

**GROWTH PERFORMANCE, BLOOD COMPONENTS AND SLAUGHTER TRAITS OF NEW ZEALAND WHITE MALE GROWING RABBITS AS AFFECTED BY DIETARY SUPPLEMENTATION WITH CALCIUM, SODIUM OR POTASSIUM, IN SUB-TROPICAL EGYPT**

**[EFECTO DE LA SUPLEMENTACIÓN CON CALCIO, SODIO O POTASIO EN EL CRECIMIENTO, COMPONENTES SANGUÍNEOS Y CARACTERÍSTICAS DE LA CANAL DE CONEJOS EN CRECIMIENTO EN LA REGIÓN SUBTROPICAL DE EGIPTO.]**

**I.F.M. Marai\*, M.S. Ayyat, and U.M. Abd El-Monem**

*Dep. Animal Production, Fac.f Agriculture, Zagazig University, Zagazig, Egypt.*

*\*Corresponding Author*

**SUMMARY**

The study aimed to investigate growth performance, blood components and slaughter traits of NZW male growing (broiler) rabbits (78 animals) as affected by dietary supplementation with calcium, sodium or potassium during 3 months in each of summer and winter, in Egypt. Effects of seasons of the year on the same traits, were also studied. Live body weight, daily body gain weight, serum total protein, albumin, globulin (blood components), urea-N, creatinine (kidney function), AST (Serum glutamic oxaloacetic transaminase) and ALT (Serum glutamic pyruvic transaminase) (liver function), pre-slaughter weight and adjusted weights of carcass, fore-part, hind-part and head of New Zealand White (NZW) male rabbits were significantly ( $P < 0.001$ , 0.01 or 0.05) lower in summer than in winter due to the effect of heat stress. Minerals supplementation affected significantly ( $P < 0.001$ , 0.01 or 0.05) male rabbit in final live body weight, daily gain weight, serum total protein and albumin and adjusted weights of carcass and head. Supplementation (per kg diet) with each of 100 mg calcium oxide, 150 mg sodium chloride or 300 mg potassium bicarbonate exceeded significantly ( $P < 0.05$ ) the control diet, at the end of the experimental period. The increase values were 21.3, 9.0 and 7.2%, respectively. Interaction between season and minerals supplementation effects were significant ( $P > 0.001$ , 0.01 or 0.05) on final live body weight, daily body gain weight, serum total protein and albumin, pre-slaughter weight and adjusted weights of liver, carcass intermediate and hind parts and head of NZW male rabbit. The magnitude of improvement was the highest with potassium bicarbonate (300 mg/kg diet) followed by calcium oxide (100 mg/kg diet), in winter. In summer, the highest improvement obtained was with sodium chloride (150 mg/kg diet) supplementation. At

the same time, the interaction effects of the other mineral supplements on the studied traits were negative in the two seasons. Pre-slaughter weight significantly affected ( $P > 0.001$  or 0.01) adjusted weights of carcass, liver, fore part, intermediate part, hind part and head.

**Key words:** Rabbits, growth performances, blood components, slaughter traits, heat stress, minerals supplementation.

**RESUMEN**

El trabajo tuvo el objetivo de estudiar el efecto de la suplementación con Ca, Na o K durante tres meses del verano e invierno sobre el crecimiento, componentes sanguíneos características de la canal de conejos (New Zealand White, NZW). El peso, la ganancia de peso, proteína sérica, albúmina, globulina (componentes sanguíneos), N-ureico, creatinina (función renal), AST y ALT (función hepática), peso de la canal, porción anterior, posterior y cabeza fueron menores en verano ( $P < 0.001$ , 0.01 or 0.05). La suplementación mineral sólo afectó peso final, ganancia diaria de peso proteína sérica total y el peso ajustado de la canal y cabeza. La suplementación (per kg dieta) con 100 mg óxido de calcio, 150 mg cloruro de sodio o 300 mg bicarbonato de potasio excedió ( $P < 0.05$ ) la dieta control en 21.3, 9.0 y 7.2%, respectivamente. El mayor incremento se obtuvo con bicarbonato de potasio en invierno. En verano el mayor incremento se obtuvo cloruro de sodio. Las necesidades de minerales de NZW en ambientes tropicales deben ser revisadas.

**Palabras clave:** Conejos, crecimiento, canal, stress calórico, suplementación mineral.

**INTRODUCTION**

In the hot climate areas of the World, it is known that the climate is characterized by a long hot and a short cool periods. Under such conditions, exposure of the

growing animals to high ambient temperature (above 30°C) affects deleteriously their growth performance traits (Habeeb *et al.*, 1992). This induced the rabbit raisers in the sub-tropical regions to limit production of the young (i.e. limit the breeding season) to be during

the short cool season of the year (Marai *et al.*, 1990, 2002).

