not get any supplement. Liveweight gain of cattle in the treated group was significantly higher ($P < 0.05$) and they produced more calves ($P < 0.01$) with lower mortality rate (15.8 vs 41.7%; $P < 0.05$) than the control. The author concluded that this response can probably be attributed to the Na rather than the P component of the supplement and Na was an important deficiency in the diet of cattle grazed in native highland pasture in Thailand.

The mineral supplement in central Thailand clearly showed the improved weight gain and conception rate (Tumwasorn *et al.*, 1980). In a 180-day study during the wet season, the unsupplemented cattle gained 176 g/d, while the supplemented group gained 230 g/d with increased conception rate of 21% (64 vs 43%). In a later study, Tumwasorn (1981) had given mineral mixture as a free choice to 43 heads of native cattle and 1/4 Brahman crossbred calves compared with the 77 heads of the non supplemented group. The effect of season (wet, dry and the extra period of supplement) on liveweight change and blood parameters were investigated. The dry-season supplement had the highest percentage of improvement, while the wet-period treatment revealed the lowest responses. The range of improvement varied considerably from 14-23% in the native and 21-31% in the crossbred cattle respectively. Blood parameters in both groups were not significantly different, but low level of Ca and P in plasma were found. The supplemented cows had a 17% higher conception rate than the unsupplemented group.

On the other hand Vijchulata *et al.* (1984), Senakas *et al.* (1984a) and Senakas *et al.* (1989b) found that mineral supplement had no effect on daily weight gain. In a 180-day grazing trial, predominantly on para grass (*Brachiaria mutica*) pasture by Vijchulata *et al.* (1984), 36 Charolais x Native crossbred cattle were divided into 3 groups, no supplement or supplemented with either bone meal + salt (2 :1) or a complete mineral premix. No significant difference on daily weight gain (approximately 340 g/day) was found among groups. Most of the minerals being analysed in plasma, liver and rib bones of slaughtered animals were in adequate concentration and were not affected by the supplements. Senakas *et al.* (1984a) studied the effect of mineral supplement on cattle grazing natural pasture in a peat swamp area. The supplemented group (n = 10) consumed mineral at an average of 85 g/h/d. However, dietary mineral did not affect the level of Ca, P, Mg, Cu, Zn, and Fe concentration in blood serum compared to the unsupplemented control.

The effect of mineral supplement on blood parameters of cattle grazing native pasture during the dry season had been determined by Senakas *et al.* (1989b). No significant difference in mineral concentration in blood serum was found between the supplemented and non-supplemented group. Both groups lost weight to the same extent (-32.29 vs -34.14 kg) . The ratio of blood urea nitrogen to serum creatinine

decreased progressively during the experiment, indicating a severe deficiency of energy and protein in the experimental diet.

The availability of Ca and P from dicalcium phosphate (DCP) and bone meal at two levels of P was compared in the study with 44 lambs for 91 days by using a comparative slaughter method for skeleton analysis (Kwaschik *et al.*, 1990) . It was found that bone meal supported higher weight gain, better feed conversion ratio (FCR) and higher mineral retention in lamb bones than DCP. No significant difference in bone mineral retention was found when Ca:P ratio was in a range of 1.4 to 2.9. Contrary to high level of P, the normal P level for both sources of mineral supplement provided superior FCR and higher P availability.

LABORATORY INSTRUMENTS AND ANALYTICAL METHODS

Most of the equipment and analytical methods used in these studies were:

Sample	Elements	Instruments	Analytical methods
Serum	P, Fe	Spectrophotometer	Fiske and Subbarow (1925)
	Na, K	Flame photometer	
	Ca, Mg, Cu Zn, Mn	Atomic absorption spectrophotometer	Fick *et al.* (1979)
	Se	Spectrophoto-fluorometer	Whetter and Ullrey (1978); Olson *et al.* (1975)
	Cu, Co, Se	Neutron activator	
Forages	P	Spectrophotometer	Pulss (1961); Gomeri (1942)
	Ca, Na, K	Flame photometer	
	Ca, Mg, Cu Zn, Mn	Atomic absorption spectrophotometer	Fick *et al.* (1979)
Soil	P	Spectrophotometer	
	Ca, Na, K	Flame photometer	
	Ca, Mg, Cu Zn, Mn	Atomic absorption spectrophotometer	

RESEARCH PRIORITY

Research priorities for a mineral nutrition study in Thailand should be as follows :

1. Survey on potential areas of mineral deficiency or toxicity

Since the study on mineral nutrition of ruminants in Thailand is rather limited, the determination of potential areas where minerals are deficient or toxic is required. The study may be based on a survey of mineral concentration in animal tissues, bone or blood parameters along with the mineral content in forages and other feeds. The information will be very useful in awaring of mineral deficiency or toxicity in such area.

2. Study on mineral availability

There are factors which affect the availability of dietary mineral such as form of minerals, mineral sources, concentration of or ratio between certain minerals, animal age and interaction of minerals with other nutrients. The data on availability will aid scientists, researchers or extention workers in formulating appropiate mineral supplement to animals in different conditions.

3. Alleviating mineral deficiency or imbalance problems.

There are many direct or indirect methods of providing minerals to grazing ruminants. Indirect methods include the application of fertilizers containing minerals and/ or altering soil pH to maximize mineral availability to plants, or encouraging growth of specific pasture species. Direct methods could be done by different means such as providing minerals to animals in the form of lick blocks, mixtures, drenching or injections. The appropriate mineral supplement by using local mineral resources either for immediate treatment (curing, remedy) or long term treatment (prevention) are of interest.

PROBLEMS AND CONSIDERATIONS

To determine the potential areas where mineral deficiency or toxicity would occur for grazing animals, the folowing points should be taken into consideration :

1. Animals should be sure to obtain adequate nutrients other than minerals otherwise the results will be confounded and leads to the misinterpretation whether it is the effect of mineral deficiency or other complications.
2. To obtain a reliable profile of the herds status, a sufficient number of samples to be analysed or studied is required. In sampling pasture it should be borne in mind that mineral content of a pasture varies considerably over the grazing season. In order to obtain a general impression of the feed over the grazing season, it is necessary to set up a proper sampling scheme.
3. In tracing deficiency, some mineral concentration in blood serum or plasma may not be affected, unless a severe deficiency occurs. Hence more relevant samples such as other excreta or tissues should be selected as the main criterion.
4. To avoid misunderstanding, the units used for expression the mineral concentration in animal parameters, plant tissues or soil samples should be clearly defined, whether it based on w/w, w/v or v/v and whether it was expressed on fresh or dry matter basis.

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