Performance of Garut Breed Rams Fed Diets Containing Various Cation-Anion Difference with or Without Fish Oil Supplementation

RAHMAT HIDAYAT[1], T. TOHARMAT[2], A. BOEDIONO[3] and I.G. PERMANA[2]

[1]*Faculty of Animal Science, Padjadjaran University, Bandung.*
[2]*Department of Animal Nutrition and Feed Science, Bogor Agricultural University, Bogor.*
[3]*Department of Anatomy, Physiology and Pharmacology, Faculty of Veterinary Science, Bogor Agricultural University, Bogor.*
Email:rahmat_1969@yahoo.com

(Diterima Dewan Redaksi 31 Mei 2011)

ABSTRAK

HIDAYAT, R., T. TOHARMAT, A. BOEDIONO dan I.G. PERMANA. 2011. Peformans domba Garut yang diberi pakan dengan perbedaan kation anion dan suplementasi asam lemak. *JITV* 16(3): 211-217.

Penelitian ini bertujuan untuk mengevaluasi pengaruh pemberian ransum dengan perbedaan kation-anion (Dietary Cation-Anion Difference = DCAD) dan suplementasi minyak ikan terhadap konsumsi bahan kering, kecernaan bahan kering dan bahan organik, pertambahan bobot hidup dan pH urin domba Garut. Dalam penelitian ini digunakan rancangan acak kelompok (3 kelompok) dengan 6 perlakuan pakan. Ransum yang diberikan adalah sebagai berikut: R0 = ransum basal (DCAD + 14) tanpa suplementasi minyak ikan; R1 = ransum basal (DCAD + 14) dengan suplementasi 3% minyak ikan; R2=ransum basa (DCAD +40) tanpa suplementasi minyak ikan; R3 ransum basa (DCAD + 40) dengan suplementasi 3% minyak ikan; R4 = ransum asam (DCAD -40) tanpa suplementasi minyak ikan; R5 = ransum asam (DCAD -40) dengan suplementasi 3% minyak ikan. Seluruh ransum mengandung 150 ppm mineral Zinc (Zn) dan dicobakan pada 18 ekor domba Garut jantan. Hasil memperlihatkan bahwa DCAD +40 dan -40 secara nyata menurunkan konsumsi bahan kering dimana ransum dengan DCAD +40 menghasilkan konsumsi bahan kering terendah. Suplementasi minyak ikan menurunkan konsumsi bahan kering dan tidak terdapat perbedaan kecernaan bahan kering dan bahan organik pada seluruh percobaan. DCAD +40 dan -40 menurunkan bobot hidup kecuali pada perlakuan R4, walaupun demikian bobot hidupnya sangatlah rendah. Nilai pH urin bervariasi mengikuti pola DCAD ransum. Disimpulkan bahwa DCAD +40 dan -40 serta suplementasi minyak ikan menurunkan konsumsi bahan kering dan bobot hidup, sedangkan pH urin mengikuti pola DCAD ransum.

Kata Kunci: Kation, Anion, Bobot Hidup, Kecernaan, Domba Garut

ABSTRACT

HIDAYAT, R., T. TOHARMAT, A. BOEDIONO and I.G. PERMANA. 2011. Performance of Garut breed rams fed diets containing various cation-anion difference with or without fish oil supplementation. *JITV* 16(3): 211-217.

This study was carried out to evaluate the effect of dietary cation-anion difference (DCAD) and fish oil supplementations on dry matter intake (DMI), dry matter digestibility (DMD) and organic matter digestibility (OMD), weight gain, as well as the acidity of urine in Garut breed rams. The experiment was done based on randomized group design with 6 treatments and 3 groups. The dietary treatments were as follows: R0= basal ration (DCAD +14) without fish oil, R1 = basal ration (DCAD +14) with 3% fish oil, R2 = base ration (DCAD +40) without fish oil, R3 = base ration (DCAD +40) with 3% fish oil, R4 = acid ration (DCAD -40) without fish oil, and R5 = acid ration (DCAD -40) with 3% fish oil. All rations contained 150 ppm of zinc and were offered to 18 of Garut breed rams. The results indicated that DCAD +40 and -40 decreased DMI significantly. The ration with DCAD +40 had the lowest DMI. Fish oil supplementation decreased DMI. No differences were observed for DMD and OMD. DCAD +40 and -40 decreased body weight of rams. However, the body weight of rams was very low. Variation of urine pH followed the DCAD pattern. It was concluded that DCAD +40 and -40, as well as fish oil supplementations decreased DMI, body weight and urine pH followed the DCAD pattern.