Many trials were carried out to alleviate the heat-stressed animals with different techniques, in order to extend the rabbit breeding season to be all the year (Habeeb *et al.*, 1994 and Marai *et al.*, 1999). Alleviation can be carried out with either physical techniques (sprinkling tap water, drinking cool water or shearing), physiological techniques (administration of either diaphoretics or diuretics) or natural techniques (minerals, amino acids or vitamins) (Marai and Habeeb, 1997).

Regarding the use of the minerals technique, unfortunately no estimates for the dietary requirements have been established for rabbits, as well as, for all animals, under the hot climate conditions. Further, studies on effects of dietary supplementation of growing rabbits with minerals in that respect, are scanty (Marai *et al.*, 1994a).

In the present study, it was aimed to investigate growth performance, blood components and slaughter traits of NZW male broiler rabbits as affected by dietary supplementation with calcium, sodium or potassium, during summer in comparison to winter, in Egypt. Effects of seasons of the year on the same traits, were also studied.

## MATERIALS AND METHODS

The present study was conducted in the Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. The experimental work was carried out in the Rabbitry of the same Department, during the period from November to January (as the mild weather; winter) and from June to August (as the hot climate; summer).

The number of 78 weaned NZW male rabbits of 35 days of age with nearly equal initial live body weight, was used for 8 weeks, during each of winter and summer seasons in the present study (674.6±8.1 and 659.2±7.9 g during winter and summer, respectively). The weaned NZW male rabbits were randomly allotted to 10 experimental groups. Five groups were raised during the winter season (38 animals: 8 in each of the first three groups and 7 in each of the other two groups) and the other five groups were raised during the summer (40 animals: 8 in each group). Within each season, one group was raised without a mineral supplement as control group. The other groups were treated with different minerals supplementation. Such treatments (/kg diet) were calcium oxide 100 mg, sodium chloride 150 mg, sodium bicarbonate 200 mg and potassium bicarbonate 300 mg, for the four groups, respectively. Supplements were added to the offered diets by mixing through spraying a solution of each supplement in water,

then the mixture was left to dry in the air. It may be revolved more than once, until complete drying.

The NZW male rabbits were fed on a pelleted ration *ad libitum*. The ration contained 16.87% crude protein, 2568 kcal (/kg diet) digestible energy, 13.25% crude fibre, 0.4% calcium, 0.11% sodium and 0.66% potassium. The offered diet covers the calcium, sodium and potassium requirements of the animals according to NRC (1977), since the estimates of animal requirements in the temperate conditions could be considered as the amounts to be given in the hot sub-tropical areas. The composition and chemical analysis of the basal diet are as shown in Table 1.

Table 1. Composition and chemical analysis of the experimental basal diet

Items	%
<b>Ingredients:</b>	
Alfalfa hay	31.0
Soybean meal	14.0
Wheat bran	25.0
Barley	25.0
Molasses	3.0
Limestone	1.6
Sodium chloride salt	0.3
Vitamin and mineral premix@	0.1
<b>Chemical analysis:</b>	
Crude protein (%)*	16.87
Crude fibre (%)*	13.25
Digestible energy (kcal/kg)**	2568.0

\* Analyzed according to AOAC (1980).

\*\* Calculated according to NRC (1977).

Each kilogram contains: Vit. A 2000000 IU, Vit. D3 150000, Vit. E 8.33 g, Vit. K 0.33 g, Vit. B1 0.33 g, Vit. B2 1 g, Vit. B5 0.33 g, Vit.6 1.7 mg, Vit. B12 8.33 g, Pantothenic acid 3.33g, Biotin 33 mg, Folic acid 0.83 g, Cholin 200 g, Zn 11.79 g, Mn 5.00 g, Fe 12.5 g, I 33.3 mg, Se 16.6 mg and Mg 66.79 g.

All animals were kept under similar managerial and hygienic conditions, during the experimental period. The rabbits were raised in cages provided with feeders and automatic nipple drinkers. The building was naturally ventilated and provided with electric fans. Indoors ambient temperature and relative humidity values were recorded. Averages of values recorded were 14.5 and 31.5°C for ambient air temperature and 55 and 79% for relative humidity, during winter and summer, respectively. The rabbits were individually weighed at beginning and end of the experiment. Weighing was carried out at 8.00 h, and live body gain weight was calculated. The feed consumption was recorded during the experimental period and feed conversion was

calculated as the amount of food consumed for production of one unit of body gain. Economic efficiency (EcE) was estimated according to Marai (1998) as the following formula:  $EcE = [(Price\ of\ body\ gain\ weight - Feed\ cost) / Feed\ cost] \times 100$ ; the other head costs were assumed constant.

