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THE EFFECT OF SALBUTAMOL ADMINISTRATION ON PERFORMANCE, SOME BLOOD PARAMETERS AND SKELETAL MUSCLES HISTOLOGY OF NZW RABBITS

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ABSTRACT

An experiment was conducted to evaluate the effect of supplementing a beta-adrenergic agonist drug (salbutamol) on growth, carcass traits and some physiological parameters in New Zealand White (NZW) rabbits. A total number of 36 unsexed 6-week-old rabbits, of a similar initial live body weight (LBW) were randomly allotted to 4 treatment groups; each of which was subdivided in to three replicates of three rabbits each. Group 1 (control) was fed a basal diet while groups 2, 3 and 4 were fed the same basal diet but injected (once/week) with salbutamol at doses of 100, 200 and 300 µg/kg LBW, respectively, for 8 weeks.

During the whole experimental period (6-14 weeks of age), salbutamol administration had no adverse effect on growth performance or carcass traits, with slight significant increase in kidney percentage for rabbits injected with a salbutamol dose of 300 µg/kg LBW. Blood plasma levels of glucose, triglycerides, total protein, albumin, globulin and T4 were not affected by salbutamol injection while creatinine and urea N concentrations were inconsistently lower in the salbutamol-treated rabbits than those of the control group. It was observed that salbutamol injection led to a significant increase in blood plasma levels of IGF-I and had a hypocholesterolemic effect compared with the control rabbits. Rabbits injected with 300 µg of salbutamol/kg LBW exhibited significantly higher blood hemoglobin concentration compared with that of the control group but other doses of salbutamol had no effect. The activity of blood plasma CPK was significantly lower with a dose-dependent trend to some extent, in the salbutamol-treated rabbits compared with that of the control group. Also, rabbits injected with 100 or 300 µg salbutamol/kg LBW showed significantly lower activities of LDH in blood plasma compared with that of the control group; however, activities of ALT and AST were not affected by salbutamol injection. On the other hand, rabbits injected with 100 µg salbutamol/kg LBW recorded significantly higher blood plasma level of T3 compared with that of the control group but other doses of salbutamol had no effect. The histological examinations indicated that salbutamol injection could improve the growth of skeletal muscles in rabbits.

Thus, it can be concluded that salbutamol injection in NZW rabbits at a dose of 100 µg/kg LBW has beneficial effects on their growth performance, muscle development and metabolic functions.

Keywords: Salbutamol, performance, blood parameters, muscle growth, rabbits

INTRODUCTION

Beta-adrenergic agonists are structurally analogs of the catecholamines, epinephrine and nor-epinephrine. They are very similar in structure to beta adrenergic agonists and both bind to four different cell surface receptors called adrenoceptors (especially α_1, α_2, β_1 and β_2). Of special interest are the effects of beta agonists on adipose and muscle tissue (Rang and Dale, 1991). In this respect, several beta-adrenergic agonists have been reported to increase muscle protein deposition by as more as 30%

in different mammalian and avian species by decreasing the rate of muscle protein degradation and increasing protein synthesis (Mersmann, 1998). During the last few years it has been established that some beta-adrenergic agonists (e.g. clenbuterol, cimaterol and salbutamol) can improve animal and poultry performance, increase both protein deposition and lean tissue, decrease fat deposition and improve feed conversion (Vanhooser *et al.*, 1995; Hamano *et al.*, 1998). Treatment with beta-agonists appears to cause muscle hypertrophy, mainly, by reducing the rate of protein degradation than by stimulating protein synthesis (Peters, 1989). The differential effects of beta-agonist treatment on skeletal muscle growth may reflect the differences in fiber type, beta-receptor type and beta-receptor density in skeletal muscle, as reported by Dawson *et al.,* (1991), or the duration of treatment since there is evidence that the effect of beta-agonist treatment is attenuated with prolonged treatment (Kim and Sainz, 1992).

Little data are available on the effect of beta-agonist treatment on the pattern of growth of individual skeletal muscles (O'Connor *et al.*, 1991). In an excellent experiment, Hulot *et al.* (1996) fed New Zealand White rabbits a complete and balanced diet including a clenbuterol additive (100 µg per day) between 70 and 98 days of age, and found that treated animals exhibited better growth performance (29.90 *vs* 26.7 g/day), feed conversion (5.45 *vs* 6.46 g feed/g gain) and carcass yield (64.37 *vs* 61.11%) while had lower relative weights of skin and digestive tract compared with their control counterparts. All organs, in which development is precocious, were found to be relatively lighter. They also observed that muscle/bone ratio of the carcass was improved in the treated rabbits (7.56 vs 6.38), resulting in a greater relative development of muscle tissue, without any change in bone tissue weight. In addition, See *et al.* (2004) reported that loin muscle area and percentage of fat-free lean meat increased and backfat thickness decreased in pigs fed ractopamine. Different beta-agonists are not equally potent, and cells and tissues vary in expression of β-adrenergic receptor types and the metabolic pathways linked to them. For the same reason, the magnitude of β-agonist effects on fat metabolism was also associated to dose and duration of treatment, type of β-agonist and species (Dunshea *et al.*, 2005). It seems that zilpaterol has an advantage in increasing carcass growth efficiency and yield without showing any adaptation problems for animals such as those experienced by the more aggressive β-agonist clenbuterol (Strydom *et al.*, 2009). Therefore, the purpose of the present study was to further investigate the possible effect(s) of a beta-adrenergic agonist drug (salbutamol) on muscle growth, productive performance, some blood metabolites and hormones, and the histological structure of muscle fibers in New Zealand White (NZW) rabbits.

