Effectivity of Mg-Sulphate and Mg-Acetate in Alleviating Temperature Stress in The Rex Rabbits

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ABSTRACT: Heat stress causes a reduction of Mg-level of cell content, hence the metabolic activities, especially those of carbohydrates-relating reactions. Its consequence is poor growth of animals. An experiment was conducted to study the inclusion Mg-acetate or Mg-sulphate into the diet on the performance of Rex rabbits when the animals were exposed to heat and cold stress. Dietary inclusion of Mg-acetate and Mg-sulphate was 0.17 and 3.0 %, respectively. A control diet [without Mg] was used to compare with. Sixty weanling Rex rabbits [6 week-old] were allocated randomly into 3 dietary treatments within each of four temperature controlled rooms [32°, 26°, 18° and 16°C]. Within each room the rabbits were caged individually. Experiment was carried out for 8 weeks and measurements were made on feed, water and oxygen intake [FI, WI and OI], bodyweight gain [BWG], feed conversion [FCR], body temperature [BT], level of plasm-Mg and plasm-thyroxin. Results from the analysis of variance followed by an LSD test indicated that no significant interaction occured between Mg inclusion with the room temperature on the measured parameters. Most measured responses were significantly influenced by environmental temperature, but not by dietary Mg-treatment. Increased room temperature [hotter] decreased FI, BWG, feed efficiency and plasm-thyroxine level. In contrast, WI, OI and BT increased with the increased room temperature. Plasm Mg-level was significantly affected by type of Mg-compound. Inorganic Mg- sulphate increased plasm-Mg level more than did the organic Mg-acetate. There was, however, a tendency that organic Mg [Mg-Acetate] had a more profound effect than the inorganic Mg. Values for intake of feed, water and oxygen, BWG, FCR, BT, plasm-Mg and plasm-thyroxine level varied from 79 to 126 g/rabbit/d, 1821 to 2734 ml/rabbit/ week and 1.29 to 2.64 cc/min/kg$^{0.75}$, 16 to 24 g/rabbit/d, 4.48 to 5.21, 38.68 to 39.99°C, 31 to 41 mg/l and from 1.55 to 1.89 ug/ml, respectively.

Key Words: Mg-Sulphate, Mg-Acetate, Temperature, Stress, Rex Rabbit

Introduction

Homeothermic, warm blooded animals require thermo- environmental comfort zone in which optimal performance may be achieved. Higher or lower environmental temperature causes stress that leads to poor performance of animals [Fuquay, 1981], and in some cases, extreme stress is fatal and causing death to the animals. Temperature stress disturbs endocrine and metabolic activities [Hafez, 1967] including thyroxine secretion and cell membrane permeability, hence the balance of intracellular mineral ions such as calcium, sodium, potassium and magnesium [Gunther, 1988]. In the tropics, heat stress is almost a common phenomenon occurs to the animal. On the other hand, the Rex rabbit, which is raised particularly for fur production, requires cold environment [Pritchard, *pers.comm.*, 1992] in order to produce prime quality fur and therfore is more likely to suffer cold stress. Heat stress increases cathecolamine synthesis in the suprarenal medulla, which leads to the increase of membrane permeability, hence decreases the intracellular Mg^{2+} concentration [Gunther, 1988]. On the other hand, Sykes et al. [1969] reported that sheep exposed to cold environment [30°C --> 8°C] lost 12 % of their Mg-plasm level. Mg^{2+} plays an important role in many ATP involving-reactions [Martin et al. 1983] in the synthesis of proteins, nucleic acids, nucleotides, carbohydrates and lipids and also in the muscle contraction. Deficiency of intracellar Mg^{2+} apparently reduces plasm thyroxine

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level in rats [Hsu et al., 1984] and the oxydative phosphorylation ratio in the mitochondria [Vitale et al. in Platner et al. 1972] hence decreases the ATP production.

Supplementation of dietary Mg-aspartate for layer [Donaghue et al. 1987], Mg-fumarate for depressed weanling pig [Gunther and Molme, 1985] and $MgCO_3$ for depressed weaned rats [Cadell et al. 1986] were reported to improve growth or increase the minerals absorption [Gunther 1988] in the gut of the animals. The use of MgO in the weanling pigs, however did not produce significant effect [Gunther, 1988]. There seemed to be effectivity difference of organic vs inorganic Mg-compounds.