At the end of the experimental period, three male rabbits from each treatment were randomly taken for slaughter. After complete bleeding, pelt, viscera and tail, were removed, and the carcass and some carcass components were weighed. Blood samples were collected at slaughter. Serum samples were obtained by centrifugation of blood at 3000 rounds / minute for 20 minutes and were kept at -20°C for analysis. Serum total protein, albumin, creatinine, urea-N and transaminase enzymes were determined by using commercial kits.

The temperature-humidity index (THI) was calculated according to Marai *et al.* (2001) using the following formula:

$$THI = db^{\circ}C - [(0.31 - 0.31 RH)(db^{\circ}C - 14.4)],$$

where  $db^{\circ}C$  = dry bulb temperature in Celsius and RH = relative humidity percentage / 100. The values obtained were then classified as follows: <27.8 = absence of heat stress, 27.8 - < 28.9 = moderate heat stress, 28.9 - < 30.0 = severe heat stress and 30.0 and more = very severe heat stress.

Statistically, the data of body weight, daily body gain and blood components were analyzed as a factorial experiment (Snedecor and Cochran, 1982) according to the following Model 1:

$$Y_{ijk} = \mu + S_i + G_j + SG_{ij} + e_{ijk},$$

where  $Y_{ijk}$  = an observation,  $\mu$  = the overall mean,  $S_i$  = the fixed effect of  $i^{\text{th}}$  season,  $G_j$  = the fixed effect of  $j^{\text{th}}$  minerals supplementation,  $SG_{ij}$  = the interaction between the  $i^{\text{th}}$  season and minerals supplementation and  $e_{ijkl}$  = random error.

The data of slaughter traits was statistically analyzed as a factorial experiment according to the following Model 2:

$$Y_{ijk} = \mu + S_i + G_j + SG_{ij} + b(X-x) + e_{ijk},$$

where  $Y_{ijk}$ ,  $\mu$ ,  $S_i$ ,  $G_j$ ,  $SG_{ij}$  and  $e_{ijk}$  were as defined in the Model 1,  $b$  = partial linear regression coefficients of  $Y_{ij}$  on slaughter weight,  $X$  = value of slaughter weight and  $x$  = overall average of slaughter weight. Significant differences were determined by Duncan's Multiple Range test (Duncan, 1955).

## RESULTS

Temperature-humidity index values were estimated as 14.5 and 30.3 during the mild (winter) and hot (summer) climate periods of the year, respectively, indicating absence of heat stress during the mild climate (less than 27.8) and exposure of the animals to very severe heat stress (>30.0) during the hot climate, in the present study.

Live body weight, daily body gain weight, serum total protein, albumin, globulin (blood components), urea-N, creatinine (kidney liver function), AST (Serum glutamic oxaloacetic transaminase) and ALT (Serum glutamic pyruvic transaminase) (liver function), pre-slaughter weight and adjusted weights of carcass, fore-part, hind-part and head of NZW male rabbits were significantly ( $P < 0.001$ , 0.01 or 0.05) lower in summer than in winter (Tables 2 - 4).

Minerals supplementation affected significantly ( $P < 0.001$ , 0.01 or 0.05) final live body weight, daily gain weight, serum total protein and albumin and adjusted weights of carcass and head (Tables 2 - 4). Supplementation with each of 100 mg calcium oxide, 150 mg sodium chloride and 300 mg potassium bicarbonate exceeded significantly ( $P < 0.05$ ) the control diet, at the end of the experimental period. The increase values were 21.3, 9.0 and 7.2%, respectively. The highest value was with 300 mg potassium bicarbonate followed by 150 mg sodium chloride and 100 mg calcium oxide/kg diet, respectively. The highest daily gain weight values were obtained by supplementation with 300 mg potassium bicarbonate followed by 150 mg sodium chloride/kg diet. Such values were 34.7 and 12.3%, respectively.

Interaction between season and minerals supplementation effects were significant ( $P > 0.001$ , 0.01 or 0.05) on final live body weight, daily body weight gain, serum total protein and albumin, pre-slaughter weight and adjusted weights of liver, carcass intermediate part and hind part and head of NZW male rabbit (Tables 2 - 4). The magnitude of improvement was the highest with potassium bicarbonate (300 mg/kg diet) followed by calcium oxide (100 mg/kg diet), in winter. In summer, the highest improvement obtained was with sodium chloride (150 mg) supplementation. At the same time, the interaction effects of the other mineral supplements on the studied traits were negative, in the two seasons.

