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BLOOD METABOLITES, GROWTH AND REPRODUCTIVE PERFORMANCE AND IMMUNE RESPONSIVENESS IN GROWING AND DOE RABBITS AS AFFECTED BY ACITROL TREATMENTS

ISMAIL A.M., M.A ABOU-EL-ELLAA, AND A. A. SEDKI

Animal Production Research Institute, Agricultural Research Centre, Ministry of Agriculture, Dokki, Egypt.

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Abstract

Experiments with weanling and doe rabbits were conducted to determine the effect of acitrol supplementation on blood parameters, growth, reproductive performance and immune function. Both experiments were conducted in the same farm at the same time and treated with the same levels.

Experiment 1. Forty New-Zealand White rabbits about 5 weeks of age and 665 g average initial body weight were assigned to four experimental groups (ten rabbits each). Water was provided *ad libitum* and supplemented with different levels of acitrol as follows : 0 supplementation as control group (1), 0.5, 1.0 and 1.5 ml/L acitrol for groups 2, 3 and 4, respectively. Experiment 2. 32 New-Zealand White does were assigned to four experimental groups and treated as in growing rabbit trial for two parities.

Results showed that acitrol supplementation improved significantly ($P<0.05$) body weight, body gain and feed/gain ratio compared to the control or low level groups. Also, great improvements in both experiments were noticed for Ht, Hb, GOT, GPT, TP, Alb, Glob, Ca, Mg, Zn, Cu and lymphocytes type due to acitrol supplementation. A reduction was recorded in pH, P and K (in both trials) values in acitrol groups compared to control group. All the reproductive performance were improved due to acitrol treatments and the second parity showed a slight improvement in all parameters studied compared to first one.

It can be concluded that supplementation of acitrol showed a great role in enhancing the immune system, improved growth performance, blood metabolites and reproductive parameters due to the inclusion of Cu, Zn, and Mn in organic form besides presence of the other components like pantothenic acid and the other acids. From the economic point 1ml/L is recommended for both growing and does rabbits.

INTRODUCTION

Trace minerals generally defined as those required at relatively low concentration in living tissues, but it is widely accepted that the trace elements now considered to be essential or beneficial to mammalian and avian species. Therefore, the breeders used to supplement the animal diets with trace elements in a traditional way through the use of inorganic salts. However, since a host of intrinsic and extrinsic factors is known to affect the bio-availability of dietary inorganic trace elements, continuous efforts have

been made over the years to improve their utilization by humans and animals. It is now well established that metal chelates of, for example, Cu, Zn and Mn with amino acids and peptides can enhance the bio-availability of these trace elements and possibly exhibit greater metabolic activity, thereby leading to less nutrient excretion, improvements and better responses in performance parameters such as growth, reproduction, immune system and general health status, especially when they are unavailable in sufficient amounts to meet animal needs (Power and Horgan, 2000).

Research in mineral metabolism has shown that the uptake of trace elements can be improved by binding them to organic ligands. The amount of essential micronutrients absorbed across the gut wall largely determines the effectiveness of nutrient supplementation.

Trace elements occur naturally in most ingredients. However, the amount and bio-availability varies considerably due to 1) their existence as parts of complex molecules which are not fully broken down during digestion; and 2) the degree to which minerals are absorbed from the small intestine and hence, available at the cell level (Smits and Henman, 2000). During digestion, the mineral ions are released and can recombine with other digesta components in the intestine to form insoluble compounds, thereby, reducing their absorption across the small intestine.

By complexing the element with an organic molecule of amino acids or peptides, the bioplex mineral, or proteinate , is prevented from breaking down into reactive ions during digestion. The mode of uptake across the intestine is altered as the chelated mineral is transported via amino acid uptake pathways rather competing for ion transport pathways (Close, 1998).

Today there are many such forms of metal complexes available in the market place for use in animal nutrition and can enhance growth performance and reproduction in spite of lower inclusion rates of copper, zinc and Mn,....etc, compared to inorganic form.

It has been generally accepted that nutrients in animals and poultry manure should be used to fertilize cropland. The application of manure should be restricted to the amount of nutrients taken by the crops. Most attention has been paid to macronutrients such as nitrogen, P and K, but it is useful to be aware of the agronomic rates of the micronutrients including zinc and copper to avoid the toxicity of soil by these metals and keep our land and environment clean, subsequently will have a healthy cropland (Carlson, 2000).

The objective of the present trial was therefore to establish whether a special supplement of organic minerals and some other nutrients provided in addition to the normal inorganic sources of minerals in the diet of growing and doe rabbits will improve

their performance, reproduction and immune parameters or not, and if decreasing the inclusion rate of these elements in the diet subsequently will decrease elements in the excretion, so we can keep our environments and lands clean from the toxicity.

This special supplement contains some organic minerals, enzymes and acids manufactured by Agrarian Marketing Corporation (Middlebury, IN, USA) and was called "Acitrol". The ingredients of acitrol are shown in Table 1.

Table 1. The ingredients of acitrol.