Keys Words: Cation, Anion, Body Weight, Digestibility, Garut Breed Rams

INTRODUCTION

High concentrate diet and fat supplementation are often carried out to increase energy in the diet in order to support high livestock growth. High concentrate diet might cause metabolic disorders such as acidosis. Fat supplementation is often used to increase feed energy, fatty acid contents and mineral absorption such as Zn (HARTATI, 1998; LERAY *et al*., 1985; HAFEZ, 1980). $NaCO_3$ is often used as *buffer* to avoid acidosis.

However, mineral supplementation is often used without determining the effect of cation-anion dietary excess.

Dietary cation-anion difference (DCAD) affects Ca metabolism, so it is thought to affect other nutrients metabolism including fatty acids (YINGST *et al*., 2001). DCAD with high anion is often used to deal with *milk fever* (HU and MURPHY, 2004). FATHUL *et al*., (2008) reported that DCAD 28, -18, 0, +14 and +32 on female Garut sheep affect pH of ration, blood, urine, and fetus number per ewe. The other researchers said that the balance of cation-anion difference in the diet of Garut sheep did not give any negative effect on feed intake, growth, digestibility, mineral absorbtion, and the microscopic characteristic of spermatozoa (ANGGREINI, 2007).

The balance of body liquid acid can be affected by dietary Na, K, Cl and S consumed (STEWART, 1983; TUCKER *et al*., 1992). The negative dietary cation-anion difference (DCAD) decreases of blood and urine pHs (MOORE *et al*,. 2000; ROCHE *et al.*, 2003a; BORUCHI *et al*., 2004). On the contrary, if DCAD are increased, it will raise blood pH, Ca plasma and urine PH but inreasing K and Cl of blood (VAGNONI and OETZEL, 1998). Anion salt isn't palatable and too much addition in the diet will decrease its consumption (HORST *et al*., 1997). CHAN *et al*. (2005) said that there will be a decrease of dietary consumption by increasing the value of DCAD. Decreasing of dietary consumption by increasing DCAD value causes the livestock insufficiency of energy. It's can be solved by supplementary fish oil in the diet. Cation-anion is absorbed by intestine channel resulting in the increase of strong ion in plasma thus enhancing alkalosis (HORST, 1997; RIOND, 2001).

The research aim was to study the effect of DCAD and fish oil supplementations in ruminant diet on: (1) dry matter intake; (2) organic and dry matter digestibility; (3) weight gain; and (4) urine pH value. This research used Garut breed rams as models. It is thought that DCAD affect dietary consumption that could affect weight gain and urine pH.

MATERIALS AND METHODS

Basal ration was a complete ration containing materials in all mash with the same nutrient contents (Table 1).

The dietary treatment is basal ration supplemented with mineral salt resulting in DCAD +14, +40 and -40 meq, each of them was added by 0 and 3% fish oil (Table 2). Base ration was gained by adding Na_2CO and K_2CO in which each of them acted as cation resource of Na and K in order to meet the value of difference cation-anion dietary (DCAD) became +40. The group of acid rations were gained by adding $MgCl_2$ and $MgSO_4$ into each of the basal ration as the anion resources of C1 and S in order to meet the value of DCAD became -40. The ration was then analized for Na, K, Cl and total S contents, continued by calculating the cation-anion difference based on the equation of TUCKER *et al*. (1992). All rations contained Zn 150 ppm/DM rations by adding $ZnSO_4$ (Table 3), zinc lethal dosage is 750 ppm/DM ration. Ration was offered to 18 Garut breed rams aged two years for 50 days. Two weeks before the application, the rams were given basal ration without supplementation $ZnSO_4$ (Table 1). Randomized Group Design (RGD) was applied as where rams were grouped based on their waights, i.e (I) 34.58 ± 2.38 kg, (II) 30.75 ± 0.42 kg and (III) 29.67 ± 0.68 kg.