Pre-slaughter weight affected significantly ( $P > 0.001$  or 0.01) adjusted weights of carcass, liver, fore part, intermediate part, hind part and head.

**Table 2.** Growth performance traits (Mean±SE) of New Zealand White male growing rabbits as affected by season, calcium, sodium and potassium supplementation and their interactions

Items	W0	W8	G0-8	FI	FC	EcE%
Season:						
Winter	674.6±8.1	1946.3±43.1 <sup>a</sup>	22.71±0.73 <sup>a</sup>	105.04	4.625	179
Summer	659.2±7.9	1708.8±29.1 <sup>b</sup>	18.80±0.43 <sup>b</sup>	94.14	5.007	159
Significance	NS	***	***			
Minerals supplementation:						
Control	655.1±15.0	1696.7±54.3 <sup>d</sup>	18.60±0.84 <sup>d</sup>	99.45	5.347	142
CaO (100 mg)	677.4±15.0	1818.8±48.4 <sup>bc</sup>	20.38±0.75 <sup>bc</sup>	105.10	5.157	150
NaCl (150 mg)	680.0±13.5	1849.3±33.2 <sup>b</sup>	20.88±0.54 <sup>b</sup>	94.85	4.543	184
NaHCO <sub>2</sub> (200 mg)	661.5±9.1	1723.1±45.5 <sup>cd</sup>	18.96±0.68 <sup>cd</sup>	97.90	5.164	150
KHCO <sub>3</sub> (300 mg)	654.5±13.4	2057.8±90.9 <sup>a</sup>	25.06±1.48 <sup>a</sup>	100.65	4.016	221
Significance	NS	***	***			
Interaction between season and minerals supplementation:						
Winter						
Control	669.6±22.5	1830.0±61.9 <sup>abc</sup>	20.72±0.88 <sup>cde</sup>	103.30	4.986	158
CaO (100 mg)	697.4±26.0	1948.5±59.7 <sup>ab</sup>	22.32±0.92 <sup>b</sup>	111.70	5.005	158
NaCl (150 mg)	669.0±18.1	1807.5±28.8 <sup>fgh</sup>	20.33±0.73 <sup>bc</sup>	98.70	4.855	166
NaHCO <sub>2</sub> (200 mg)	660.0±11.0	1757.5±55.6 <sup>fgh</sup>	19.60±0.84 <sup>bcd</sup>	101.00	5.153	150
KHCO <sub>3</sub> (300 mg)	677.0±18.9	2388.8±51.9 <sup>a</sup>	30.57±0.70 <sup>a</sup>	110.50	3.615	257
Summer						
Control	638.4±19.2	1544.3±48.5 <sup>d</sup>	16.18±0.81 <sup>d</sup>	95.60	5.909	118
CaO (100 mg)	657.5±13.2	1690.0±41.5 <sup>cd</sup>	18.44±0.70 <sup>cd</sup>	98.50	5.342	149
NaCl (150 mg)	692.6±20.5	1897.1±61.9 <sup>abc</sup>	21.51±0.77 <sup>bc</sup>	91.00	4.231	205
NaHCO <sub>2</sub> (200 mg)	663.0±15.3	1688.8±73.7 <sup>cd</sup>	18.32±1.08 <sup>cd</sup>	94.80	5.175	150
KHCO <sub>3</sub> (300 mg)	632.0±16.1	1726.9±37.9 <sup>fgh</sup>	19.55±0.44 <sup>bc</sup>	90.80	4.645	178
Significance	NS	***	***			

Means in the same column within each classification with different letters, differ significantly ( $P < 0.05$ ).

\*\*\*  $P < 0.001$  and NS = Not significant.

W0 = Initial body weight (g), W8 = Body weight (g) at 8 weeks, G = Daily gain weight (g), FI = Feed intake (g/day), FC = Feed conversion (g feed/g gain) and EcE = Economic efficiency.

## DISCUSSION

The significant lower final body and daily gain weights during summer were probably due to the lower feed intake (10.4%) and feed conversion (8.3%). These results were similar to those obtained by Marai *et al.* (1994a, b, 1999 and 1998) and Ayyat and Marai (1997). Decrease in feed intake and feed utilization and the consequent reduction in substrates and hormones are responsible for the depression in gain weight (Habeeb *et al.*, 1992). The decrease in economic efficiency (11.2%) in the rabbits reared under summer conditions compared to those reared under winter conditions was similar to that reported by Ayyat and Marai (1997) and Marai *et al.* (1999). The decrease in each of the blood components during summer season was in agreement with values obtained by Marai *et al.* (1994a and 1998).