MATERIALS AND METHODS

The experimental work of the present study was carried out in the Poultry Production Farm; Station of Agricultural Research and Experiments, Faculty of Agriculture, Mansoura University, from November 2008 to January 2009. The main objective of study was to evaluate the effect of a beta-adrenergic agonist drug (salbutamol) on growth performance, carcass characteristics, some blood metabolites and the histological structure of muscles in rabbits.

Rabbits and Management:

A total number of 36 unsexed, 6 weeks old, New Zealand White (NZW) rabbits were randomly allotted to 4 treatment groups of nine rabbits each. The average initial body weight of rabbits was nearly similar in all groups (950±30 g). Each group was further subdivided into three replicates of 3 rabbits each.

Rabbits were housed in one-tier battery of 12 cages equipped with suitable feeders and drinkers (nipples), and each of which served as a replicate unit. Rabbits were fed *ad libitum* a commercial growing diet formulated to cover the recommended requirements of growing rabbits (NRC, 1977).

Experimental Design:

Rabbits were injected with salbutamol (once/week), and the experimental period lasted 8 weeks (6-14 weeks of age), as follows:

Group 1: rabbits were fed on the basal diet (no injection) and served as a control.

Group 2: rabbits were fed on the basal diet and injected with salbutamol (100 µg/kg live body weight).

Group 3: rabbits were fed on the basal diet and injected with salbutamol (200 µg/kg live body weight).

Group 4: rabbits were fed on the basal diet and injected with salbutamol (300 µg/ kg live body weight).

Measurements:

The growth performance of NZW rabbits during the whole period was assessed by live body weight (LBW), body weight gain (BWG), feed intake (FI) and feed conversion (FC). BWG, FI and FC were determined on a replicate group basis. Composition and calculated analysis of the basal diet is shown in Table 1.

Carcass characteristics:

At the conclusion of the feeding trial (14 weeks of age), five rabbits from each group, whose body weights were near the average of their respective group, were selected for slaughter test. Just prior to slaughter and again after complete bleeding, the rabbits were individually weighed, and immediately their carcasses with fur and legs were skinned and then eviscerated. Records on weights of individual eviscerated carcass, giblets (including heart, liver and kidney) and abdominal fat contents were maintained. Carcass yield was calculated as eviscerated carcass plus giblets. All carcass traits were expressed as % of live body weight at slaughter.

Blood samples:

Blood samples from slaughtered rabbits (5/treatment) were collected in heparinized tubes, centrifuged at 4000 rpm for 15 minutes and the obtained plasma were stored at -20^{o}C until analysis. Subsequently, individual blood plasma samples were divided in two halves. The first one was used for blood hemoglobin determination according to method of Suzuki (1998). The remaining samples were analyzed, using commercial kits (Immunotech. Corp.

France) for the determination of level of total protein (Doumas *et al.*, 1981), albumin (Doumas *et al.*, 1971), creatinine (Owen *et al.*, 1954), urea-N (Fawcett and Scott, 1960), glucose (Trinder, 1969) cholesterol (Allain *et al*., 1974) and triglycerides (Fossati and Prencipe, 1982), and activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) as described by Reitman and Frankel (1957), lactate dehydrogenase (LDH; McKenzie and Henderson, 1974) and creatine phosphokinase (CPK; Rosalki, 1967) in blood plasma. Thyroid hormones [triiodothyronine (T3) and thyroxine (T4)] and insulin-like growth factors (IGF-I) were measured by RIA techniques according to the methods of Britton *et al.* (1975) and Houston and O'Neill (1991), respectively.