Table 1. Composition and nutrients content of basal ration

Feed composition	% of DM ration
Corn roughage	35.0
Rice hull/bran	7.0
Cassava waste	10.5
Corn seed	17.5
Copra meal, mech extr.	8.0
Soybean meal	22.0
Total	100.0
Nutrient content of basalration	% of DM
Dry matter	89.41
Ash	8.19
Crude Protein	14.94
Fat	2.98
Crude Fiber	14.71
Nitrogen free extract	56.17

DM= dry matter

Tabel 2. Dietary cation-anion difference and fish oil supplementation of rations

Rations	DCAD	Fish oil (%DM)
R0	+14	0
R1	+14	3
R2	+40	0
R3	+40	3
R4	-40	0
R5	-40	3

R0 = DCAD + 14 without fish oil
R1 = DCAD + 14 + 3% fish oil
R2 = DCAC + 40 without fish oil
R3 = DCAD + 40 + 3% fish oil
R4 = DCAD - 40 without fish oil
R5 = DCAD - 40 + 3% fish oil

Table 3. Supplementation of minerals and fish oil of the ration

	Rations					
	R0	R1	R2	R3	R4	R5
Supplementation of mineral and fish oil (g/100 g DM)						
ZnSO4	0.030	0.030	0.030	0.030	0.030	0.030
Na2CO3	-	-	4.356	4.356	-	-
K2CO3	-	-	1.663	1.663	-	-
MgSO4	-	-	-	-	12.36	12.36
MgCl2	-	-	-	-	2.26	2.26
Fish oil	0.0	3.0	0.0	3.0	0.0	3.0
Minerals content (g/100g DM of ration)						
Sodium	0.041	0.041	1.957	1.957	0.041	0.041
Potassium	0.1076	0.1076	1.048	1.048	0.1076	0.1076
Chlorine	0.193	0.193	0.193	0.193	1.882	1.882
Sulphur	0.151	0.151	0.151	0.151	3.447	3.447
Calcium	0.020	0.020	0.020	0.020	0.020	0.020
Phosphorus	0.019	0.019	0.019	0.019	0.019	0.019
Magnesium	0.42	0.42	0.42	0.42	3.043	3.043
Zinc	0.150	0.150	0.150	0.150	0.150	0.150

R0 = DCAD + 14 without fish oil
R1 = DCAD + 14 + 3% fish oil
R2 = DCAC + 40 without fish oil
R3 = DCAD + 40 + 3% fish oil
R4 = DCAD - 40 without fish oil
R5 = DCAD - 40 + 3% fish oil

The observed parameters included (1) dry matter intake (g/dayThe amount of daily ration was calculated as follow The amount of consumption (gram) = the amount of given ration (g) – the amount of remaining ration in the next morningRation consumption was measured every morning during the research (50 days Feed consumption was calculated based on the dry (DM) of the ration. The amount of every day fresh ration consumption was converted into DM in order to determine DM (g/day). (2) Dry matter digestibility (DMD) and organic matter digestibility (OMD) (%). Feces samples wer collected from the 14th day to the 20th day of the research period for DMD and OMD. Total wet feces were collected and weighed daily. Feces were dried up under the sun shine and weighed aproximately 10% of the dried feces on dry condition. About 10% of dried feces at the same treatment was collected for further analysis of DMD and OMD. (3) Body weight gain (BWG) (g/day), was obtained by calculating the final body weight minus the initial body weight (4). Urine pH measured weekly, (day -7, 0, 7, 14, 21, 28, 35, 42 and 49). Urine was collected from 06.00 a.m. using urine bag. pH of the urine was measured using using digital pH meter.

Data of the research were analized using analysis of variance (ANOVA) in SAS programme (SAS, 2005), if there was a significant difference ($P < 0.05$) it was followed by Duncan Multiple Range Test and contrast orthogonal (MATTJIK and SUMERTAJAYA, 2002).