With regard to the dietary supplements used in the present study, it is known that calcium is the mineral present in the largest quantity in animal body (bones and teeth represent about 99% of the body calcium). In addition, it has a role in blood clotting, contraction of heart muscle and transmission of nerve impulses to muscle (Cheeke, 1987). Sodium chloride plays a role in maintaining the proper osmotic pressure in the cells of the body, helps in transfer of nutrients and removal of waste products from the cells and it has a role in each of muscle contraction and bile production (Ensminger and Olentine, 1978). Regarding potassium, it is known that potassium bicarbonate stimulates the appetite of the animals and it increases fibre digestibility (Erdman *et al.*, 1980) and improves feed efficiency (Magliad *et al.*, 1987).

**Table 3.** Blood constituents (Mean±SE) of New Zealand White male broiler rabbits as affected with season, minerals supplementation (calcium, sodium and potassium) and their interactions

Items	Total protein (g/100 ml)	Albumin (g/100 ml)	Globulin (g/100 ml)	Urea-N (mg/100 ml)	Creatinine (mg/100 ml)	AST (U/l)	ALT (U/l)
Season:							
Winter	7.25±0.14	3.91±0.09	3.33±0.07	16.2±0.3	1.09±0.02	28.0±0.5	13.4±0.3
Summer	6.51±0.09	3.43±0.06	3.08±0.05	13.4±0.4	1.03±0.01	23.7±0.4	11.4±0.2
Significance	***	***	**	***	*	***	***
Minerals supplementation:							
Control	6.48±0.19 <sup>c</sup>	3.42±0.12 <sup>c</sup>	3.07±0.08	15.1±0.9	1.06±0.02	25.2±1.2	12.1±0.6
CaO (100 mg)	6.62±0.17 <sup>c</sup>	3.48±0.12 <sup>c</sup>	3.13±0.10	15.6±0.9	1.06±0.36	25.0±0.7	12.3±0.7
NaCl (150 mg)	6.93±0.09 <sup>b</sup>	3.72±0.07 <sup>b</sup>	3.22±0.08	14.7±0.6	1.08±0.01	25.5±1.1	12.2±0.6
NaHCO <sub>2</sub> (200 mg)	6.97±0.13 <sup>b</sup>	3.72±0.07 <sup>b</sup>	3.25±0.10	14.5±0.8	1.08±0.03	25.9±1.2	12.7±0.5
KHCO <sub>3</sub> (300 mg)	7.38±0.38 <sup>a</sup>	4.02±0.24 <sup>a</sup>	3.37±0.14	14.3±0.9	1.06±0.03	27.5±1.5	12.8±0.4
Significance	***	***	NS	NS	NS	NS	NS
Interaction between season and minerals supplementation :							
Winter							
Control	6.87±0.09 <sup>bc</sup>	3.67±0.03 <sup>bc</sup>	3.20±0.10	16.9±0.3	1.09±0.03	27.7±0.8	13.7±0.5
CaO (100 mg)	6.97±0.09 <sup>bc</sup>	3.73±0.09 <sup>bc</sup>	3.23±0.17	17.0±0.8	1.08±0.08	25.9±0.9	13.6±0.6
NaCl (150 mg)	7.07±0.09 <sup>b</sup>	3.77±0.07 <sup>bc</sup>	3.30±0.06	15.4±0.8	1.08±0.01	27.4±0.8	13.1±0.9
NaHCO <sub>2</sub> (200 mg)	7.13±0.18 <sup>b</sup>	3.87±0.03 <sup>b</sup>	3.27±0.19	16.2±0.7	1.11±0.04	28.1±1.1	13.3±1.0
KHCO <sub>3</sub> (300 mg)	8.20±0.15 <sup>a</sup>	4.53±0.07 <sup>a</sup>	3.67±0.09	15.7±0.7	1.09±0.03	30.8±0.7	13.4±0.4
Summer							
Control	6.10±0.15 <sup>c</sup>	3.17±0.09 <sup>d</sup>	2.93±0.09	13.3±0.6	1.02±0.02	22.8±0.9	10.5±0.4
CaO (100 mg)	6.27±0.09 <sup>dc</sup>	3.23±0.03 <sup>d</sup>	3.03±0.12	14.2±1.2	1.04±0.02	14.1±1.1	11.0±0.2
NaCl (150 mg)	6.80±0.12 <sup>bc</sup>	3.67±0.12 <sup>bc</sup>	3.13±0.15	14.0±0.9	1.07±0.02	23.6±1.2	11.2±0.4
NaHCO <sub>2</sub> (200 mg)	6.80±0.15 <sup>bc</sup>	3.57±0.03 <sup>c</sup>	3.23±0.12	12.8±0.4	1.04±0.04	23.6±0.7	12.1±0.2
KHCO <sub>3</sub> (300 mg)	6.57±0.12 <sup>cd</sup>	3.50±0.15 <sup>c</sup>	3.07±0.03	12.8±1.1	1.02±0.02	24.3±0.7	12.1±0.3
Significance	***	***	NS	NS	NS	NS	NS