Table 1: Composition and chemical analysis of basal diet fed to the rabbits

Ingredients (%)	**Growing diet (6-14 weeks old)**
Alfalfa hay	30
Wheat bran	32
Soy bean meal (44% CP)	11
Barley	21
Dicalcium phosphate	1.2
Limestone	1.0
Vitamin. & Mineral. permix	0.3
Common salt	0.5
Molasses	3.0
Calculated analyses (NRC, 1977)	
Digestible energy; kcal/kg	2623
Crude protein; %	17.7
Ether extract; %	2.59
Crude fiber; %	12.75
Calcium; %	1.16
Non-phytate P; %	0.83
Lysine; %	0.87
Methionine; %	0.21
Meth.+ cyst.;%	0.51

*** Each 3 kg Vitamin. & Mineral. permix contains Vit. A, 10,000,000 IU; Vit. D_3, 1,000,000 IU; Vit. E, 10 g; Vit. K_3, 1.0 g; Vit. B_1, 1.0 g; Vit. B_2, 4.0 g; Vit. B_6, 1.5 g; Nicotinic acid, 20 g; Pantothenic acid, 10 g; Vit. B_{12}, 10 mg; Biotin, 50 mg; Folic acid, 30 g; Choline chloride, 50 g; Fe, 30 g; Mn, 40 g; Cu, 3.0 g, I, 0.45 g; Zn, 45 g and Se, 0.1 g.**

Tissues specimens and histological procedures:

Tissue samples from femur muscles were taken during slaughtering, immediately fixed in 10% formalin-saline solution, and then dehydrated in ascending concentrations of alcohol solutions ranged from 70% to absolute ethanol alcohol. Samples were cleared in xylene, and then embedded in melted paraffin wax, to obtain tissue blocks. They were then sectioned and stained with haematoxylin and eosin stain (Junquerira *et al.*, 1971). Sections were examined under light microscope and photographed by using a digital camera.

Statistical analysis:

Statistical analysis for the obtained data was performed by analysis of variance using the method of least square analysis of Co-variance (SAS, 1996). Duncan's multiple range test was used to separate significant differences among means (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance of NZW rabbits:

Table 2 shows the effect of salbutamol administration on LBW of NZW rabbits during the whole experimental period (6- 14 weeks of age). No significant differences were observed in live body weight of NZW rabbits between 6 to 13 weeks of age between the control group and those injected with 100, 200 or 300 µg of salbutamol/kg. However, group 2, which injected with 100 µg of salbutamol/kg, insignificantly achieved the highest body weight at 13 wk of age. Means of final LBW at 14 weeks of age were 2.327, 2.438, 2.279 and 2.221(kg) for rabbit groups injected with 0.0, 100, 200 and 300 µg salbutamol/kg, respectively. Group 2 which injected with 100 µg/kg LBW achieved the highest LBW at 14 weeks of age, while the lowest LBW was recorded for group 4 (injected with 300 µg/kg); but both did not differ significantly from that of the control group.

Table 2: Effect of salbutamol administration on weekly LBW (kg) of NZW rabbits

Age (weeks)	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
6	0.940	0.990	0.940	0.910	0.031	NS
7	1.059	1.083	1.037	0.994	0.043	NS
8	1.18	1.124	1.090	1.085	0.057	NS
9	1.270	1.250	1.170	1.180	0.062	NS
10	1.420	1.410	1.310	1.370	0.047	NS
11	1.661	1.672	1.585	1.583	0.041	NS
12	1.889	1.985	1.842	1.842	0.051	NS
13	2.044	2.148	1.995	1.993	0.058	NS
14	2.327^{ab}	2.438^{a}	2.279^{ab}	2.221^{b}	0.057	*

$^{a-b}$: Means in the same raw with different superscripts differ significantly (P≤ 0.05).

Results in Table 3 show that salbutamol administration to NZW rabbits had insignificant effect on BWG during the period from 6 to 11 weeks of age. However, during the period from 11- 12 weeks old, the BWG of rabbits injected with 100 µg of salbutamol/kg LBW was significantly higher ($P<0.05$) compared with that of the control rabbits. During that period, the means of BWG were 0.228, 0.312, 0.257 and 0.259 kg/animal for groups of rabbits injected with 0.0, 100, 200 and 300 µg of salbutamol/kg LBW, respectively. Beyond this period to 14 weeks of age this significant difference was disappeared, and furthermore no significant differences were detected among groups in BWG for the whole period from 6 to 14 weeks of age.

Table 3: Effect of salbutamol administration on BWG (kg) of NZW rabbits at different ages.

Age (weeks)	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
6-7	0.117	0.087	0.098	0.085	0.014	NS
7-8	0.120	0.041	0.053	0.090	0.029	NS
8-9	0.093	0.123	0.080	0.092	0.019	NS
9-10	0.147	0.167	0.138	0.193	0.021	NS
10-11	0.240	0.258	0.276	0.213	0.019	NS
11-12	0.228^{b}	0.312^{a}	0.257^{ab}	0.259^{ab}	0.024	*
12-13	0.155	0.163	0.152	0.151	0.023	NS
13-14	0.283	0.290	0.284	0.228	0.037	NS
6-14	1.385	1.444	1.341	1.313	0.055	NS

a-b: Means in the same raw with different superscripts differ significantly (P≤ 0.05).