RESULTS AND DISCUSSION

Dry matter intake

Mean of dry matter intake (DMI) of Garut breed rams fed ration containing different DCAD and fish oil were shown in Table 4. DMI in all treatments in the first week of experiment were at the lowest level, then increased significantly during the following

experimental period. Garut breed rams fed basal diet DCAD (+14) had the higest DMI then followed by rams offered rations with DCAD +40 and -40 DCAD. DMI decreased significaltly when fish oil, anion and cation were supplemented. It was indicated that the odor of fish oil in the rations were not accepted by the Garut breed rams. In addition, both DCAD 40 and -40 rations did not allow the optimum physiological process in the animal body and reduced the DMI. Feeding rations with DCAD outside the normal range such as +40 or -40 decreased DMI significantly. The DCAD +40 had the worse effect on feed intake compare to the DCAD -40.

Increasing some minerals either cation or anion decreased ration palatability and DM intake. Decreasing of DM intakes were very drastic so the rams offered ration with DCAD -40 or +40 obtained less nutrient than their requierements. MORTON and ROACH (2002) and CHAN et al. (2005) reported that the more increase in DCAD value in rations, the more decrease in the DM intake of the animal. On the other hand, DELAQUIS and BLOCK (1955) and RIOND (2001) reported that increasing DCAD ration value equal with the increasing of DM intake. Other result indicated that DCAD value did not affect DM intke (ROMO *et al*., 1991). SARWAR *et al*., (2007a) reported that giving ration with DCAD -11, +11, +22 and +33 to Thali sheeps resulted in a linear increase in DM intake. Less of DM intake in the sheep fed ration with DCAD -11 was related to the increase in anion of ($CaCl_2$) which was not palatable. Athought, these results indicated different response of animal to DCAD value, the DCAD -40 and +40 were out of normal ranges for normal physiological conditions. Garut breed rams had good consumption regulation system, since the higher the amount of cation or anion intake, the higher the reduction of dry matter intake and anion or cation. The intake mechanism minimized the negative effect of the excess of cation or anion intake on the physiological conditions.

Dry matter and organic matter digestibility and daily gain

Dry matter digestibility (DMD) ranged between 67.33-74.67%, and organic matter digestibility (OMD) ranged between 69.67-78.33%. The DMI and OMD values were higher than the average values for the normal diet. The components of the experimental ration such as Copra meal, rice bran, cassava waste, corn seed and soybean meal are high in their degestibility in ruminant. The higher digestibility of the rations showed that the feedstuff had good quality and supported the availability of nutrient for optimum metabolism process.

Digestibility of nutrient can be influenced by the folowing factors: environmental temperature, the rate of passage, physical properties, and nutrient content. However in this experiment, the DMD and OMD of rations were not affected by DCAD value of the ration. The DCAD +40 or -40 did not alter the digestion process of nutrients in Garut breed rams. Ruminants produce saliva as *buffer* that is able to neutralize rumen pH from an excess or lack of cation or anion to maintain the normal pH range of 6,5-7,5. Normal pH of rumen keeps rumen microbes work optimally to digest DM and OM components. SARWAR (2007a) reported that dry matter digestibility in sheeps offered ration with DCAD -110 was higher than that in sheeps offered ration with DCAD +10, +22 and +33. DCAD -40 up to +40, were still can be neutralize by saliva excretion.

Reduction in DM of rams offered rations with DCAD +40 or -40 resulted in the low nutrient intake and reduction in body weight. Garut breed rams offered diets with DCAD +40 and -40 indicated more loss body wight of -40 g/day and -37 g/day, respectively. The decreased body weight might be caused by acidosis metabolism which was related to the low DCAD value (SARWAR, 2007a). Garut breed rams fed ration with DCAD +14 without fish oil supplementation had the highest daily gain (133 g/day) with DMI rate of 871 g DM/day. Decreasing body weight was solely associated with acidosis metabolism, low palability of ration and therefore the decreaseses in ration intake of ration with DCAD +40 and -40 or fish oli supplementation.

Value of urine pH

Mean urine pH of Garut breed rams fed ration containing different DCAD and fish oil are showen in Table 5. All of the experimental rams had similar values of the urine pH in the range of 8,65-9,46, during the seven days of adaptation period and a day before treatments. The similar urine pH value when the all rams were fed control ration indicated that all the rams had the same fisiological condition. The urine pH of rams changed when the experimental rations were offered. The urine pH of the rams in the first seventh day untill the day 21 had the same pattern. The experimental ram fed ration with DCAD +14 and +40 had the same urine pH value of 7,81-9,44. While urine pH of rams fed ration with DCAD -40 had lower pH value of 4,994-5,78. The low urine pH value showed that excess of anion intake was excreted through urine which manifested in low urine pH value. It was a proof that the anion had a great effect on urine pH.