Availability, efficacy and cost of the feed supplement are factors to be considered in the ration formulation. Mg-aspartate and Mg-fumarate [organic] are not only expensive, but also hardly available locally. MgO, $MgCO_3$ and $MgSO_4$ are more available and less costly, but could also be less effective. This experiment was conducted to study the use of Mg-acetate and $MgSO_4$ in the rabbits exposed to hot and cold environment.

Experimental Procedures

Sixty weanling Rex rabbits [6 weeks old] were divided randomly into a 4 x 3 factorial experiment. First factor was environmental temperatures [32, 26, 18 and 13°C, ± 2°C each]. Second factor was types of dietary Mg-supplement [no Mg-supplement, Mg-acetate and $MgSO_4$]. Each combination treatment consisted of 5 individual rabbit replicates. Composition of basal diet [% air dry basis] was soyabean meal [20], fish meal [3], corn [20], rice bran [25], bagasse [5], elephant grass [5], molasses [3], oil [3] premix [0.25], salt [0.25], lime [0.5], methionine and lysine, each of 0.2]. Level of Mg supplemented was 0.17 % for Mg-acetate [Gunther and Molme, 1985 *in* Gunther, 1988] and 3% for $MgSO_4$ which was a doubled level of the Mg requirement for growing rabbits [Evans et al. 1983]. Diet and water were available at all time. Experiment was run for 8 weeks. Measurements were made on feed, water and oxygen intake [FI, WI and OI], bodyweight gain [BWG], feed conversion ratio [FCR], body temperature [BT] and level of plasm-Mg and plasm-thyroxine. Results were subjected to a one-way ANOVA followed by an LSD test for treatment means.

Results and Discussion

In general, results indicated that there were no significant interaction between type of Mg-supplement and the environmental temperature [ET°] on the measured parameters. Type of dietary Mg used, surprisingly, did not have significant effect on most parameters, except for plasm Mg-level. On the other hand, ET° had significant effect on FI, WI, OI, BWG, FCR, BT and plasma thyroxine level.

Responses of FI, WI and BWG to treatments were shown in Table 1, 2 and 3, respectively. Higher ET° [hotter condition] decreased FI and BWG, but increased WI significantly. Similar observations were reported by Stephan et al. [1980] in Large Silver rabbits exposed from 5° to 30°C and by Suardjaja [1985] in local and NZW rabbits raised at 18 to 33°C. Fuquay [1981] indicated that during stress, due to heat accumulation, homeothermic-warm blooded animals reduce their heat-producing

Table 1. Feed intake of rabbits [g/rabbit/d] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	73	86	82	79 ± 8^a
26	110	114	104	109 ± 12^b
18	123	113	119	118 ± 12^{bc}
13	130	113	128	126 ± 15^c
Mean	111 ± 23	109 ± 14	108 ± 22	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
a,b,c within the same column differ significantly [P<0.05]

Table 2. Water consumption of rabbits [ml/rabbit/d] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	350	442	402	391 ± 98^b
26	319	318	388	343 ± 67^b
18	249	257	268	259 ± 38^a
13	254	254	268	260 ± 43^a
Mean	290 ± 89	308 ± 89	335 ± 86	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
a,b within the same column differ significantly [P<0.05]

Table 3. Bodyweight gain of rabbits [g/rabbit/d] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	15	15	18	16 ± 3^a
26	24	26	24	25 ± 4^b
18	27	21	26	25 ± 4^b
13	25	18	26	24 ± 5^b
Mean	23 ± 5	22 ± 5	23 ± 5	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg-acetate]
a,b within the same column differ significantly [P<0.05]

metabolic activities, such as feed consumption and/or physical activities and increase water consumption. On the other hand, lower temperature [colder] increased feed consumption and decreased water intake as the animal activates heat-producing metabolism to maintain body temperature [Sykes et al., 1969]. Significantly higher FI, but not BWG of rabbits raised at 13° vs those of 26°C in present experiment supported such observation.

