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Effect of Supplementation of *Yucca schidigera* Extract to Growing Rabbit Diets on Growth Performance, Carcass Characteristics, Serum Biochemistry and Liver Oxidative Status

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ABSTRACT

This study was performed to investigate the effect of dietary supplementation with *Yucca schidigera* Extract (YE) as growth promoter and natural antioxidant on performance, carcass characteristics, serum metabolites and liver oxidative status in growing rabbits. A total of 80, New Zealand White (NZW) rabbits at 5 weeks of age were randomly assigned to four treatments with four replicates. The dietary treatments consisted of the basal diet as control, YE groups receiving 200, 400 and 600 g kg^{-1} YE added to the basal diet. Body weights of rabbits were measured at 5, 7, 9 and 13 weeks, feed intake was measured at the same periods and feed conversion was calculated, accordingly. At weeks13, carcass characteristics, blood profile and antioxidant status in liver were determined. Live Body Weight (LBW) and Body Weight Gain (BWG) were not significantly influenced by the dietary treatments. Giblets percentage and relative weights (organ weight, g/100 g of body weight) of the heart, liver, spleen and lungs of rabbits at 13 weeks were not affected by dietary treatments. However, carcass yield percentage and relative organs of kidneys, skin and legs were statistically ($p<0.05$) influenced by dietary treatments. There were no differences ($p<0.05$) in total protein, globulin, AST, ALT and LDL-cholesterol due to treatments. While, the other blood parameters were statistically affected by YE supplementation. Dietary supplementation of YE to basal diet exhibited a significantly positive effect on immune related parameters (albumin, ALB immunoglobulin, IgG and IgM) and serum ammonia. The lowest value of ammonia achieved by animals fed diet contained YE 200 mg kg^{-1} diet. Rabbits fed YE 400 and 600 mg kg^{-1} of diet produced the best results of total-cholesterol in blood versus other diets, also HDL-cholesterol was gradually decreased with increasing YE supplementation. Hepatic Superoxide Dismutase (SOD) activity and reduced Glutathione (GSH), Malondialdehyde (MDA) concentrations were not significantly affected by the different levels of YE. But lipid peroxidation was slightly decreased with increasing YE supplementation. Dietary supplementation of YE to control diet exhibited a significantly positive effect on Glutathione Peroxidase (GSH-Px) and Catalase (CAT) activities. It could be conducted that, rabbits fed diet supplemented with YE did not affect growth performance in general but improved the immunity responses, in addition, animals fed diet supplemented with phytogenic additive had lower ammonia in blood, MDA in liver and increased hepatic antioxidant activities.

Key words: Rabbits, *Yucca* extract, performance, serum metabolites, oxidative status

INTRODUCTION

Phytogenic feed additives are plant-derived products used in animal and poultry feeding to improve the performance of agricultural livestock. Phytogenic additives (often also called phytobiotics or botanicals) are commonly defined as plant-derived compounds incorporated into diets to improve the productivity of livestock through amelioration of feed properties, promotion of the birds and animals' production performance and improving the quality of food derived from those animals. Beneficial effects of herbal extracts or active substances in animal nutrition may include the stimulation of appetite and feed intake, the improvement of endogenous digestive enzyme secretion, activation of immune response and antibacterial, antiviral, antioxidant and antihelminthic actions (Collington *et al*., 1990).

Yucca schidigera is a medicinal plant that grows widely in the deserts. *Yucca* plant is a source of steroidal saponins and is used commercially used as a saponin source. *Yucca* is also a source of polyphenolics, including resveratrol and a number of other stilbenes (yuccaols A, B, C, D and E). These phenolics have anti-inflammatory activity (Cheeke *et al*., 2006). *Yucca schidigera* has a very high level of saponins and phenolic compounds with antioxidant action. The products of *Yucca schidigera* are used as feed additives, cosmetics and in the pharmaceutical industry (Chrenkova *et al*., 2012). The main application of *Yucca* products is in animal nutrition, in particular as a feed additive to reduce ammonia and fecal odors in animal excreta. The positive effects of dietary supplementation with yucca products on the growth rates, feed efficiency and health of livestock seem to be not only due to the saponin constituents but also to other constituents (Piacente *et al*., 2005).