On day 28 and 42, rations with DCAD +40 clearly affect the urine pH value. Garut rams fed ration with DCAD +14 exreted urine with higher pH value compared to those fed ration with DCAD -40 or -14. A similar urine pH was observed on day 35 and 49 of the experimental period, although rams offered ration with DCAD +14 and fish oil had a similar pH value with those offered ration with DCAD +40. Ration with

Tabel 4. Average of DMI, DMD and OMD, and ADG of Garut Breed Rams at two years old

Ration	DMI (g/day) - week								DM digestibility (%)	OM digestibility (%)	ADG (g/day)
	1	2	3	4	5	6	7	Average 1-7			
R0	655^{a}±100	815^{a}±25	945^{a}±112	912^{a}±92	940^{a}±119	950^{a}±105	861^{a}±19	871^{a}±90	73.33±0.02	77.67±0.01	133.34^{a}±38
R1	522^{b}±107	498^{b}±50	606^{b}±51	690^{b}±5	688^{b}±91	760^{b}±58	783^{b}±55	631^{b}±161	74.67±0.03	78.33±0.03	90.00^{b}±36
R2	231^{c}±24	282^{c}±70	302^{c}±84	299^{c}±91	331^{c}±133	322^{c}±144	575^{b}±291	297^{c}±86	67.33±0,01	69.67±0.00	-40.00^{d}±25
R3	202^{c}±13	232^{c}±3	246^{c}±16	292^{c}±63	285^{c}±54	293^{c}±53	411^{c}±74	260^{c}±31	71.00±0,04	73.00±0.04	-30.00^{d}±26
R4	381^{c}±177	415^{c}±203	436^{c}±161	480^{b}±152	569^{b}±87	576^{b}±86	618^{b}±134	479^{b}±133	74.00±0.05	78.00±0.05	36.66^{c}±86
R5	216^{c}±116	266^{c}±1	264^{c}±22	288^{c}±40	375^{c}±184	437^{c}±282	441^{c}±176	311^{c}±75	68.33±0.05	71.33±0.04	-36.66^{d}±29
Sig.	*	*	*	*	*	*	*	*	NS	NS	*

R0 = DCAD + 14 without fish oil
R1 = DCAD + 14 + 3% fish oil
R2 = DCAC + 40 without fish oil
R3 = DCAD + 40 + 3% fish oil
R4 = DCAD -40 without fish oil
R5 = DCAD -40 + 3% fish oil
DM = dry matter
OM = organic matter
ADG = average daily gain
NS = not significantly different
* = significantly different (P < 0.01)

Tabel 5. Average of urine's pH of Garut breed rams fed by ration containing different DCAD and fish oil supplmentation at two years old

Urine's pH on prelium stage day-		Ration	Urine's pH on day-						
-7	0		7	14	21	28	35	42	49
9.24±0.70	8.70±0.55	R0	8.54^{a}±0.59	7.81^{a}±1.23	8.65^{a}±0.63	8.35^{b}±0.14	8.71^{b}±0.45	8.37^{a}±1.00	8.60^{b}±0.52
9.22±0.47	9.39±0.85	R1	8.92^{a}±0.69	8.55^{a}±0.79	8.60^{a}±0.24	8.45^{b}±0.30	8.25^{ab}±0.50	8.58^{a}±0.62	8.75^{ab}±0.67
8,75±0.59	8.81±0.64	R2	9.09^{a}±0.50	8.60^{a}±0.77	8.98^{a}±0.20	8.69^{a}±0.46	9.29^{a}±0.35	9.14^{a}±0.30	9.21^{a}±0.28
8.93±0.89	9.46±0.06	R3	8.92^{a}±0.41	$8,81^{a}$±0.44	9.12^{a}±0.71	9.44^{a}±0.21	8.98^{a}±0.31	9.14^{a}±0.27	9.68^{a}±0.09
9.34±0.26	8.65±0.71	R4	4.94^{b}±0.37	5.46^{b}±0.58	5.43^{b}±0.47	4.93^{c}±0.18	4.87^{d}±0.23	5.24^{b}±0.62	5.54^{c}±1.08
8.87±0.98	9.01±0.56	R5	5.74^{b}±1.40	5.78^{b}±0.34	5.24^{b}±0.57	5.70^{c}±0.84	5.89^{c}±0.56	5.75^{b}±0.79	5.19^{c}±0.20
NS	NS	Sig.	*	*	*	*	*	*	*