Ingredients (per 1000 ml)	
Copper Proteinate (0.65% Copper)	70 ml
Manganese Proteinate (0.03% Manganese)	20 ml
Zinc Proteinate (0.09% Zinc)	40 ml
Calcium lactate	15 ml
Protease	125ml
Amylase	125 ml
Mono-Saccharides	80 g
Papain	20 g
Calcium pantothenate	2 g
Sodium potassium tartrate	20 g
Citric acid	25 ml
Lactic acid	20 ml
Aspartic acid	14 ml
Hydrochloric acid	4 ml
Propylene glycol	120 ml
Acetic acid	200 ml
Distilled water up to 1000 ml	

MATERIALS AND METHODS

Experiment 1. Forty New-Zealand White rabbits about 5 weeks of age and 665 g average initial body weight were assigned to four experimental groups. Ten rabbits were randomly placed in individual wire cages for each treatment. Rabbits were fed a commercial diet containing 17% CP and 2700 Kcal DE (Table 2). Water was supplemented with different levels of acitrol as follows: 0 supplementation as control group (1), 0.5, 1.0 and 1.5 ml acitrol/L for groups 2, 3 and 4 respectively. Feed and water were available *ad libitum*.

Table 2. The ingredients and chemical composition of the pellted diet.

Items	%
Ingredients	
Wheat bran	35.00
Alfalfa meal (14%)	33.60
Yellow corn	10.50
Soybean meal (44%)	15.77
Molasses	2.60
Bone meal	1.40
Limestone	0.30
Salt	0.40
Vitamins &minerals premix*	0.30
DL- Methionine	0.11
L- Lysine	0.02
Total	100.00
Calculated analysis	
Digestible energy (DE),kcal/kg	2721
Crude protein (CP), %	17.12
Crude fiber (CF), %	13.30
Calcium (Ca), %	1.13
Phosphorus (Ph), %	0.82
L-Lysine, %	1.00

*Vitamins and minerals premix per kilogram contain:

Vit. A, 6000 IU; Vit. D, 900 IU; Vit. E, 40 mg; Vit. K3, 2 mg; Vit. B1, 2 mg; Vit. B2, 4 mg; Vit. B6, 2 mg; Vit. B12, 10 mcg; Nicotinic acid, 50 mg; Biotin, 50 mcg; Folic acid, 10 mg; Choline chloride, 250 mg; Zinc, 50 mg; Manganese, 85 mg; Iorn, 50 mg; Copper, 5 mg; Iodine, 0.2 mg; Selenium, 0.1 mg; Cobalt, 0.1 mg.

Body weight and feed intake were recorded biweekly, body gain and feed conversion were calculated. Blood samples were taken for determination of hemoglobin concentration, hematocrit, pH, albumin and total protein by the colorimetric methods according to Merck (1974), glutamic oxaloacetic transaminase (GOT) and pyruvic transaminase activity (GPT) by kits from Bio Merieux, and white blood cells differential were done according to Hawkey and Dennett (1989). Carcass traits have been recorded for four rabbits from each group.

Plasma minerals concentration were determined by using kits from Pointe Scientific INC, Michigan, USA and measured according to spectrophotometrically technique.

Experiment 2. Thirty- tow New-Zealand White does were assigned to four experimental groups treated with the same levels of acitrol as in growing trial. The same blood parameters were determined by mid pregnancy in two parities as in growing trial. Litter size and weight at birth and at weaning, mortality rate and milk yield were recorded for two parity either.

Statistical analysis was conducted by analysis of variance using SAS package (1995). The means and standard error of all parameters were estimated and Tukey's test was used to detect significant differences among means of the experimental groups.

RESULTS AND DISCUSSION

The average final body weight, total body weight gain, and feed intake and feed/gain ratio (F/G ratio) are shown in Table 3. There was a significant increase in live body weight in treated groups especially with the two high levels compared to control group or low level with no significant changes between the two high levels or between the other two groups. The best results were recorded with 1 ml/L acitrol (group 3) followed by 1.5 ml/L (group 4), where 1 ml/L (group 3) gave the highest body weight and body gain and the best F/G ratio. Body gain and F/G ratio were improved by 30, 18% and 23, 15.2% in group 3 compared to control and low level groups, respectively.

Improvement of the growth performance as a result of acitrol supplementation of growing rabbits, can be attributed mainly to the increase of animals resistance to pathogens and any physiological and/or environmental stress. Also, to the increase of the bio-availability of some organic minerals in this compound and the other component which have a great effects on growth, improving the animal health and increasing the responsiveness of immune system besides the other functions (numerous) that can affect in some way or another growth performance.

Looking to Table 4, we can notice that the acitrol high doses groups showed a small increase in dressing % compared to control or low dose groups, where the dress-

ing % increased by about 2%. Also, there were no appreciable differences in the other parameters taken as a percentage like spleen, liver and kidney .