Saponins contained in the *Yucca* plant it just one of the many natural biosecurity substances which increase the efficiency of farm animals (Jaques, 1989). Saponin-containing *Yucca* Extract (YE) are currently used in the feed industry for control of ammonia and odour. The active components in this function are probably carbohydrates, rather than saponins. Specific roles of saponins in *Yucca* and its products may involve modification of gut microbes (Windisch *et al*., 2008). In recent time, this plant and its extract have been used to produce drugs that are applied to treat various human diseases. It also improves performance and health of the livestock in addition to feed in various concentrations (Duffy and Brooks, 2007).

Yucca products are applied primarily in animal nutrition, where they reduce the ammonia content in the environment and animal faeces odour. One of the essential requirements of growing rabbits is high, synchronous and balanced reproduction (Bulla *et al*., 2008).

The aim of this study was to evaluate the potential of increasing levels of *Yucca schidigera* extract as a natural antioxidant and growth promoter in growing rabbit diets, using higher inclusion levels than in previously published experiments.

MATERIALS AND METHODS

Animals, experimental design and feeding: The present investigation was carried out at Rabbit Research Farm, Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. All experimental procedures were carried out according to the Local Experimental Animal Care Committee and approved by the ethics of the Institutional Committee of Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

A total number of 80 New Zealand White (NZW) growing rabbits of 5 weeks of age with initial body weight of 625.13±2.94 g were used in a complete randomized design experiment with four

treatments, twenty rabbits in four replicates (4×4×5). Rabbits were housed in galvanized wire cages (40 cm high×50 cm width×60 cm length) in (five rabbits each) and fresh water was automatically available at all time. Dietary treatments were as follows: (1) Control basal diet (2) Basal diet+200 mg *Yucca* extract/kg diet (3) Basal diet+400 mg *Yucca* extract/kg diet (4) Basal diet+600 mg Y*ucca* extract/kg diet. Each group of rabbits was fed the experimental diet (in pellet) from 5-13 weeks of age. Feed and water were offered ad-libitum through the experimental period. All rabbits were kept under the same managerial, hygienic and environmental conditions. Rabbits were fed to cover their requirements according to NRC (1977). The formulation and composition of commercial rabbit diet is shown in Table 1. *Yucca schidigera* extract purchased from Free Trade Egypt Company, Behira, Egypt.

Traits measured: Animals were weighed individually at weekly intervals. Mortality was recorded daily. Average Daily Feed Intake (ADFI), Body Weight Gain (BWG) and Feed to Gain Ratio (FCR) was calculated from these data by period and cumulatively. Feed wastage was recorded on daily basis and the data was used to estimate feed consumption. At the termination of experiment, twenty rabbits (five each group) were sampled randomly for carcass evaluations at 13 weeks of age, weighed and manually slaughtered. Carcass weight (the main body, head, kidneys, liver, heart and other total edible parts) was determined according to Blasco *et al.* (1993). The carcasses were weighed and the weights of the skin, legs, liver, spleen, kidneys, heart and lungs were recorded and expressed as g kg^{-1} of Slaughter Weight (SW). Carcass and dressed weights studied (dressed weight = carcass weight plus giblets weight)/live body weight.

Table 1: Formulation and composition of commercial growing rabbit diet

Ingredients	Control diet
Yellow corn	20.00
Soybean meal 44 (%)	20.00
Wheat bran	16.00
Berseem hay	30.00
Barely grain	10.00
Molasses	2.00
Limestone	1.00
Salt	0.50
Premix*	0.50
Total	100.00
Calculated composition**	
ME (Kcal kg^{-1})	1903.00
Crude protein (%)	17.50
Calcium (%)	0.88
Nonphytate P (%)	0.20
Chemical analysis***	
Crude protein (%)	16.54
Ether extract (%)	2.25
Crude fiber (%)	12.33
DM (%)	88.06
OM (%)	90.57
NFE	59.45