R0 = DCAD + 14 without fish oil
R1 = DCAD + 14 + 3% fish oil
R2 = DCAC + 40 without fish oil
R3 = DCAD + 40 + 3% fish oil
R4 = DCAD -40 without fish oil
R5 = DCAD -40 + 3% fish oil
DM = dry matter
OM = organic matter
ADG = average daily gain
NS = not significantly different.
* = significantly different (P < 0.01)

DCAD -40 had a stronger effect on urine pH compared to DCAD +40. The ration with DCAD -40 consistently decreased urine pH during the experiment period.

Oil supplementation in DCAD -40 or +40n tended to increase urine pH. Ration with DCAD -40 had more consistent effect and decreased urine pH directly. The urine pH followed the DCAD pattern. Increase in addition of $MgCl_2$ and $MgSO_4$ to meet DCAD -40 resulted in axcess Cl and S intake. The rams maintained acid base balance by excreting anion through urine which is manifested by the decrease in urine pH. CHAN *et al.* (2006) explained that decreasing in urine pH was associated with the anion intake. Sheep fed ration with DCAD +40 containing mineral salt of Na_2CO_3 and K_2CO3 led to excess intake of Na and K. SARWAR *et al.* (2007b) reported that Na_2CO_3 in ruminant ration led to high urine pH indicating that kidney was able to maintain pH of body fluid.

CONCLUSIONS

Ration with DCAD +40 and -40 and fish oil supplementation decreased dry matter intake, but had no effect on dry matter and organic matter digestibility. It's indicated that DCAD +40 and -40 were out of the normal range, and therefore decreased body weight of rams. Excess of anion or cation intake was excreted via urine and therefore changed urine pH.

REFERENCES

ANGGREINI, D. 2007. Konsumsi dan Kecernaan Nutrien serta Kualitas Semen Domba Garut dengan Ransum yang Bernilai Neraca Kation-anion Berbeda. *Thesis*. Sekolah Pascasarjana. Institut Pertanian Bogor. Bogor.

BORUCHI, S.L., L.E. PHILLIP, V. GIRARD and A. TREMBLAY. 2004. Altering dietary cation-anion difference in lactating dairy cows to reduce phosphorus excretion to the environment. *J. Dairy Sci*. 87: 1751-1757.

CHAN, P.S., J.W. WEST and J.K. BERNARD. 2005. Effects of dietary cation-anion difference on intake, milk yield, and blood components of the early lactation cow. *J. Dairy Sci*. 88: 4384-4392.

CHAN, P.S., J.W. WEST and J.K. BERNARD. 2006. Effect of prepartum dietary calcium on intake and serum and urinary mineral concentrations of cows. *J. Dairy Sci*. 89: 704-713.

DELAQUIS, A.M. and E. BLOCK. 1995. Dietary cation-anion difference, acid-base status, mineral metabolism, renal function, and milk production of lactating cows. *J. Dairy Sci*. 78: 2259.2284.

DIREKTORAT JENDERAL PETERNAKAN. Departemen Pertanian Republik Indonesia 2005. Statistik Peternakan 2005. Ditjennak. Jakarta.

FATHUL, F., T. TOHARMAT, I.G. PERMANA dan A. BOEDIONO. 2008. Keasaman cairan tubuh dan rasio kelamin anak domba Garut (*Ovis aries*) yang diberi kation-anion ransum yang berbeda. *Media Petern*. 31: 87-98.

HAFEZ, E.S.E. 1980. Reproduction In farm Animal. Lea and Febiger, Philadelphia.