Quick look to the ingredients of Acitrol we can found the copper, manganese and zinc in an organic form (proteinate) and those three minerals and their roles in improving growth performance are established and well known as a growth enhancer in inorganic form. Recent studies suggest that organic sources of minerals in general and Cu, Zn and Mg in particular may be more effective in promoting growth by about 5% in daily feed intake and growth rate when compared to inorganic form given at the same rate (Close, 1999). Work in rats has also shown a considerably higher utilization of Cu from organic sources compared with copper sulfate, resulting in significant higher levels in body tissue and blood plasma (Table 5), cell mitogenic activity is also increased and this leads to higher hormonal and therefore metabolic status, resulting in improved performance. Beneficial effect of copper can be attributed to improved fiber utilization which would increase energy availability, reducing the wall thickness of caecum (Anugwa. *et al.*, 1980), by its antimicrobial action in the gut, had a role in metabolism and absorption of iron and haemoglobin biosynthesis (Table 5), and red blood cell maturation, enhances growth through a wide variety of biological systemic functions related to growth. Back to zinc proteinate, we know that Zn is a component of many metabolic functions and plays a vital role in hormone secretion, especially, those relating to growth, reproduction and immune system, where zinc has a positive effect on both the immune response to pathogens and the prevention of disease by maintaining healthy epithelial tissue.

In a study, providing 250 ppm of zinc methionine or 160 zinc sulphate gave equal performance to 2000 ppm of zinc oxide, this may also have environmental implications. Since less zinc will be excreted with the lower level of the organic zinc included in the diet. Close (1999). Zinc is required as a component of over 300 enzymes in different species of all phyla (Vallee and Falchuk, 1993). These include carbonic anhydrase, alcohol dehydrogenase and alkaline phosphatase. In its association with enzymes, zinc plays an active role in most major metabolic pathways and having significant effects on the reduction, secretion and interactions of hormone especially, steroid and peptide which of course may offer an explanation for some of the well documented effects of zinc deficiency such as growth retardation, impaired reproductive development function, aberrant water and cation balance and parakeratosis. Also, zinc performs unique structural functions at a nucleic acid level and protein synthesis.

Actually, the mode of action behind feeding Zn in stimulating growth is unknown and it would appear to be similar to that of feeding copper, where Carlson *et al.* (1998) reported that feeding 300 ppm Zn as zinc oxide altered duodenal morphology (deeper crypts and greater total thickness) and increased intestinal metallothionein concentration which indicates that high amounts of zinc have an enteric effect on the

nursery animals.

The third mineral in this study (manganese proteinate) like other essential trace elements can function both as an enzyme activator and as a constituent of metalloenzymes. Mn containing enzymes includes arginase, pyruvate carboxylase and Mn-supper oxide dismutase. Although the number of Mn-metalloenzymes is limited, a large number of enzymes can be activated by Mn. These include hydrolases, kinases, decarboxylases and transferases. Mn is a vital element for correct bone growth protein, carbohydrate and lipid metabolism, immune and nervous system function and reproduction (Power and Horgan, 2000). For all these reasons, the growth and other parameters of performance like total body gain, feed intake and feed gain ratio should be improved as what reported in this study regardless of the other improvement in mineral profile, blood and immunity indicators parameters where there is no way to ignore the great role and effects of this compound on these parameters . Also, it is not easy to ignore the rest of the acitrol components which have a biological effect on growth and immunity responsiveness (like pantothenic acid which is a constituent of coenzyme A) that regulates the metabolism of proteins, CHO and fats, where it plays a central role in the synthesis and degradation of fats. Pantothenic acid is indispensable for normal functioning of the skin and mucosa, for pigmentation of the hair and for resistance to infections (Mcdowell, 1989).

One of the most important functions of coenzyme A is to act as a carrier mechanism for carboxylic acid reactions. The most important of these reactions is the combination of coenzyme A with acetate to form "active acetate". In the form of active acetate, acetic acid can also combine with choline to form acetylcholine, the chemical transmitter at the nerve synapse and can be used for detoxification of drugs including sulfonomides. Also, succinic acid resulting from decarboxylation of ketoglutaric acid in the citric acid cycle can be converted to the "active" form by linkage with coenzyme A. This active succinate and glycine are together involved in the first step of heme biosynthesis. This fact can explain and present another interpretation for increasing the haemoglobin value and hematocrit % in treated groups, besides the roles of minerals especially, the "Cu". Pantothenic acid also stimulates synthesis of antibodies, which increase resistance of animals to pathogens. It appears that when pantothenic acid is deficient, the incorporation of amino acids into blood albumin fraction is inhibited which would explain why there is a reduction in the titer of antibodies (Mcdowell, 1989). This theory simply explains our results where, the treated groups recorded a significant increase in total protein, albumin and globulin. Also, it is easy to notice the great increase in albumin compared to globulin increase, and this was so clear with the high doses of acitrol. Also, the improvements in growth can be attributed to the presence of protease, amylase, papain enzymes which have effect on CHO and protein digestion and increase the digestion coefficient, subsequently, increase and improvements in ab-

sorption and utilization; this improvement is reflected on animal health, growth and disease resistance. Also, there was a lot of growth promoters inclusion of acitrol like, Mono-saccharides, propylene glycol, citric, aspartic, hydrochloric, lactic and acitic acids, where all these factors are well documented as growth promoters through their effects on increasing the activity of metabolic cycles (citric acid cycle for example), microbial fermentation and reducing the cecal pH, subsequently, reduction of the pathogenic load encountered by the animal under farm conditions (Parks *et al.*, 2000) and prohibiting the growth of certain intestinal microbes (pathogenic) by increasing the acidity due to the fermentation of mono-saccharides that (produce volatile fatty acids "VFAs") and the other acid (lactic.....etc.) present in the compound. Presence of these acids explains the lower pH recorded in treated groups especially with the high level of acitrol.