*Each one kg of premix (minerals and vitamins mixture) contains Vit. A: 20000 IU, Vit. D3: 15000 IU, Vit. E: 8.33 g, Vit. K: 0.33 g, Vit. B1: 0.33, Vit. B2: 1.0 g, Vit. B6: 0.33 g, Vit. B5: 8.33 g, Vit. B12: 1.7 mg, Pantothenic acid: 3.33 g, Biotine: 33 mg, Folic acid: 0.83 g, Choline chloride: 200, **Calculated according to NRC (1994), ***Chemical analysis according to AOAC (2006)

Blood samples were collected from sacrificed rabbits in clean sterile tubes. Samples were let to coagulate and centrifuged at 3500 rpm for 15 min to obtain serum and serum samples were kept in Eppendorf tubes at -20°C until analyzed. The following serum biochemical parameters were determined: Total Protein (TP), Albumin (ALB), Globulin GLB (TP-ALB), Total Cholesterol (TCHO), High Density Lipoprotein (HDL) cholesterol, Low-Density Lipoprotein (LDL) cholesterol, Triglyceride (TRG), Aspartate Aminotransferase (AST) and Alanine aminotransferase (ALT), Immunoglobulin G (IgG) and M (IgM) levels were determined spectrophotometrically using commercial diagnostic kits provided by Biodiagnostic Co. (Giza, Egypt). Serum ammonia concentration was determined using coupled enzymatic assay (Ishihara *et al*., 1972).

For antioxidant assays, liver samples from six rabbits each treatment were homogenized (10% w/v) in potassium phosphate buffer solution (pH 7.4) then centrifuged at 3000 rpm for 15 min. The samples were centrifuged and the already prepared supernatants and sera were subjected to the measurement of Superoxide Dismutase (SOD), Catalase (CAT) and Glutathione Peroxidase (GSH-Px) activities as well as reduced Glutathione (GSH) and Malondialdehyde (MDA) levels by spectrophotometric methods using a spectrophotometer. Activity of SOD was measured by the xanthine oxidase method which monitors the inhibition of reduction of nitro blue tetrazolium by the sample (Winterbourn *et al*., 1975). Activity of CAT was measured according to Aebi (1984). Activity of GSH-Px was detected with 5, 5'-dithiobis-p-nitrobenzoic acid and the change of absorbance at 412 nm was monitored using a spectrophotometer (Hafeman *et al*., 1974). Reduced glutathione (GSH) concentration was analyzed by the methods of Beutler *et al*. (1963). The MDA level was analyzed with 2-TBA, monitoring the change of absorbance at 532 nm with the spectrophotometer (Jensen *et al*., 1997).

Statistical analysis: Data was subjected to analysis of variance procedures appropriate for a completely randomized design using the GLM procedures of SPSS (2008). The differences among means were determined using the student Newman keuls test. The Mean values and Standard Error (SE) are reported. Statements of statistical significance are based on $p<0.05$.

RESULTS AND DISCUSSION

Growth performance: The effects of YE supplementation on growth performance of growing rabbits during the experiment are shown in Table 2. There were no differences ($p<0.05$) in BW and BWG due to treatments at all studied periods. Abaza and El-Said (2005) found that BWG significantly ($p<0.01$) increased in rabbits fed with *Yucca schidigera* powder at level of 100 mg kg^{-1} of diet. But, the high levels of *Yucca schidigera* powder (150 and 200 mg kg^{-1} of diet) gave 9.8 and 11.7%, respectively, less body weight gain compared to control diet. On the same context, Al-Bar *et al*. (1992) reported that increased body weight gain in rabbits fed with *Yucca schidigera* at level of 125 mg kg^{-1} of diet as compared with animals on the control diet. Cabuk *et al*. (2004) cleared that body weight of birds were significantly ($p<0.05$) increased by adding *Yucca schidigera* at level of 120 mg kg^{-1} of broiler diet.