\*\* P<0.01, \*\* P<0.01, \* P<0.05 and NS= Not significant.

Means in the same column within each classification with different letters, differ significantly (P<0.05).

When comparison between the minerals supplemented, dietary supplementation with 300 mg potassium bicarbonate/kg diet showed the highest final live body weight (P<0.05), daily gain weight (P<0.05) economic efficiency, serum total protein (P<0.05), albumin (P<0.05), globulin, AST and ALT, pre-slaughter live body weight and adjusted carcass weight (P<0.05) and hind part, and the lowest feed conversion and urea-N. The comparison between sodium chloride and sodium bicarbonate as different sources of sodium supplementation showed that the former surpassed significantly (P<0.05) the latter in the growth performance traits, feed utilization and economic efficiency of the male broiler rabbits.

During the winter season, dietary supplementation with 300 mg potassium bicarbonate showed the highest values of live body weight, daily body gain weight economic efficiency and serum total protein, albumin, globulin and AST and pre-slaughter weight, adjusted weights of carcass and fore part of NZW male broiler

rabbits. The feed conversion was improved (27.5%) with the same treatment, during the summer season. Dietary supplementation of heat-stressed growing rabbits with 150 mg sodium chloride / kg diet restored the loss pertaining to heat stress and surpassed the winter control in live body weight (3.7%), daily gain weight (3.8%), economic efficiency (29.7%), pre-slaughter weight (4.5%), adjusted weights of carcass (2.9%), intermediate part (10.4%), hind part (14.7%) and head (5.0%). Feed conversion was improved (15.1%) with the same treatment. With regard to blood components, all values were improved than in the summer control group and became either equal or near the values of the winter control, with the same treatment. At the same time, the negative interaction effects of the other mineral supplement levels on the studied traits in the two seasons may indicate that the offered levels of such supplements are not suitable during the mentioned seasons, i.e. may be higher or lower than the actual growing rabbit requirements, under the sub-tropical conditions.

**Table 4.** Actual pre-slaughter live body weight (g) and adjusted carcass, liver weights and carcass cutability (g; Mean  $\pm$  SE) of New Zealand White male broiler rabbits as affected by season, minerals supplementation (calcium, sodium and potassium) and their interactions