The beneficial effects of acitrol on animal performance, feed utilization and health status can be detected also or it had been reflected on blood parameters.(Underwood, 1981]).The role of pantothenic acid in heme biosynthesis and its role in increasing the total protein, albumin (especially with high doses), globulin and the number of lymphocyte (indicator of immunity response) is recorded in all treated groups compared to control or low dose groups. The lymphocytes are considered the main or limiting type of white blood cells and can be taken as a good indicator of increase in the immunity efficiency.

In spite of increase in GOT and GPT activities in acitrol high doses groups compared to other groups, this increase, within normal range and with no symptoms of toxicosis was observed. This increase can be attributed to the inclusions of acitrol to a lot of factors which can affect liver activity.

Table 3 . Means ± SE for final body weight (FBW), total feed intake (TFI), total body gain (TBG), and feed gain ratio (F/G ratio).

Treatment	FBW g	TFI g	TBG g	F/G ratio
1	1425.00[a]	3105	760.00[b]	4.09
	±37.92	±89.53	±37.35	
2	1465.00[a]	3157	800.00[b]	3.95
	±39.96	±97.95	±39.22	
3	1650.00[b]	3290	983.00[a]	3.35
	±35.91	±87.11	±35.16	
4	1646.00[b]	3318	981.00[a]	3.38
	±35.91	±76.34	±35.16	

[a, b] means in the same column with different superscripts are significantly different ($P<0.05$).

Table 4. Means and percentages for carcass traits as affected by acitrol levels.

Treatment		Live weigh	Dressing	Liver	Spleen	Kidneys
1	g	1382.50[b]	786.50[b]	57.25[b]	1.23	17.88[b]
		±13.66	±9.73	±0.66	±0.11	±0.27
	%	-	56.89	4.74	0.1	1.48
2	g	1447.50[b]	814.94[b]	57.75[b]	1.26	17.93[b]
		±13.66	±9.73	±0.66	±0.11	±0.27
	%	-	56.3	4.7	0.1	1.46
3	G	1635.0[a]	960.00[a]	65.50[a]	1.49	22.08[a]
		±13.66	±9.73	±0.66	±0.11	±0.27
	%	-	58.72	4.66	0.11	1.57
4	G	1637.50[a]	951.88[a]	69.50[a]	1.5	21.73[a]
		±13.66	±9.73	±0.66	±0.11	±0.27
	%	-	58.13	4.92	0.11	1.54

The changes in mineral concentration of blood plasma were so great and showed a big contradiction due to acitrol treatments. For example, there was significant increase in Ca, Na, Mg, Zn and Cu levels in treated groups with no significant differences either between the low and the control groups or between the two high doses groups (Table 5). Meanwhile, the P and K significantly decreased in high doses groups compared to the other two groups, with no significant difference between them. Actually, most of plasma minerals especially Ca level in rabbits are not regulated homostatically as in other species, but, varies in direct proportion to dietary Ca level, and the absorption rate of Ca is not regulated to meet the metabolic need for Ca (Cheeke, 1987). The same trend was observed as in Ca level, where the other minerals were increased in direct proportion to acitrol supplementation. This responses were so clear with the high doses of acitrol. Also, the effect of organic form of the three minerals included in acitrol can be touch. The Ca/P ratio did not differ too much when compared to Na/K ratio where the Ca/P ratio ranged between 2.60 in both control and low dose groups to 3.55 and 3.80 in the two high dose groups, respectively, due to acitrol treatments. The Na/K ratio ranged between 22.16 and 23.45 in control and low doses groups, respectively, to 35.34 and 36.30 in the two high levels groups, respectively. It seems that Na/K fluctuated dramatically more than any of other two ion like Ca and P (Table 5continued).

Experiment 2. Concerning the blood parameters taken through the mid pregnancy in does rabbits, we can notice that all parameters followed the same pattern and trend as in growing rabbits with a little bit exception. The following parameters were in the same trend but a little bit higher or equal in doe rabbits compared with growing rabbits, pH, Ht, Ca, Mg, Zn, GOT, GPT, Alb, Cu, Hb and the white blood cells differential (Tables 5 and 7) and (Tables 6 and 8). On the contrary, the globulin and P were low in does rabbits compared to growing rabbits values. Looking to the Na and K values, it was noticed that there was no trend, where, Na was higher in does with low level and control groups compared to growing rabbits, but, with the high doses, Na was higher in growing rabbits than does rabbits, while, the K values were on the contrary to Na values. Subsequently, the Na/K followed the Na trend, where it increased with the increasing of Na. Ca/P ratio was higher in doe rabbits than the growing rabbits due to higher Ca and low P in does rabbits as mentioned before. The Alb/Glob ratio, was the best ratio as a good indicator for increasing the immunoglobulin, subsequently, the immunity responsiveness was recorded with growing rabbits compared to female rabbits with all levels of acitrol. We got excellent results with one dose of the three doses used in this study with doe rabbits. These results were 1.03 with 1ml/L acitrol. GOT/GPT ratio was a little bit higher in doe rabbits or almost equal to growing rabbits. As mentioned before, the effect of acitrol levels exactly showed the same effect and result in doe rabbits as in growing rabbits. So, we can recommend the 1ml/L level as we recommend this dose in growing rabbits. It could be easy to ignore the effect of parity on blood pa-