HARTATI, E. 1998. Suplementasi Minyak Lemuru dan Seng ke Dalam Ransum yang Mengandung Silase Pod Kakao dan Urea untuk Memacu Pertumbuhan Sapi Holstein Jantan. *Disertasi*. Program Pascasarjana, Institut Pertanian Bogor, Bogor.

HORST, R.L., J.P. GOFF, T.A. REINHARDT and D.R. BUXTON. 1997. Strategies for preventing milk fever in dairy cattle. *J. Dairy Sci*. 80: 1269-1280.

HU, W. and M.R. MURPHY. 2004. Dietary cation-anion difference effects on performance and acid-base status of lactatung dairy cows: A meta-analysis. *J. Dairy Sci*. 87: 2222-2229.

LERAY, C., G. NONOTTE, P. ROUBAND and C. LEGER. 1985. Incidence of (n-3) esential fatty acid deficiency on trout reproductive processes. *Reprod. Nutr. Dev*. 25: 567-581.

MATTJIK, A.A. dan M. SUMERTAJAYA. 2002. Perancangan Percobaan dengan Aplikasi SAS dan MINITAB. Jilid I. Edisi ke-2. Institut Pertanian Bogor Press, Bogor.

MOORE, S.J., M.J. VANDERHAAR, B.K. SHARMA, T.E. PILBEAM, D.K. BEEDE, H.F. BUCHOLTZ, J.S. LIESMAN, R.L. HORST and J.P. GOFFT. 2000. Effects of altering dietary cation-anion difference on calcium and energy metabolism in peripartum cow. *J. Dairy Sci*. 83: 2095-2104.

MORTON, J. and C. ROACH. 2002. Potash-How does it affect production and cow health. Proc of the Westpac Trust Dairy Conference. New Zealand. pp. 19-23.

RIOND, J.L. 2001. Animal nutrition and acid-base balance. *Eur. J. Nutr*. 40: 245-254.

ROCHE, J.R., D. DALLEY, P. MOATE, C. GRAINGER, M. RATH and F. O'MARA. 2003a. Dietary cation-anion difference and the health and production of pasture-fed dairy cows. 1. Dairy cows in early lactation. *J. Dairy Sci*. 86: 970-978.

ROCHE, J.R., D. DALLEY, P. MOATE, C. GRAINGER, M. RATH and F. O'MARA. 2003b. Dietary cation-anion difference and the health and production of pasture-fed dairy cows. 2. Dairy cows in early lactation. *J. Dairy Sci*. 86: 979-987.

ROMO, G.A. 1991. Some blood minerals and hormones in cow fed variable mineral levels and ionic balance. *J. Dairy Sci*. 74: 3068-3077.

SALT INSTITUTE. 2001. Salt and trace minerals for lifestock, poultry and other animals: *Zinc for Animals*. http//www.salt institute.com.html (16 Juni 2006).

SARWAR, M., M.A. SHAHZAD and M. NISA. 2007a. Nutrient intake, acid base status and growth performance of Thalli lambs fed varying level of dietary cation-anion difference. *Asian-Aust.J. Anim. Sci*. 20: 1713-1720.

SARWAR, M., M.A. SHAHZAD and M. NISA. 2007b. Influence of varying level of sodium bicarbonat on milk yield and its composition in early lactating Nili Ravi buffaloes. *Asian-Aust. J. Anim. Sci*. 20: 1858-1864.

STATISTICAL ANALYSIS SOFTWARE (SAS). 2005. SAS 6.12. Help and Documentation. SAS Institute Inc. USA.

STEWART, P.A. 1983. Modern quntitative acid-base chemistry. *Can. Physiol. Pharmacol.* 61: 1444-1461.

TUCKER, W.B., G.A. HARRISON and R.W. HEMKEN. 1992. Sulfur should be included when calculating the dietary cation-anion balance of diets for lactating dairy cows. *Anim. Sci. Res. Rep*. 37: 141-150.

VAGNONI, D.B. and G.R. OETZEL. 1998. Effects of dietary cation-anion difference on the acid-base status of dry cows. *J. Dairy Sci*. 81: 1643-1652.

YINGST, D.R., J. DAVIS and R. SCHIEBINGER. 2001. Effects of extracellular calcium and potassium on the sodium pump of rat adrenal glomerulosa cells. *Am. J. Physiol. Cell Physiol*. 280: C119-C125.