Supplemental dietary YE up to 600 mg kg^{-1} to control diet led to numerically improvement in the final LBW ($p<0.05$). This observable improvement in LBW with phytogenic additive groups compared to control diet may be due to provide some compounds that enhance digestion and absorption of some nutrients in the diets. Also, that may be attributed to the bioactive components such as steroidal saponins (sarsapogenin, smilagenin, markogenin, samogenin, gitogenin and neogitogenin) and phenolic compounds (resveratrol and yuccaols) were found in the yucca plant, causing greater efficiency in the utilization of feed, resulting in enhanced growth.

Table 2: Effects of *Yucca schidigera* extract on performance of NZW growing rabbits at 13 weeks of age

	Yucca schidigera extract (Basal diet mg kg^{-1})					
Parameters	Control	200 (mg)	400 (mg)	600 (mg)	SEM[1]	p-value[2]
Live body weight (g) at						
5 weeks	629.81	623.87	627.62	618.87	4.72	0.883
7 weeks	1153.02	1112.32	1114.25	1114.00	16.77	0.816
9 weeks	1492.58	1452.44	1520.00	1520.83	24.51	0.772
11 weeks	1883.37	1819.58	1829.41	1749.41	21.40	0.356
Final (13 weeks)	1985.08	1969.70	2052.49	2038.33	31.45	0.778
Body weight gain (g)						
5-7 weeks	37.42	36.93	34.75	35.36	1.21	0.875
7-9 weeks	24.20	22.25	28.98	29.05	1.13	0.346
9-11 weeks	27.91	26.22	22.10	19.63	1.30	0.205
11-13 weeks	7.26	10.69	15.90	17.63	1.88	0.205
Overall (5-13 weeks)	24.20	24.02	25.44	25.34	0.57	0.766
Daily feed intake (g)						
5-7 weeks	72.95	81.14	74.99	77.03	1.53	0.125
7-9 weeks	66.41^{ab}	67.11^{ab}	76.13^{a}	60.23^{b}	2.07	0.031
9-11 weeks	75.85^{ab}	82.81^{a}	78.83^{a}	67.43^{b}	2.15	0.049
11-13 weeks	63.82	70.94	69.40	75.29	3.84	0.654
Overall (5-13 weeks)	69.76	75.50	74.84	70.00	1.31	0.268
Feed conversion ratio (g)						
5-7 weeks	1.97	2.22	2.20	2.20	0.07	0.633
7-9 weeks	2.90	3.18	2.74	2.08	0.19	0.231
9-11 weeks	2.77	3.27	3.71	3.65	0.21	0.430
11-13 weeks	8.93^{a}	6.64^{ab}	4.33^{b}	5.82^{b}	0.58	0.023
Overall (5-13 weeks)	2.89	3.14	2.95	2.78	0.05	0.159

Different superscripts within 1 rows are significantly different ($p<0.05$), SEM[1]: Standard Error Means, [2]Overall treatment p-value

There were no differences ($p<0.05$) in FI between treatments except through periods 7-9 and 9-11 weeks of age. During the periods 7-9 and 9-11 weeks of age, diet of rabbits FI containing 600 mg kg^{-1} of YE were lower ($p>0.05$) than those of animals that are diets containing 400 mg kg^{-1}. Contrary to these findings Abaza and El-Said (2005) reported that FI significantly ($p<0.01$) decreased by increasing *Yucca schidigera* powder amount. The highest feed intake was recorded in rabbits fed control diet while the lowest feed intake recorded with the group fed *Yucca schidigera* powder at level of 200 mg kg^{-1} of diet.

No effects of YE supplementation on FCR were observed in the present experiment except during period 11-13 weeks of age. Supplementing 400 and 600 mg kg^{-1} of YE markedly enhanced FCR at 11-13 weeks of age ($p<0.05$). This improvement in FCR with YE supplementation by 400 or 600 mg kg^{-1} of diet may be due to the synergetic effect of chemical constituents present in YE such as steroidal saponins and phenolic compounds. These chemical constituents had antimicrobial (Wang *et al*., 1999; Czeczot *et al*., 2003) antioxidant, anti-inflammatory, anti-carcinogenic, antifungal (Olas *et al*., 2002, 2003) and antiviral components (Docherty *et al*., 1999). Hussain *et al*. (1996) observed that supplementation of rabbit diets with *Yucca schidigera* at level of 250 mg kg^{-1} of diet improved feed conversion. Also, Johnston *et al*. (1982) noted that *Yucca schidigera* saponin at level of 121 ppm in feed improved daily gain and feed conversion in broiler. Cheek (1998) reported that *Yucca schidigera* feeding improved growth and productivity in poultry.