rameters only, where there is no significant effect between the two parities. However, it was noticed that the most of the blood parameters studied were increased in the 2nd parity except TP, Glob and K which were decreased compared to the 1st parity, and the A/G ratio got worst compared to the 1st parity. The reproductive parameters as affected by acitrol levels and parity are shown in Table 9. There was an increase in litter size and litter weight at birth and at weaning due to acitrol treatments and parity. The level of 1ml acitrol/L and the 2nd parity were the best in all parameters studied except the litter weight at weaning, where the high dose 1.5ml acitrol/L recorded the best results, also, the 1st parity preceded the second parity (Table 9). These results could be attributed to the increase of the litter size at weaning (best record 5.50) with 1ml level vs. 4.56 with 1.5 ml level and (4.50 vs. 4.10) in second and first parities, respectively. As we know, there was a negative correlation between litter size and individual body weight either at birth or at weaning. The differences between the tow high levels and the two parities were not significant.

The milk yield increased gradually according to the increase of the acitrol level, where, the high doses 1.5 ml gave the best yield compared to all other treatments with significant differences to control (250 g more than the control yield), and with no significant differences to other levels. The second parity was in advance, where, the milk yield increased by about 100 g compared to 1st parity. Any improvement in the second parity in any parameter could be attributed to the accumulation effect of the acitrol's components which had direct effect on reproduction like Zn, Cu, Mn, propylene glycol, and the acids which could affect indirectly through there effect on the pH of the genital tract.

Table 5. Means ± SE for blood parameters in growing rabbits as affected by acitrol levels.

Treatment	Blood Parameters[1]									
	Ht %	Hb g/dl	TP g/100ml	Alb g/100ml	Glb g/100ml	Alb/Glb ratio	pH	GOT µ/dl	GPT µ/dl	GOT/GPT ratio
1	30.00^{c} ±0.82	10.6^{b} ±0.95	5.87^{a} ±0.08	2.95^{a} ±0.06	2.92^{a} ±0.05	1.01	7.51 ±0.20	22.99^{a} ±0.36	15.40^{a} ±0.28	1.49
2	33.50^{b} ±0.82	11.68^{b} ±0.95	5.85^{a} ±0.08	2.89^{a} ±0.06	2.96^{a} ±0.05	0.98	7.58 ±0.20	21.74^{a} ±0.36	15.10^{a} ±0.28	1.44
3	39.00^{a} ±0.82	16.00^{a} ±0.95	6.60^{b} ±0.08	3.39^{b} ±0.06	3.21^{b} ±0.05	1.06	7.3 ±0.20	30.72^{b} ±0.36	21.04^{b} ±0.28	1.46
4	38.75^{a} ±0.82	16.30^{a} ±0.95	6.66^{b} ±0.08	3.43^{b} ±0.06	3.23^{b} ±0.05	1.06	7.33 ±0.20	30.98^{b} ±0.36	21.33^{b} ±0.28	1.45

Table 5. Continued.

Treatment	Blood Parameters								
	Ca mg/dl	P mg/dl	Ca/P Ratio	Na ppm	K ppm	Na/K Ratio	Mg mg/dl	Zn mg/dl	Cu ppm
1	15.70^{a} ±0.21	6.09^{b} ±0.05	2.58	141.19^{b} ±13.20	6.37^{a} ±0.07	22.16	5.07^{b} ±0.09	73.81^{b} ±0.53	31.01^{b} ±1.41
2	16.35^{a} ±0.21	6.29^{b} ±0.05	2.6	143.98^{b} ±13.20	6.14^{a} ±0.07	23.45	5.25^{b} ±0.09	74.44^{b} ±0.53	31.16^{b} ±1.41
3	19.20^{b} ±0.21	5.41^{a} ±0.05	3.55	180.95^{a} ±13.20	5.12^{b} ±0.07	35.34	6.61^{a} ±0.09	79.66^{a} ±0.53	35.38^{a} ±1.41
4	19.32^{b} ±0.21	5.08^{a} ±0.05	3.8	186.94^{a} ±13.20	5.15^{b} ±0.07	36.3	6.37^{a} ±0.09	79.61^{a} ±0.53	35.48^{a} ±1.41

[1]Ht, hematocrit value; Hb, hemoglobuin concentration; TP, total protein; Alb, albumin; Glb, globulin; U-N, urea-N; GOT, glutamic oxaloacetic transaminase; GPT, glutamic pyruvic transaminase; Chol., cholesterol; Alk. Phos., alkaline phosphatase.

$^{a, b, c}$ means in the same column with different superscripts are significantly different ($P<0.05$).

Table 6. Means ± SE for white blood cell's differential in growing rabbits as affected by acitrol levels.