Items	Pre-slaughter body weight (g)	Carcass weight (g)	Liver weight (g)	Fore weight(g)	Intermediate part weight (g)	Hind weight (g)	Head weight (g)
Season:							
Winter	1988.7 $\pm$ 87.8	1176.6 $\pm$ 9.7	71.8 $\pm$ 1.3	310.3 $\pm$ 9.0	254.5 $\pm$ 9.0	379.6 $\pm$ 8.0	112.3 $\pm$ 1.9
Summer	1807.3 $\pm$ 43.5	1208.6 $\pm$ 9.7	66.3 $\pm$ 1.3	267.1 $\pm$ 9.0	269.5 $\pm$ 9.0	419.1 $\pm$ 8.0	119.4 $\pm$ 1.9
Significance	*	NS	NS	**	NS	**	*
Minerals supplementation:							
Control	1760.0 $\pm$ 83.5	1137.3 $\pm$ 22.9	69.1 $\pm$ 3.2	276.5 $\pm$ 14.2	256.0 $\pm$ 14.2	386.6 $\pm$ 12.5	117.2 $\pm$ 3.0
CaO (100 mg)	1878.3 $\pm$ 96.6	1162.6 $\pm$ 21.8	96.8 $\pm$ 3.0	310.4 $\pm$ 13.5	266.9 $\pm$ 13.5	397.0 $\pm$ 11.9	114.4 $\pm$ 2.8
NaCl (150 mg)	1870.0 $\pm$ 85.6	1085.0 $\pm$ 21.8	67.5 $\pm$ 3.0	266.5 $\pm$ 13.6	242.7 $\pm$ 13.5	376.4 $\pm$ 11.9	123.1 $\pm$ 2.8
NaHCO <sub>2</sub> (200 mg)	1885.0 $\pm$ 66.2	1165.3 $\pm$ 21.8	60.4 $\pm$ 3.0	289.2 $\pm$ 13.5	278.8 $\pm$ 13.4	423.8 $\pm$ 11.9	106.5 $\pm$ 2.8
KHCO <sub>3</sub> (300 mg)	2096.7 $\pm$ 188.2	1193.2 $\pm$ 24.1	66.6 $\pm$ 3.3	301.1 $\pm$ 15.0	265.6 $\pm$ 14.9	412.9 $\pm$ 13.2	118.1 $\pm$ 3.1
Significance	NS	*	NS	NS	NS	NS	**
Interaction between season and minerals supplementation:							
Winter							
Control	1870.0 $\pm$ 130.0	1120.0 $\pm$ 30.8	74.2 $\pm$ 4.3	295.4 $\pm$ 19.2	259.4 $\pm$ 19.0	369.7 $\pm$ 16.9	111.5 $\pm$ 4.0
CaO (100 mg)	2030.0 $\pm$ 145.3	1191.3 $\pm$ 31.6	69.4 $\pm$ 4.4	334.7 $\pm$ 19.6	287.1 $\pm$ 19.5	393.2 $\pm$ 17.3	103.2 $\pm$ 4.1
NaCl (150 mg)	1786.7 $\pm$ 146.2	1018.1 $\pm$ 31.3	75.0 $\pm$ 4.4	286.4 $\pm$ 19.5	199.2 $\pm$ 19.3	328.8 $\pm$ 17.1	129.1 $\pm$ 4.0
NaHCO <sub>2</sub> (200 mg)	1846.7 $\pm$ 88.8	1149.0 $\pm$ 30.9	54.9 $\pm$ 4.3	314.8 $\pm$ 19.2	252.4 $\pm$ 19.1	426.7 $\pm$ 16.9	99.3 $\pm$ 4.0
KHCO <sub>3</sub> (300 mg)	2410.0 $\pm$ 274.3	1217.9 $\pm$ 40.7	64.9 $\pm$ 5.7	320.2 $\pm$ 25.3	273.3 $\pm$ 19.1	379.6 $\pm$ 22.3	118.5 $\pm$ 5.2
Summer							
Control	1650.0 $\pm$ 76.4	1154.5 $\pm$ 33.4	64.0 $\pm$ 4.5	257.6 $\pm$ 20.7	252.6 $\pm$ 20.6	403.4 $\pm$ 18.3	122.8 $\pm$ 4.3
CaO (100 mg)	1726.7 $\pm$ 50.4	1133.9 $\pm$ 32.1	70.1 $\pm$ 4.5	286.2 $\pm$ 19.9	246.7 $\pm$ 19.8	400.8 $\pm$ 17.5	125.5 $\pm$ 4.1
NaCl (150 mg)	1953.3 $\pm$ 91.3	1152.0 $\pm$ 30.9	60.0 $\pm$ 4.3	246.1 $\pm$ 19.2	286.3 $\pm$ 19.1	424.0 $\pm$ 16.9	117.1 $\pm$ 4.0
NaHCO <sub>2</sub> (200 mg)	1923.3 $\pm$ 112.0	1181.6 $\pm$ 30.8	65.9 $\pm$ 4.3	263.5 $\pm$ 19.2	304.2 $\pm$ 19.0	420.9 $\pm$ 16.9	113.7 $\pm$ 4.0
KHCO <sub>3</sub> (300 mg)	1783.3 $\pm$ 60.7	1168.4 $\pm$ 31.4	68.4 $\pm$ 4.4	282.0 $\pm$ 19.5	257.9 $\pm$ 19.4	446.2 $\pm$ 17.2	117.6 $\pm$ 4.0
Significance	*	NS	*	NS	*	*	**

\*\* P<0.01, \* P<0.05 and NS= Not significant.

Analysis of covariance showed that pre-slaughter weight affected significantly (P<0.001) carcass and liver weights.

## CONCLUSIONS

It can be concluded that the most suitable supplements (/kg diet) in the present study were potassium bicarbonate (300 mg/kg diet) followed by calcium oxide (100 mg/kg diet) during winter and 150 mg sodium chloride, during summer, under the sub-tropical conditions of Egypt. At the same time, It can also be added that further studies are needed to define the actual growing rabbit requirements of the studied supplements, under the sub-tropical conditions.