Carcass characteristics: The effect of dietary supplementation with YE on carcass traits at the end of experimental period is presented in Table 3. Results of experiment indicate that dressing, carcass yield percentage and relative organs of kidney, skin and legs were statistically ($p<0.05$) influenced by dietary treatments. The highest values of dressing and carcass yield were observed in rabbits fed YP at level of 600 mg kg^{-1} of diet. While, the lowest values were recorded in rabbits fed YE 200 mg kg^{-1} of diet.

Animals fed diets supplemented with YE produced the lightest ($p<0.05$) value of skin and legs compared with those in control at 13 weeks-old. On the other hand, the heaviest values of kidneys were achieved in animals fed 400 and 600 mg kg^{-1} of YE or control diet compared to the diet containing YE 200 mg kg^{-1}. In the present study, giblets percentage and relative weights (organ weight, g/100 g of body weight) of the heart, liver, spleen and lunge of rabbits at 13 weeks were not affected by dietary treatments ($p<0.05$). These results are disagreement with those obtained by Abaza and El-Said (2005). Abaza and El-Said (2005) reported that dressing percentage significantly ($p<0.05$) decreased with increasing YP level but the highest dressing value was observed in rabbits fed YP at level of 50 mg kg^{-1} of diet. Giblets percentage significantly ($p<0.05$) increased with increasing YP level but the lowest value was recorded by rabbits fed YP at level of 50 mg kg^{-1} of diet.

Blood parameters: Biochemical blood parameters are usually related to health status. These parameters are good indicators of physiological, pathological and nutritional status of an animal and have the potential of being used to elucidate the impact of nutritional factors and additives supplied in diet.

The effect of YE supplementation on serum biochemical parameters of rabbits are shown in Table 4. There were no differences ($p<0.05$) in total protein, globulin, AST, ALT and LDL-cholesterol due to treatments. While, the other blood parameters were statistically affected by YE supplementation. There results were partially agreed with Kaya *et al.* (2004) who indicated that serum total protein concentration was not changed by dietary treatments but albumin level was decreased in quails fed 100 ppm yucca powder. Abaza and El-Said (2005) Cleared that blood total

Table 3: Effects of *Yucca schidigera* extract on carcass yield and proportions of various carcass parts and organs of NZW growing rabbits at 13 weeks of age

	Yucca schidigera extract (Basal diet mg kg^{-1})					
Parameters	Control	200 (mg)	400 (mg)	600 (mg)	SEM[1]	p-value[2]
Slaughter weight (SW), g	1988.00	1873.00	2004.00	1989.00	31.80	0.489
Carcass weight (g)	1110.00	994.00	1134.00	1183.00	30.00	0.131
Carcass yield (%)	55.82^{bc}	52.79^{c}	56.65^{ab}	59.47^{a}	0.84	0.013
Heart (g kg^{-1} SW)	2.77	2.55	2.71	2.67	0.06	0.759
Kidneys (g kg^{-1} SW)	6.85^{a}	6.18^{b}	7.01^{a}	6.82^{a}	0.11	0.023
Liver (g kg^{-1} SW)	35.84	32.79	35.22	28.31	1.50	0.297
Spleen (g kg^{-1} SW)	0.89	0.59	0.60	0.55	0.06	0.279
Lungs (g kg^{-1} SW)	7.79	7.69	8.23	7.40	0.43	0.948
Skin and legs (g kg^{-1} SW)	216.00^{a}	199.00^{b}	196.00^{b}	203.00^{b}	2.62	0.013
Giblets (%)	4.54	4.17	4.50	3.77	0.16	0.331
Dressing (%)	60.36^{ab}	56.95^{b}	61.15^{a}	63.25^{a}	0.82	0.022