Treatment	White Blood Cells[1]				
	Lym %	Neut %	Mono %	Baso %	Eosino %
1	56.00^{b} ±0.91	38.75^{a} ±1.10	2.75^{b} ±0.22	1.50^{a} ±0.20	0.75^{b} ±0.11
2	55.25^{b} ±0.91	38.00^{a} ±1.10	3.75^{a} ±0.22	1.75^{a} ±0.20	1.50^{a} ±0.11
3	64.75^{a} ±0.91	29.75^{b} ±1.10	2.50^{b} ±0.22	1.50^{a} ±0.20	1.50^{a} ±0.11
4	64.00^{a} ±0.91	30.00^{b} ±1.10	3.25^{c} ±0.22	1.00^{b} ±0.20	1.75^{a} ±0.11

[1]Lym, lymphocytes; Neut, neutrophils; Mono, monocytes; Baso, Basophils; Eosino, Eosinophils.

$^{a, b}$ means in the same column with different superscripts are significantly different ($P<0.05$).

About the mortality, the acitrol treatments recorded 0% stillbirths, while, the control group recorded almost 7.83%; most of these percentages (double) were recorded in the 2nd parity. Total mortality was decreased to 50% in acitrol treatments from the control value, and the best results were obtained with the high doses; this can be attributed to the acitrol's components which had a great effect on immune system and improved it. Besides that, the great role of propylene glycol on decreasing mortality rate and its positive effect on weight and body gain was so clear and the most improvements in reproduction could be due partially to propylene glycol as reported in other studies concerning about its effect on rabbit reproduction (Luzi *et al.*, 2000). Also, there was an effect on mortality rate due to parity, where total mortality was decreased by about 3% in the 2nd parity compared to the 1st parity regardless of the acitrol treatments.

Finally, the benefits of including trace minerals at the level required by the animal and in the most readily absorbed form, are valuable in increasing performance with lower inclusion rate, better health and welfare. In this respect, organic minerals would play an important role in animal and poultry nutrition, not only for meeting the true requirements of the animal for optimal performance with lower iclusion rate, but also for providing healthy meat for the consumer and harmless manure for the cropland, subsequently, would have a pure and clean or at least not harmful crops and free environments of pollution.

Table 7 . Blood parameters in doe rabbits as affected by acitrol levels and parity.

Parameters[1]	Parity	Treatments				
		1	2	3	4	Overall
pH	1st	7.53±0.20	7.58±0.20	7.37±0.20	7.37±0.20	7.46
	2nd	7.56±0.20	7.55±0.20	7.41±0.20	7.46±0.20	7.5
	Overall	7.55	7.57	7.39	7.42	
Ht	1st	32.25±0.82	35.00±0.8	40.50±0.8	39.75±0.8	36.88
	2nd	30.00±0.82	35.75±0.8	41.25±0.8	39.75±0.8	36.69
	Overall	31.33^{c}	35.38^{b}	40.88^{a}	39.75^{a}	
Hb	1st	10.78±0.95	12.05±0.9	15.30±0.9	16.75±0.9	13.72
	2nd	10.93±0.95	13.23±0.9	16.18±0.9	15.50±0.9	13.96
	Overall	16.86^{b}	12.64^{b}	15.74^{a}	16.13^{a}	
GPT	1st	15.98±0.28	17.38±0.2	21.25±0.2	22.11±0.8	19.18
	2nd	14.67±0.28	16.85±0.2	22.98±0.2	22.55±0.2	19.26
	Overall	15.33^{b}	17.12^{b}	22.12^{a}	22.33^{a}	
GOT	1st	23.80±0.36	24.57±0.3	32.59±0.3	32.23±0.3	28.3
	2nd	24.39±0.36	24.80±0.3	32.03±0.3	32.95±0.3	28.54
	Overall	24.10^{b}	24.69^{b}	32.31^{a}	32.59^{a}	
GOT/GPT	1st	1.49	1.41	1.53	1.46	1.48
	2nd	1.66	1.47	1.39	1.46	1.48
	Overall	1.57	1.44	1.46	1.46	
Alb (A)	1st	3.07±0.06	2.93±0.06	3.52±0.06	3.52±0.06	3.26
	2nd	3.33±0.06	4.28±0.06	3.27±0.06	3.28±0.06	3.68
	Overall	3.20^{b}	3.61^{a}	3.40^{ab}	3.67^{a}	
Glob (G)	1st	2.88±0.05	3.21±0.05	3.28±0.05	3.31±0.05	3.17
	2nd	2.57±0.05	2.14±0.05	3.32±0.05	2.72±0.05	2.68
	Overall	2.73^{b}	2.68^{b}	3.30^{a}	3.02^{a}	
A/G ratio	1st	1.06	0.91	1.07	1.06	1.03
	2nd	1.3	2	0.99	1.4	1.37
	Overall	1.18	1.46	1.03	1.23	
TP	1st	5.95±0.08	6.14±0.08	6.80±0.08	6.83±0.08	6.43
	2nd	5.90±0.08	6.24±0.08	6.59±0.08	5.64±0.08	6.36
	Overall	5.93^{b}	6.28^{ab}	6.70^{a}	6.69^{a}	

[1] Ht, hematocrit value; Hb, hemoglobuin concentration; TP, total protein; Alb, albumin; Glb, globulin; U-N, urea-N; GOT, glutamic oxaloacetic transaminase; GPT, glutamic pyruvic transaminase; Chol., cholesterol; Alk. Phos., alkaline phosphatase.