The effect of salbutamol treatments on weekly FI is presented in Table 4. During the 7th week of age, FI was significantly higher (P<0.05) for the second group of rabbits (injected with 100 µg salbutamol/kg LBW) compared with that of the control rabbits (0.272 *vs.* 0252 kg); other salbutamol doses, however, had no effect on FI of rabbits. In addition, means of FI of NZW rabbits during the period from 7 to 11 weeks of age were not significantly affected by salbutamol treatments. During the 12th week of age, FI of the treated rabbits was comparable to that of the control group, with slight significant differences between groups 3 and 4 (injected with 200 and 300 µg salbutamol/kg LBW, respectively). From 12 to 14 weeks of age, unexpected reductions in feed intake were observed for all experimental groups of rabbits. In general, results of the present study show that the groups 1 (control) and 2 (injected with 100 µg salbutamol/kg LBW) consumed slightly more feed than the other groups during the whole experimental period (6-14 weeks of age). This holds true as the first two groups of rabbits achieved heavier LBW and higher BWG at the end of the experimental period than those of groups 3 and 4.

Table 4: Effect of salbutamol administration on FI (kg) of NZW rabbits at different ages

Age (week)	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
6-7	0.252^{bc}	0.272^{a}	0.246^{c}	0.260^{ab}	0.003	*
7-8	0.374	0.341	0.314	0.326	0.025	NS
8-9	0.406	0.399	0.356	0.353	0.020	NS
9-10	0.577	0.520	0.534	0.577	0.034	NS
10-11	0.853	0.890	0.845	0.835	0.015	NS
11-12	1.021^{ab}	1.082^{ab}	0.893^{b}	1.180^{a}	0.070	*
12-13	0.988	1.002	0.841	0.874	0.061	NS
13-14	1.070	1.044	0.967	0.951	0.034	NS
6-14	5.543	5.552	5.001	5.358	0.172	NS

a-c: Means in the same raw with different superscripts differ significantly (P≤ 0.05).

FC did not differ significantly among all treatments during the period from 6 to 11 weeks of age (Table 5). During the period from 11 to 12 weeks of age, significantly better (P<0.05) means of FC were achieved by the second and third groups of rabbits (injected with 100 and 200 µg salbutamol/kg LBW) as compared to that of the control group, but FC of the fourth group (injected with 300 µg salbutamol/kg LBW) was not significantly different from that of the control rabbits. During the period from 12 to 14 weeks of age, FC of rabbits was not affected by salbutamol treatments. In general, the second and third groups of rabbits (injected with 100 and 200 µg salbutamol/kg LBW) exhibited an insignificantly better FC for the whole period as compared to the other experimental groups. This result may reflect a beneficial effect of salbutamol on FC of NZW rabbits.

Table 5: Effect of salbutamol administration on FC (feed: gain) of NZW rabbits at different ages

Age (week)	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
6-7	3.36	4.22	3.75	4.10	0.483	NS
7-8	2.69	6.74	5.27	4.80	1.47	NS
8-9	4.57	3.17	4.57	4.13	0.95	NS
9-10	3.95	3.11	4.05	3.16	0.449	NS
10-11	3.59	3.52	3.09	3.91	0.273	NS
11-12	4.51^{a}	3.46^{b}	3.49^{b}	4.63^{a}	0.266	*
12-13	6.70	6.36	5.83	6.04	0.976	NS
13-14	4.06	3.62	3.48	4.58	0.701	NS
6-14	4.00	3.85	3.72	4.08	0.113	NS

$^{a-b}$: **Means in the same raw with different superscripts differ significantly (P≤ 0.05).**

Carcass traits:

Results given in Table 6 show the effect of salbutamol on carcass traits of NZW rabbits at 14 week of age. The results showed that salbutamol administration had no significant effect on relative weights of carcass yield, liver, heart or giblets, while kidney percentage was significantly (P<0.05) increased when the salbutamol dose reached 300 µg/kg.

Table 6: Effect of salbutamol administration on carcass traits (% of LBW at slaughter) in 14-week-old NZW rabbits

Criteria	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
LBW (kg)	2.284	2.429	2.238	2.175	0.089	NS
Carcass yield (%)	55.40	54.65	53.08	53.90	0.717	NS
Liver (%)	3.81	3.83	3.73	3.68	0.273	NS
Kidney (%)	0.634^{b}	0.688^{ab}	0.642^{b}	0.786^{a}	0.043	*
Heart (%)	0.246	0.266	0.280	0.250	0.020	NS
Giblets (%)	4.698	4.788	4.654	4.724	0.281	NS

$^{a-b}$: **Means in the same raw with different superscripts differ significantly (P≤ 0.05).**

It may be speculated that, as salbutamol dose increased the kidneys become enlarged on account of a physiological load on kidney tissue to cope with reabsorption of some metabolites.

Blood metabolites, enzymes and hormones:

As illustrated in Table 7, blood plasma levels of total protein, albumin and globulin were not affected by salbutamol administration to NZW rabbits. However, blood plasma levels of creatinine and urea N of salbutamol-treated groups were inconsistently lower than those of the control group. It is well known that creatinine and urea are the end products of protein metabolism in rabbits. So, the decreased levels of blood plasma creatinine and urea N, reported herein, are good indicators for enhancement of protein metabolism by salbutamol treatment. This is in close agreement with the findings of Hulot *et al.* (1996) who reported an improvement in protein turnover in rabbits treated by clenbuterol drug.