In addition, Scibillia et al. [1987] on calves and Wheeler and Blackshaw [1986] on merino sheep also reported that higher energy were required by animals exposed to colder ET°, as indicated by lower plasma glucose level [93.8 vs 101.6 mg/100 ml and 4.4 vs 4.7 mM, when animals were raised from 10 to 4°C and from 24 to 11°C, respectively]. Furthermore, bodyweight gain were depressed only with the animals exposed to 32°C. Although there were no significant interaction nor differences between type of Mg supplement, it is interesting to note that [1] in ET° 13 and 18°C, FI and BWG were much lower in rabbits fed diet supplemented with $MgSO_4$ - which might indicate adverse effect of $MgSO_4$ in cold environment; [2] higher water intake of rabbits fed Mg-acetate diet [especially in the less heat to cold ET°] - which might indicate more attempt to increase metabolic activity and [3] higher BWG of rabbits fed Mg-acetate diet raised at 32°C [18g/rabbit/d] - indicating more positive effect of Mg-acetate to alleviate heat stress.

Efficiency of feed utilization as indicated by FCR [Table 4] showed that increased or decreased ET° [above or below comfort zone -> 15 - 20°C for rabbits - Cheeke et al. 1987] caused less feed efficiency [higher FCR value]. In the first case, the effect was more likely due to less FI, while in the latter case was due more to higher heat requirement for maintaining normal body metabolism. Best BWG and FCR were obtained from rabbits raised at 18°C, as were also suggested in Cheeke et al. [1987].

Table 4. Feed conversion ratio of rabbits exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	4.99	5.73	4.61	4.95 ± 0.87^{ab}
26	4.79	4.26	4.34	4.48 ± 0.67^{a}
18	4.64	5.45	4.54	4.86 ± 0.61^{a}
13	5.24	6.16	5.04	5.31 ± 0.55^{b}
Mean	4.91 ± 0.81	5.21 ± 0.87	4.64 ± 0.44	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
^{a,b,c} within the same column differ significantly [P<0.05]

It is also noteworthy to observe that FCR of rabbits fed diet containing Mg-acetate was higher, although not significantly different, than those of animals fed control diet. Less efficient FCR was obtained from rabbits fed $MgSO_4$ diet.

Oxygen intake [OI], body temperature [BT] and plasm thyroxine level of the treated animals are presented in Table 5, 6 and 7, respectively. Similar to feed consumption [Table 1], increasing temperature decreased oxygen intake or vice versa. Johnson *in* Shafie et al. [1970] showed that higher ET° Caused animals to decrease their activities or lower ET°Caused animals to increase activities, activate fat catabolism, which require higher O_2 for more energy production. It is somewhat surprising, however, that in the hot stress, when the animals are panting - in which O_2 intake is supposedly high - the O_2 intake of rabbits raised at 32°C was low. Report by Yousef [1985] indicated similar situation occured to Bedouin desert fowl, in which OI was dropped 8% when the birds was exposed from 30 to 40°C, but thereafter OI was increased 18% as ET° increased to 48°C.

Oxygen intake seemed to be more profoundly affected by type of Mg used in the hotter condition. Mg-acetate diet caused higher OI, which might be indicating more active body metabolisms.

Clearly, body temperature [BT] was influenced by ambient temperature [ET°]. Slight but significant increase of BT occured with the increasing ET°. The difference, however was not significant between rabbits raised at 18° and 13°C. Similar observations were reported by Arad et al. [1975] on laying hens and by Wheeler and Blackshaw [1986] on Merino sheep. Inspite of ET°, Itokawa et al [1974] showed that BT was also influenced by level of dietary Mg, as Mg^{2+} together with Ca^2 is involved in the CNS [Central Nerves System], through neurohumoral transmitter, in theregulation of BT and blood pressure. Mg-deficient diet caused lower BT of rats. Results of present experiment supported the Itokawa's result particularly those of with Mg-acetate diet, although the difference was not significant statistically compared with two other diets.