[a, b] Means in the same column with different superscripts are significantly different (P<0.05).

Table 7 . Continued.

Parameters	Parity	Treatments				
		1	2	3	4	Overall
	1st	15.81±0.21	17.12±0.21	19.89±0.21	19.50±0.21	18.08
Ca	2nd	16.41±0.21	18.13±0.21	21.30±0.21	20.32±0.21	19.04
	Overall	16.11[b]	17.63[b]	20.60[a]	19.91[a]	
	1st	6.13±0.05	6.24±0.05	5.16±0.05	4.87±0.05	5.6
P	2nd	6.18±0.05	6.02±0.05	5.00±0.05	4.75±0.05	5.49
	Overall	6.16[a]	6.13[a]	5.08[b]	4.81[b]	
	1st	2.58	2.74	3.75	4	3.23
Ca/P ratio	2nd	2.66	3.01	4.26	4.28	3.47
	Overall	2.62	2.88	4.06	4.14	
	1st	145.86±13.2	151.20±13.	183.58±13.	185.80±13.	166.61
Na	2nd	153.54±13.2	165.83±13.	176.06±13.	179.95±13.	168.85
	Overall	149.70[b]	158.52[b]	179.82[a]	182.88[a]	
	1st	6.37±0.07	5.84±0.07	5.26±0.07	5.30±0.07	5.69
K	2nd	6.03±0.07	5.68±0.07	5.20±0.07	5.39±0.07	5.58
	Overall	6.20[a]	5.76[a]	5.23[b]	5.35[b]	
	1st	22.9	25.89	34.9	35.06	29.28
Na/K ratio	2nd	25.46	29.2	33.86	33.39	30.26
	Overall	24.15	27.52	34.38	34.18	
	1st	5.12±0.09	5.66±0.09	6.49±0.09	6.86±0.09	6.03
Mg	2nd	5.22±0.09	5.66±0.09	6.58±0.09	6.78±0.09	6.06
	Overall	5.17[b]	5.66[b]	6.54[a]	6.82[a]	
	1st	75.63±0.93	78.60±0.93	83.94±0.93	82.95±0.93	80.28
Zn	2nd	76.91±0.93	78.83±0.93	84.55±0.93	82.95±0.93	80.81
	Overall	76.27[b]	78.72[b]	84.25[a]	82.95[a]	
	1st	31.71±1.41	34.20±1.41	36.65±1.41	35.80±1.41	34.59
Cu	2nd	32.57±1.41	34.95±1.41	36.48±1.41	36.42±1.41	35.1
	Overall	32.14[c]	34.58[b]	36.57[a]	36.11[a]	

[a, b] Means in the same column with different superscripts are significantly different ($P<0.05$).

Table 8 . White blood cell's differential in doe rabbits as affected by acitrol levels and parity.

Parameters	Parity	Treatments				
		1	2	3	4	Overall
Lymphocytes	1st	55.50±0.91	65.00±0.9	65.25±0.9	64.00±0.9	60.19
	2nd	55.50±0.91	58.00±0.9	65.75±0.9	63.50±0.9	60.69
	Overall	55.50^{b}	57.00^{b}	65.50^{a}	63.75^{a}	
Neutrophils	1st	38.75±1.10	37.00±1.1	29.50±1.1	29.75±1.1	33.75
	2nd	37.75±1.10	35.25±1.1	30.75±1.1	30.50±1.1	33.56
	Overall	38.25^{a}	36.13^{a}	30.13^{b}	30.13^{b}	
Monocytes	1st	3.00±0.22	3.75±0.22	2.50±0.22	3.25±0.22	3.13
	2nd	4.00±0.22	3.00±0.22	3.00±0.22	3.00±0.22	3.25
	Overall	3.50^{a}	3.38^{a}	2.75^{b}	3.13^{a}	
Basophils	1st	1.50±0.20	1.75±0.20	1.50±0.20	1.75±0.20	1.63
	2nd	1.50±0.20	2.00±0.20	0.50±0.20	1.50±0.20	1.38
	Overall	1.50^{b}	1.88^{a}	1.00^{c}	1.63^{ab}	
Eosinophils	1st	1.00±0.11	1.75±0.11	1.50±0.11	1.25±0.11	1.38
	2nd	1.25±0.11	1.75±0.11	0.75±0.11	1.25±0.11	1.25
	Overall	1.13^{b}	1.75^{a}	1.13^{b}	1.25^{b}	

$^{a, b}$ Means in the same column with different superscripts are significantly different ($P<0.05$).

Table 9 . Reproductive performance in two parities as affected by acitrol levels and parity.