Different superscripts within 1 rows are significantly different ($p<0.05$), SEM[1]: Standard Error Means, [2]Overall treatment p-value

Table 4: Effects of *Yucca schidigera* extract on blood profiles of NZW growing rabbits at 13 weeks of age

	Yucca schidigera extract (Basal diet mg kg^{-1})					
Parameters	Control	200 (mg)	400 (mg)	600 (mg)	SEM[1]	p-value[2]
Total protein (g dL^{-1})	5.64	6.01	6.16	6.58	0.16	0.275
Albumin (g dL^{-1})	2.41^{c}	3.53^{b}	4.18^{a}	4.11^{a}	0.21	<0.001
Globulin (g dL^{-1})	3.22	2.48	1.98	2.47	0.18	0.081
ALT (IU mL^{-1})	38.82	49.23	56.61	56.70	4.00	0.387
AST (IU mL^{-1})	49.72	61.70	60.12	54.15	3.25	0.604
Ammonia-N (Mmol L^{-1})	3.35^{a}	2.34^{d}	3.08^{b}	2.97^{c}	0.11	<0.001
Triglycerides (mg dL^{-1})	104.70^{b}	123.56^{ab}	159.07^{a}	134.36^{ab}	7.71	0.047
Total cholesterol (mg dL^{-1})	103.05^{ab}	108.35^{a}	98.27^{b}	90.06^{c}	2.20	0.001
HDL-cholesterol (mg dL^{-1})	54.31^{a}	43.19^{b}	42.54^{b}	32.30^{c}	2.58	0.002
LDL-cholesterol (mg dL^{-1})	27.96	34.40	42.42	48.04	4.04	0.349
IgG (mg dL^{-1})	1.57^{b}	1.73^{b}	1.69^{b}	2.95^{a}	0.19	0.008
IgM (mg dL^{-1})	12.70^{b}	13.04^{b}	21.89^{a}	20.05^{a}	1.36	0.002

Different superscripts within 1 rows are significantly different ($p<0.05$), SEM[1]: Standard Error Means, [2]Overall treatment p-value

protein and total albumin were not significant affected by different levels of *Yucca schidigera* powder but the highest total protein value recorded in the group received 100 mg kg^{-1} of diet.

Dietary supplementation of YE to basal diet exhibited a significantly positive effect on IgG, IgM and albumin. In poultry production, it is very important to improve immunity to prevent infectious diseases. A variety of factors such as vaccination failure, abuse of antibiotics can induce immunodeficiency and infection by immune-suppressive diseases. Use of immune stimulators is one solution to enhance immunity and to decrease susceptibility to infectious disease. Herbal plant that are rich in flavonoids such as Yucca powder or extract extend the activity of vitamin C, act as antioxidants and may therefore improve immune functions (Acamovic and Brooker, 2005). Immunoglobulin (IgG and IgM) significantly affected by different treatments, the level of 600 and 400 mg kg^{-1} concentration produced the highest IgG and IgM value in blood, that increase activation of immune response, respectively. It is likely that a higher dosage of herbal natural feed additives may be needed to stimulate humoral immune response.

Ammonia is one of the microbial products that are known to have negative health effects in birds, animals and humans. Serum ammonia was markedly decreased with YE supplementation compared to the control diet. The lowest value of ammonia achieved by animals fed diet contained YE 200 mg kg^{-1} diet. This result explained before may be due to the binding of Sarsaponin present in *Yucca schidigera* and ammonia in the intestine which is the source of urea thus may be beneficial for improving the health, by reducing ammonia emission in rabbit buildings (Colina *et al*., 2001). These results support the findings of Amber *et al*. (2004) who reported that the supplementation of yucca extract to diets decrease urea and ammonia levels in the blood and caecal and thus may be beneficial for improving the health, by reducing ammonia emission in the rabbit farms. Reduction of plasma ammonia concentrations due to supplemental dietary *Yucca* extract has been reported in poultry by Balog *et al*. (1994) and in rabbits by Hussain *et al*. (1996) Al-Bar and Al-Aghbari (1996). They suggested that this may be possibly due to the saponins of *Yucca* extract affecting gut wall permeability. Also, these findings are also concordant with Hussain *et al*. (1996) who found that addition of *Yucca schidigera* extract at level of 250 mg kg^{-1} of rabbit's diet decreased plasma urea and ammonia.