Table 5. Oxygen consumption of rabbit [cc/kg$^{-0.75}$/min] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	1.26	1.22	1.36	1.29 ± 0.18^{a}
26	2.32	2.04	2.41	2.27 ± 0.31^{b}
18	2.43	2.48	2.43	2.45 ± 0.16^{b}
13	2.62	2.63	2.67	2.64 ± 0.26^{b}
Mean	2.20 ± 0.54	2.15 ± 0.53	2.23 ± 0.58	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
^{a,b} within the same column differ significantly [P<0.05]

Table 6. Body temperature of rabbits [°C] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	40.14	39.88	39.91	39.99 ± 0.38^c
26	38.96	39.26	39.26	39.15 ± 0.27^b
18	38.70	38.73	38.60	38.68 ± 0.34^a
13	38.56	38.75	38.79	38.68 ± 0.27^a
Mean	39.03 ± 0.65	39.10 ± 0.52	39.17 ± 0.62	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
a,b,c within the same column differ significantly [$P<0.05$].

Mg-acetate containing diet produced higher plasma thyroxine level, although did not differ statistically at 5% from other type of diets used. Thyroxine stimulates oxidation reactions including oxydative phosphorylation, intracellular enzymes oxydase activity, etc. [Guyton, 1976]. These results supported the fact of higher OI [Table 5], higher BT [Table 6] and better feed efficiency [Table 4]. Furthermore, Hsu et al. [1984] reported lower Mg level caused less thyroxine production, less quantity and activity of mitochondria hence less ATP produced and consequently low BWG of rats was obtained. However, it is unclear why plasma thyroxine level dropped significantly when the animals were exposed to cold stress [ET° 13°C]. The rule of thumb was that lower ET°Caused hypothalamus to release TRH to trigger hypofisis to produce TSH, which in turn would stimulate thyroid glands to produce thyroid hormones [e.g. thyroxine] [Martin et al., 1983; Ganong, 1987].

Unlike any other parameters, Plasm-Mg level was significantly influenced by type of dietary Mg, but not by ET°. Highest plasm-Mg level was obtained from rabbits fed 3% $MgSO_4$. The effect of this high level of plasm-Mg, however was not reflected on the performance of the animals. Instead, poorer results were obtained indicating that $MgSO_4$ is not a suitable source of Mg for alleviating temperature stress. In addition, high level of plasm-Mg was not necessarily effective to induce more metabolic activities or plasm-Mg is not a good indicator for measuring the effectivity of the role of Mg in the intrasellular metabolism.

Compared with the results of the use of Mg-fumarate in swine [Gunther and Mohme *in* Gunther 1988] or Mg-aspartate [Donoghue et al., 1987] in laying hens, our results with Mg-acetate apparently was much less effective. Fumarate and aspartate are components involved in the Tricarboxylic acid [Kreb's] cycle, in which production of ATP is high, and therefore the use of Mg-containing such components could be more easily utilized in the metabolism.

Table 7. Plasm-thyroxine level of rabbits [μg/100ml] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	1.37	2.08	2.23	1.89 ± 0.45^b
26	1.94	1.77	1.63	1.78 ± 0.15^b
18	1.68	1.73	2.09	1.83 ± 0.22^b
13	1.50	1.54	1.60	1.55 ± 0.05^a
Mean	1.62 ± 0.25	1.78 ± 0.22	1.89 ± 0.31	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg- acetate]
a,b,c within the same column differ significantly [$P<0.05$].

Table 8. Plasm-Mg level of rabbits [mg/l] exposed to various room temperatures and fed diets with or without Mg-sulphate or Mg-acetate.

Temp. °C	Diet 1	Diet 2	Diet 3	Mean
32	33.67	33.50	31.00	32.44 + 4.47
26	34.33	42.67	34.00	37.00 + 9.84
18	27.67	42.00	29.67	33.11 +10.15
13	28.33	48.00	35.25	35.78 +10.72
Mean	31.00±.07[a]	41.07±0.68[b]	32.70±6.17[a]	

Diet 1 [No Mg], Diet 2 [+ Mg-sulphate], Diet 3 [+ Mg-acetate]
[a,b,c] within the same row differ significantly [$P<0.05$].

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