Parameters	Parity	Treatment				
		1	2	3	4	Overall
Litter size at birth	1st	4.63±0.40	4.75±0.40	6.75±0.50	5.38±0.20	5.38
	2nd	4.88±0.50	5.38±0.40	6.75±0.50	5.75±0.40	5.69
	Overall	4.76^{c}	5.07^{bc}	6.75^{a}	5.57^{b}	
Av. litter weight at birth	1st	46.18±2.30	56.58±3.10	57.78±3.11	60.23±1.76	55.19
	2nd	50.77±1.89	58.60±3.30	60.93±2.92	54.13±2.10	57.36
	Overall	48.48^{b}	57.59^{a}	59.36^{a}	59.68^{a}	
Av. litter size at weaning	1st	2.88±0.20	3.75±0.30	5.25±0.40	4.50±0.40	4.1
	2nd	3.25±0.40	4.38±0.40	5.75±0.50	4.63±0.50	4.5
	Overall	3.07^{c}	4.07^{b}	5.50^{a}	4.56^{b}	
Av. litter weight at weaning	1st	335.22±7.60	385.00±5.51	390.48±8.11	402.22±10.1	378.23
	2nd	336.92±5.40	391.43±6.76	383.04±7.13	394.60±8.73	376.5
	Overall	336.07^{b}	388.22^{a}	386.76^{a}	398.41^{a}	
		No. **%**	**No.** **%**	**No.** **%**	**No.** **%**	**No.** **%**
Still birth	1st	2 5.4	0 0	,0 0	0 0	0.5 1.35
	2nd	4 10.26	0 0	0 0	0 0	1 2.57
	Overall	3 7.83	0 0	0 0	0 0	
		No. **%**	**No.** **%**	**No.** **%**	**No.** **%**	**No.** **%**
Total Mortality	1st	14 37.84	8 21.05	12 22.22	7 16.28	10.25 24.35
	2nd	13 33.33	8 18.6	8 14.81	9 14.57	9.5 21.58
	Overall	13.5 35.59	8 19.83	10 18.52	8 17.93	
Milk yield	1st	1741.25±20.60	2030.00±19.80	2012.50±20.19	2056.00±26.20	1960
	2nd	1925.00±17.90	2073.75±27.30	2108.75±23.40	2108.75±29.20	2054.06
	Overall	1833.10^{b}	2051.84^{a}	2060.66^{a}	2082.50^{a}	

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مظاهر النمو والأداء التناسلى والإستجابات المناعية فى الأرانب النامية والإناث البالغة نتيجة المعاملة بمركب الأسيترول

أحمد اسماعيل – مختار أحمد أبو العلا – عبد المنعم صدقى

معهد بحوث الإنتاج الحيوانى – مركز البحوث الزراعية – وزارة الزراعة– الدقى – مصر

أُجْريت تجربتان على الأرانب النامية والإناث البالغة لتحديد أثر المعاملة بمركب الأسيترول على مكونات الدم ومظاهر النمو والأداء التناسلى وكذلك مدى الإستجابة الوظيفية للجهاز المناعى.

تجربة ١ : تم إستخدام ٤٠ أرنبا من نوع نيوزيلندى أبيضا عمر ٥ أسابيع ومتوسط وزن ٦٦٥ جم حيث قسمت على ٤ مجاميع تجريبية. تم إضافة ٤ مستويات من الأسيترول إلى المياه كالتالى (مستوى صفر "كنترول" و ٠,٥و ١و ١,٥ مل/لتر مياه للمجاميع ١، ٢، ٣، ٤ على الترتيب).

تجربة ٢ : تم إستخدام ٣٢ أنثى بالغة عُوملت بنفس المعاملات السابقة وبنفس المستوى وذلك لمدة حَمْلين متتاليين.

أظهرت النتائج ما يلى :

١. تحسن وزن الجسم والزيادات المكتسبة فى الوزن و كذلك معدل التحويل الغذائى نتيجة المعاملة بالأسيترول وكانت المستويات العالية هى المؤثرة عن المستوى المنخفض.

٢. تحسنت القيم التالية فى كلتا التجربتين لكل من الهيماتوكريت، الهيموجلوبين، البروتين الكلى، الألبيومين، الجلوبيولين، الكالسيوم، الماغنسيوم، الزنك، النحاس وكذلك أنزيمات الكبد وخلايا كرات الدم البيضاء (ليمفوثايتس) نتيجة المعاملة بمركب الأسيترول.

٣. لوحظ إنخفاض قيم الفوسفور والبوتاسيوم وكذلك درجة الحموضة (*pH*) فى المجاميع المعاملة فى كل من التجربتين.

٤. تحسنت كل مظاهر الأداء التناسلى نتيجة المعاملة بالأسيترول وأظهرالحمل الثانى تحسناً لا بأس به مقارنة بالحَمْل الاول فى كل المقاييس التى تمت دراستها.

من هنا يمكن القول أن إضافة مركب الأسيترول رفع من كفاءة الجهاز المناعى وكذلك مظاهر النمو والأداء التناسلى وذلك لإحتوائه على عناصر النحاس والزنك والمنجنيز فى صورة عضوية، بجانب إحتوائه على حمض البانتثونيك والسيتريك واللاكتيك وبعض الأنزيمات، ويمكن إضافته بنسبة ١مل/لتر لكل من الأرانب النامية والبالغة لتحقيق أحسن المعدلات.