Table 7: Effect of salbutamol administration on plasma total protein, albumin, globulin, creatinine and urea N in 14-week-old NZW rabbits

Parameters	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
Total protein (g/dl)	7.58	8.22	8.68	7.52	0.468	NS
Albumin (g/dl)	4.36	4.21	4.56	3.98	0.283	NS
Globulin (g/dl)	3.22	4.01	4.12	3.54	0.360	NS
Creatinine (mg/dl)	1.258[a]	1.088[b]	1.140[ab]	1.108[b]	0.047	*
Urea N (mg/dl)	11.84[a]	10.52[ab]	9.81[b]	10.15[b]	0.504	*

[a-b]: **Means in the same raw with different superscripts differ significantly (P≤ 0.05).**

Concerning blood plasma cholesterol concentrations the obtained results showed that injection of rabbits with salbutamol had a hypocholesterolemic ($P<0.05$) effect as compared to that of the control group (Table 8). The lowest blood plasma cholesterol level was recorded for group 4 of rabbits (injected with 300 µg/kg LBW). Blood plasma concentrations of triglycerides and glucose did not differ among all the experimental groups. Hemoglobin concentration of group 4 (which injected with 300 µg of salbutamol/kg LBW) was significantly higher ($P<0.05$) than that of the control group, while hemoglobin levels of the other salbutamol-treated groups were not significantly different from that of the control rabbits.

Table 8: Effect of salbutamol administration on blood plasma glucose, cholesterol and triglycerides, and blood hemoglobin in 14-week-old NZW rabbits

Parameters	Salbutamol treatments (µg/kg LBW)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
Glucose (mg/dl)	103.7	132.3	116.5	105.4	9.14	NS
Cholesterol (mg/dl)	40.62[a]	33.76[b]	31.73[bc]	26.54[c]	2.01	*
Triglycerides (mg/dl)	66.86	76.42	66.86	77.91	8.37	NS
Hemoglobin (g/dl)	13.75[b]	15.82[ab]	16.82[ab]	17.45[a]	1.007	*

[a-c]: **Means in the same raw with different superscripts differ significantly (P≤ 0.05).**

The cholesterol lowering effect of salbutamol, observed herein (Table 8), may indicate a role of the drug in fat metabolism. In this connection, Merkel *et al.* (1987) stated that adipose tissues of pigs were reduced by ractopamine treatment. The observed increase in blood hemoglobin concentration in rabbits following salbutamol injection in the present study may be due to enhanced metabolic processes by treatments. As shown in Table 9, means of CPK activity in blood plasma of salbutamol-treated rabbits were significantly lower ($P<0.05$) compared with that of the control group. Even though, this reduction in CPK activity showed a dose- dependent descending order, no significant differences were detected between groups of rabbits injected with 200 or 300 µg salbutamol/ kg. It is well accepted that blood plasma CPK level is a good physiological indicator for protein metabolism, since protein catabolism causes significant increase in its level. In this respect, the present results are in line with this concept. On the other hand, rabbits treated with 100 or 300 µg salbutamol/kg LBW exhibited significantly higher means of LDH activity in blood plasma compared with that of the control group. But rabbits injected with 200 µg salbutamol/kg recorded insignificantly higher LDH activity as compared to their control counterparts. However, activities of blood plasma ALT and AST of rabbits were not affected by salbutamol treatments.

Table 9: Effect of salbutamol administration on blood plasma activity of LDH, CPK, ALT and AST enzymes in 14-week-old NZW rabbits

Parameters	Treatments (µg/kg)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
CPK (U/L)	90.13^{a}	76.42^{b}	68.45^{c}	66.07^{c}	1.82	*
LDH (U/L)	126.4^{b}	149.8^{a}	136.4^{ab}	149.2^{a}	4.42	*
ALT (U/L)	342	324	280	278	23.2	NS
AST (U/L)	152	154	114	108	17.8	NS

$^{a-c}$: Means in the same raw with different superscripts differ significantly ($P\leq 0.05$).

Blood plasma T4 levels in the experimental rabbits were not significantly affected by salbutamol treatments (Table 10). However, rabbits injected with 100 µg salbutamol/kg LBW recorded significantly higher ($P<0.05$ blood plasma level of T3 compared with that of the control group (Table 10), but levels of T3 of rabbits treated with 200 or 300 µg salbutamol/kg LBW were insignificantly higher as compared to their controls. Blood plasma levels of IGF-I of salbutamol-treated rabbits were significantly higher ($P<0.05$ than that of the control group. These concomitant increases in T3 and IGF-I may reflect a physiological synergism between thyroid hormones (especially T3) and IGF-I and a stimulatory effect of salbutamol. The observed effect may be due in part to the role of thyroid hormone in improving oxygen consumption and/or the erythropoietic effect of IGF-I which accelerates the formation and delay apoptosis of erythrocytes. This observation can be supported by the findings of Young *et al.* (1995) who reported a significant role of thyroid hormone, IGF-I and the ß-adrenergic agonists in the regulation of erythrocyte formation and different oxidative processes in the living organisms.