## REFERENCES

- AOAC 1980. Official Methods of Analysis. 13th Edition. Association of Official Analytical Chemists, Washington, USA.
- Ayyat M.S. and Marai I.F.M. 1997. Effects of heat stress on growth, carcass traits and blood components of New Zealand White rabbits fed various dietary energy-fibre, under Egyptian conditions. *Journal of Arid Environments*, 37: 557-568.
- Cheeke, P.R. 1987. Rabbit feeding and nutrition. Academic Press, INC., Oriando, Florida, 32887.
- Duncan D.B. 1955. Multiple Range and Multiple F-test. *Biometrics*, 11: 1-42.
- Ensminger M.E. and Olentine C.G. 1978. Feeds and Nutrition-Complete. The Ensminger Publishing Co., Clovis C.A.

- Erdman R.A., Botts R.I., Hemken R.W. and Bull L.S. 1980. Effect of dietary sodium bicarbonate and magnesium oxide on production and physiology in early lactation. *Journal of Dairy Science*, 63: 923-928.
- Habeeb A.A., Marai I.F.M. and Kamal T.H. 1992. Heat stress. In *Farm Animals and Environment*, edited by C. Phillips and D. Piggins, C.A.B. International, U.K., pp 27-47.
- Habeeb A.A., Marai. I.F.M., El-Sayiad Gh.A. and Nessem M.Z. 1994. Effect of internal and external cooling techniques on growth and physiological functions of New Zealand White and Californian rabbits maintained under hot summer conditions of Egypt. *Proceedings of the First International Conference "Rabbit Production in Hot Climate"*, Egypt, edited by M. Basega and I.F.M. Marai, *Options Mediterraneennes*, 8 (Supplement): 626-633.
- Magliad M., Elhag G.A. and Saeed A. Hussien 1987. Influence of sodium bicarbonate supplementation on growth and blood components in dairy calves. *Indian Journal of Animal Sciences*, 27: 743-746.
- Marai I.F.M. 1998. Evaluation of the economic efficiency of rabbit production units or farms. *Egyptian Journal of Rabbit Science*, 8: 183-193.
- Marai I.F.M., Abd El-Kariem A.E.B. Zeidan A. and Selem T.S.T. 1998. Reproductive performance of heat-stressed low fertile male rabbits as affected by type of Gn-Rh injection. *International Conference on Animal Production and Health in Semi Arid Areas*.
- Marai I.F.M., Abd El-Samee A.M. and El-Gafarry M.N. 1990. Criteria of response and adaptation to high temperature for reproductive and growth traits in rabbits. 2<sup>nd</sup> Conference on Rabbit production and Genetics in the Mediterranean Area, Zagazig University, Zagazig, Egypt.
- Marai I.F.M., Ayyat M.S. and Abdel-Monem U.M. 2001. Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation under Egyptian conditions. *Tropical Animal Health and Production*, 33: 1-12.
- Marai I.F.M., Ayyat M.S., Gabr H.A., and Abdel-Monem U.M. 1999. Growth performance, some blood metabolites and carcass traits of New Zealand White broiler male rabbits as affected by heat stress and its alleviation, under Egyptian conditions. *Cahiers Options Mediterraneennes*, 41: 35-42.
- Marai I.F.M., El-Masry K.A. and Nasr A.S. 1994a. Heat stress and its amelioration with nutritional, buffering, hormonal and physical techniques for New Zealand White rabbits maintained under hot summer conditions of Egypt. *Cahiers Options Mediterraneennes*, 8 (Supplement): 475-487.
- Marai I.F.M. and Habeeb A.A.M. 1997. Managerial practices to ameliorate heat stress. *Proceedings of the international Conference on Animal Production and health*. Cairo, Egypt, pp 179-183.
- Marai I.F.M., Habeeb A.A.M., El-Sayiad Gh.A. and Nessem M.Z. 1994b. Growth performance and physiological response of New Zealand White and Californian rabbits under hot summer conditions of Egypt. *Cahiers Options Mediterraneennes*, 8 (Supplement): 619:625.
- Marai, I.F.M., Habeeb, A.A.M. and Gad, A.E. 2002. Rabbit's productive, reproductive and physiological traits as affected by heat stress (A Review). *Livestock Production Science* 78: 71 – 90.
- NRC 1977. National Research Council. *Nutrient Requirements of Rabbits*. 2<sup>nd</sup> Ed. Washington, D.C.
- Snedecor, G.W. and Cochran, G.W. 1982. *Statistical methods*. 6<sup>th</sup> Ed. The Iowa State University. Press Ames., USA.

*Submitted August 30, 2005 – Accepted July 13, 2006*  
*Revised received July 17, 2006*