In this present study, it was obvious that YE 400 and 600 mg kg^{-1} of diet produced the best results of total-cholesterol in blood versus other diets. Additionally, HDL-cholesterol was gradually decreased with increasing YE supplementation. Conversely, triglycerides was significantly ($p<0.05$) increased in YE groups compared to the control diet. The disturbance in lipid profile may be attributed to increased biosynthesis and accumulation of cholesterol in liver and/or impaired biliary function.

Liver antioxidant indices: The effects of YE supplementation on the antioxidant parameters including liver activity of SOD, CAT, GSH, GSH-Px and MDA of growing rabbits were illustrated in Table 5. Hepatic SOD activities, GSH and MDA concentrations were not significantly affected by the different levels of YE. But lipid peroxidation (MDA) was slightly decreased with increasing YE supplementation. Where, the concentration of liver MDA is an indicator for evaluating antioxidant systems. These results show that YE diets reduce the oxidative reactions in the rabbit body and production rate of hpid peroxidation. It could improve the meat quality via the reduction of peroxide and free radical. Present results are in line with what described by Lin *et al.* (2003), reported that the intake of herbs in chickens results in an increase in serum antioxidant enzyme activities and a decrease in MDA concentration.

Dietary supplementation of YE to control diet exhibited a significantly positive effect on GSH-Px and CAT activities. Antioxidant enzymes including GSH-Px, CAT and SOD are synthesized and regulated endogenously. The SOD plays an important role in protecting cells from damage caused by reactive oxygen species but this process requires dietary supply of the appropriate nutrients (Yesilbag *et al.*, 2011). Such antioxidant effects would be expected to improve the health of poultry. From these results, it can be stated that supplementation with the natural antioxidants YE could be applied in the future to improve the nutritional quality of poultry meat.

It seems that YE supplementation to control diet were effective in enhancing the antioxidant ability of animals which appeared to lower mortality. Since, yucca plant is a rich source of beneficial phenolic compounds, the resveratrol and yuccaols having strong antioxidant and anti-inflammatory activity (Cheeke *et al.*, 2006). *Yucca schidigera* plant is suitable complement compound feed, it has a positive impact on the growth, health and animal production activities (Anthony *et al.*, 1994). Based on these findings, The YE might play an important role as an exogenous antioxidant and could also be applicable as a protective agent against tissue damage.

Table 5: Effects of *Yucca schidigera* extract on oxidative status in liver of NZW growing rabbits at 13 weeks of age

	Yucca schidigera extract (Basal diet mg kg^{-1})					
Parameters	Control	200 (mg)	400 (mg)	600 (mg)	SEM[1]	p-value[2]
Oxidative status						
SOD (U mL^{-1})	293.85	409.90	323.25	353.10	26.31	0.504
Catalase (nmol g^{-1} tissue)	37.83^{b}	68.17^{a}	59.72^{a}	51.73^{ab}	4.24	0.038
GPX (Mmol min^{-1} mL^{-1})	171.85^{c}	266.15^{a}	211.95^{b}	275.30^{a}	12.90	0.011
GSH (ng g^{-1} tissue)	7.06	7.40	8.48	8.60	0.34	0.332
MDA (μm)	5.65	5.23	4.24	4.21	0.37	0.769

Different superscripts within 1 rows are significantly different ($p<0.05$), SEM[1]: Standard Error Means, [2]Overall treatment p-value

CONCLUSION

In view of the above findings and discussion, a conclusion could be drawn that YE supplementation (200, 400 and 600 mg kg^{-1}) did not affect growth performance but improved the immunity responses, in addition, rabbits fed diet supplemented with medicinal plant had lower ammonia in blood and MDA in liver and increased hepatic antioxidant activity.

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