Table (10): Effect of salbutamol administration on blood plasma levels of T4, T3 and insulin-like growth factor-I (IGF-I) in 14-week-old NZW rabbits

Parameters	Treatments (µg/kg)				SEM	Significance
	1 (0.0)	2 (100)	3 (200)	4 (300)		
T4 (ng/ml)	20.03	21.67	22.61	23.20	1.1	NS
T3 (ng/ml)	3.96^{b}	4.75^{a}	4.31^{ab}	4.62^{ab}	0.216	*
IGF-I (ng/ml)	187.5^{b}	248.9^{a}	238.7^{a}	239.9^{a}	11.06	*

$^{a-b}$: **Means in the same raw with different superscripts differ significantly (P≤ 0.05).**

In conclusion, the present results may indicate that salbutamol had some potential to improve protein metabolism, possibly via its role in controlling the physiological functions of some blood enzymes (*i.e.* reduced CPK and increased LDH activity) and increasing of some anabolic hormones (*i.e.* T3 and IGF-I) without adversely affecting liver function, as indicated by the insignificant changes in the activity of ALT and AST enzymes (Tables 9 and 10).

Histological observations:

The histological structure of muscles from different treatment groups of rabbits revealed considerable changes. Fig. 1 shows a longitudinal section (LS) in muscles of control rabbits where muscle fibers are surrounded and supported by different layers of connective tissues (CT). It is clear that the growth pattern of the selected muscle has significant muscle fiber degeneration indicated by reduced endomysial and perimysial spacing between the muscle fibers which appear fragmented.

The growth development of muscle fibers in salbutamol-treated rabbits shows different pattern. It is clear that salbutamol enhanced muscle growth as indicated by the hypertrophy of muscle fibers (Fig: 2). All fibers became elongated with a very well demarcation between fibers. The nuclei were oval-shaped and well-arranged in the myofibrils. A very thin layer(s) of CT was observed between the muscle fibers, while no degenerative areas occurred between muscles.

Fig. 3 shows a transverse section (TS) in muscles of salbutamol treated (200 µg/kg) rabbits. It is clear that more nuclei are present in the section which reflects progressive proliferation of muscle fibers. This hyperplasia had different growth schedules as the muscle fibers appeared with great variations in their diameter. Many degenerative areas or spaces could be seen in the section which may indicate accumulative fluids resulting from progressive development.

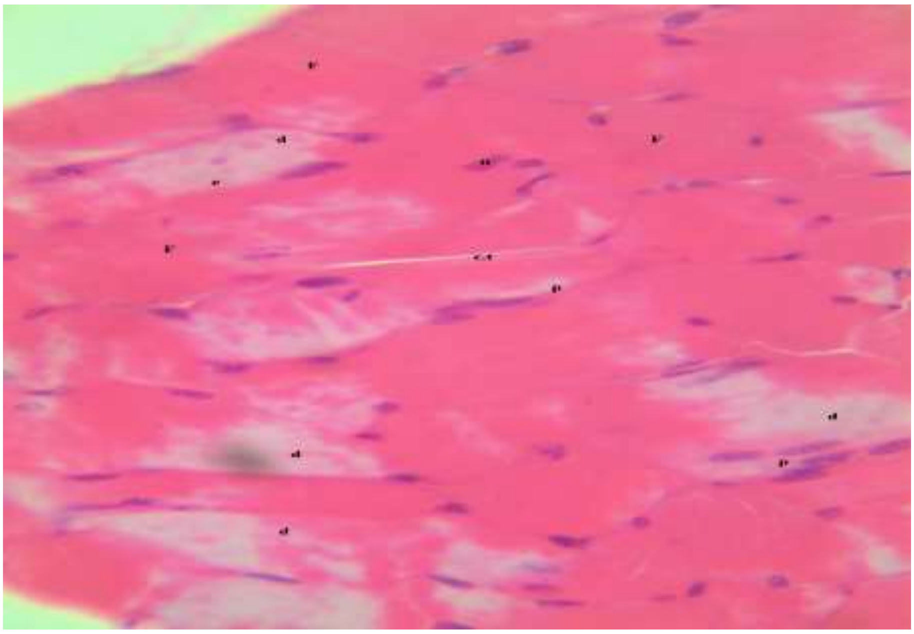

Fig. (1): L.S. in muscles of control rabbits (H+E x 40)

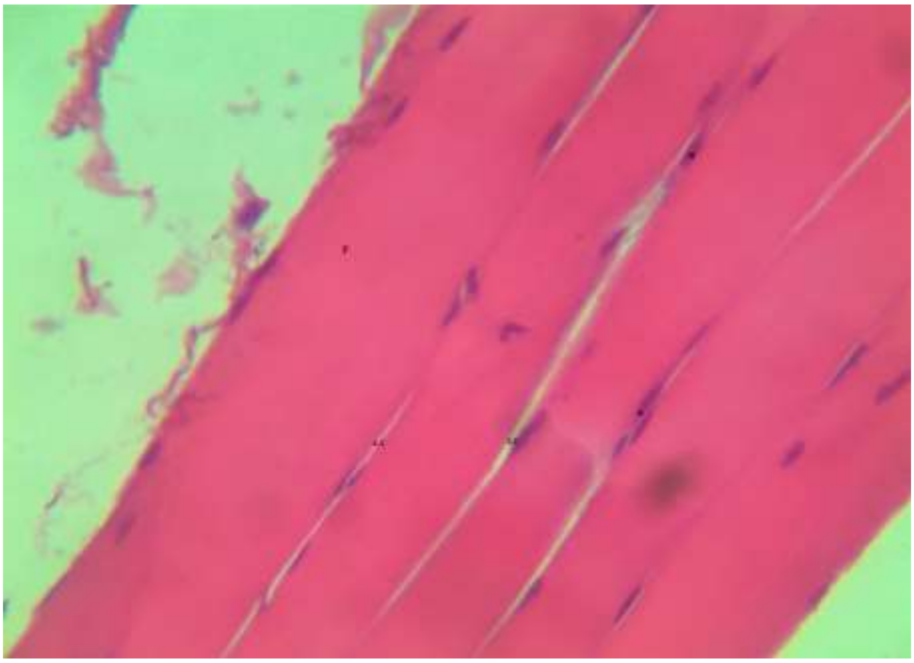

Fig. (2): L.S. in muscles of salbutamol-treated (100 µg/kg) rabbits (H+E x 40)

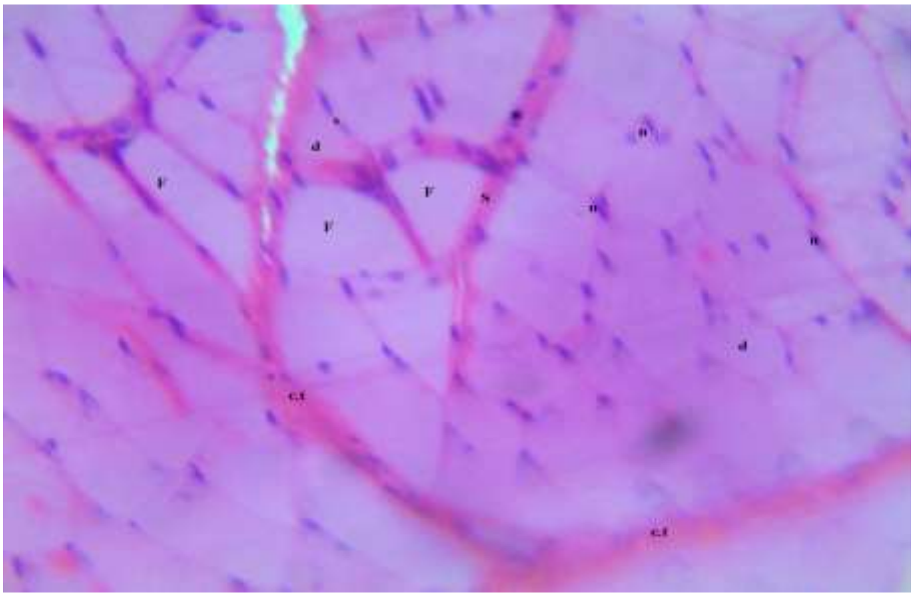

Fig. (3): T.S in muscles of salbutamol-treated (200 µg/kg) rabbits (H+E x 40)

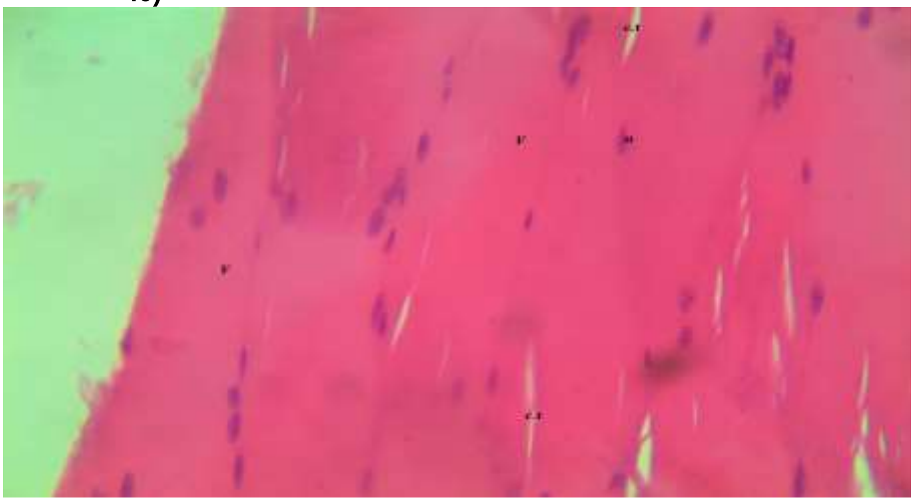

Fig. (4): T.S in muscles of salbutamol-treated (300 µg/kg) rabbits (H+E x 40)

Conclusion

Thus, it can be concluded that salbutamol injection in NZW rabbits at 100 µg/kg LBW has beneficial effects on their growth performance, muscle development and metabolic functions.

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تـأثير الحقـن بعقـار السـلبوتامول علـي الأداء الإنتـاجي وبعـض معاييرالـدم وتكـوين العضلات الهيكلية لأرانب النيوزلاندي الأبيض

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أجريت هذة الدراسة لقياس تـاثير الحقن بعقـار السلبوتامول علي الأداء الإنتـاجي وصـفات الذبيحة وبعض القياسات الفسيولوجية لأرانب النيوزلاندي الأبيض. تم إستخدام عدد 36 أرنبا عند عمر 6 أسـابيع وذات أوزان متشـابهة حيث تم توزيعها عشوائياً علي 4 معاملات وتضمنت كل معاملة 3 مكررات بكل منها 3 أرانب. تم تغذية مجموعة الكنترول علي عليقة قاعدية بينما تغذت المجموعـات الثانيـة الثالثـة الرابعـة علـي عليقـة الكنتـرول بالأضـافة إلـي حقنها أسـبوعيا بمـادة السلبوتامول بمعدل 100، 200 أو 300 ميكروجرام/كجم من وزن الجسم على الترتيب لمدة 8 أسابيع.

ويمكن تلخيص النتائج المتحصل عليها للفترة التجريبية الكلية (6-14 أسبوعا من العمر) فيما يلي: لم يكن لإعطاء مـادة السلبوتامول تـأثيرا سلبيا على نمو الأرانب أو صفات الذبيحة، مع ملاحظة زيادة معنوية بسيطة في الوزن النسبي للكلى في الأرانب المحقونة بالسلبوتامول بمعدل 300 ميكروجرام/كجم من وزن الجسم. لم يكن للمعاملة بالسلبوتامول تـأثير معنوي على مستويات بلازما الدم من الجلوكوز، الجليسريدات الثلاثية، البروتين الكلي، الألبيومين، الجلوبيولين، وهرمون الثيروكسين (T4)، بينما إنخفض بشكل غير متناغم تركيز الكرياتنين ونيتروجن اليوريا في الأرانب المحقونة بالسلبوتامول عنها في مجموعة المقارنـة. أحدثت المعاملة بالسلبوتامول زيادة معنوية في مستويات بلازما الدم من عامل النمو المشابه للإنسولين-1 (IGF-I) كما أدت المعاملة بالسلبوتامول إلى إنخفاض ملحوظ في مستوى الكوليستيرول بالدم عنها في الأرانب الغير معاملة. لوحظ إرتفاع معنـوي فـي تركيـز هيموجلـوبين الـدم فـي الأرانـب التـي تـم حقنهـا بالسـلبوتامول بمعـدل 300 ميكروجرام/كجم من وزن الجسم، ولم يتأثر مستوي الهيموجلوبين بباقي الجرعات. أحدثت المعاملة بالسلبوتامول إنخفاضا معنويا ومرتبط بالجرعة في نشاط إنزيم كرياتين فوسفوكينيز (CPK) عنها في مجموعة المقارنة. أيضا أدت المعاملة بالسلبوتامول بمعدل 100 أو 300 ميكروجرام/كجم من وزن الجسم إلى حدوث إنخفاض معنوي في نشاط إنزيم لاكتيت ديهيدروجينيز (LDH) عنها في مجموعـة المقارنـة، بينمـا لـم يتـأثر نشـاط إنزيمـي ألانـين أمينوترانسـفيريز (ALT) وأسـبارتيت أمينوترانسفيريز (AST) في بلازما الدم. من ناحية أخرى، حدثت زيادة معنوية في مستوى هرمون الثيـرونين ثلاثـي اليـود (T3) نتيجـة الحقـن بالسـلبوتامول بمعـدل 100 ميكروجـرام/كجم مـن وزن الجسم، ولم يتأثر مستوي الهرمون بباقي الجرعات. أوضحت شرائح الفحص الهستولوجي أن الحقن بالسلبوتامول أحدث أثرا إيجابيا على نمو العضلات الهيكلية في الأرانب. ويمكن الإستنتاج أن حقن أرانب النيوزلاندي الأبيض بالسلبوتامول بمعدل 100 ميكروجرام/كجم من وزن الجسم يمكن أن يؤثر إيجابيا على نمو وتطور العضلات والوظائف الميتابولزمية في الأرانب.

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