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Research Article
Efficiency of Utilization of Sugar Beet Tops Hay and Prebiotic in Diets of Growing Rabbits

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Abstract
Background: The challenge for the feed formulation is to obtain the least cost diets that fully match the animal requirements. In Egypt, large amounts of sugar beet tops are produced. Using such an agricultural by-product as a feed ingredient for fattening rabbits can participate in solving the problem of feedstuffs' shortage and reduce the environmental pollution. **Materials and Methods:** A factorial experiment (3×2) was carried out to investigate the potential of including Sugar Beet Tops (SBT) in diets of growing New Zealand white rabbits at three levels (0.0, 20 and 30%) as a substitute for alfalfa hay in presence (1.0 g kg^{-1}) or absence of a prebiotic. Fifty four rabbits were randomly distributed to six groups, each with three replications. Six experimental diets were formulated and fed to rabbits from 6-12 weeks of age. All rabbits were reared under similar hygienic and managerial conditions. The response of rabbits was evaluated as growth performance, carcass characteristics and blood plasma constituents. **Results:** Replacing dietary alfalfa hay with SBT produced positive effects on growth performance of rabbits although feed intake was higher than that of the control group, irrespective of the added prebiotic. Similarly, rabbits fed the prebiotic-supplemented diets displayed superior growth performance to that of the control group. Apart from prebiotic addition, feeding the SBT-diets significantly increased Carcass Yield (CY) and Total Edible Parts (TEP) but reduced the Abdominal Fat (AF) of rabbits. Dietary prebiotic supplementation caused positive effects on the percentages of CY, TEP and AF weight of rabbits. Neither dietary SBT level nor added probiotic adversely affected the blood plasma constituents measured herein. Dietary SBT level by added prebiotic interactions were not significant for all criteria measured. **Conclusion:** It is concluded that SBT can completely replace alfalfa hay in growing rabbits' diets with better performance and carcass traits, prebiotic performs further improvements in rabbit growth, feed conversion and dressing-out percentage.

Key words: Dietary sugar beet tops, prebiotic, rabbit's growth, carcass characteristics, blood constituents

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Raising the semi-ruminant animals such as rabbits is considered to be one of the possible ways to solve the large shortage in meat production worldwide, particularly in the developing countries. It is well known that the feeding cost represents about 60-70% of the total cost of rabbit production. The challenge for the feed formulation is to obtain the least cost diets that fully match the animal requirements. Minimizing the feed cost could be achieved through the use of untraditional cheaper feed ingredients or improving the utilization of common feeds by using some feed additives. Sugar beet cultivation has been increased in Egypt during the last three decades, being 186,000 acres yearly. In Egypt, about 1.5 million tons of sugar beet tops are produced yearly. Using such an agricultural by-product as a feed ingredient for fattening rabbits can participate in solving the problem of feedstuffs' shortage and reduce the environmental pollution. Recently, some studies were designed to utilize some agricultural and agro-industrial by-products in rabbit feeding, especially as alternatives to clover hay or alfalfa hay, which commonly represents about 30-40% of the complete pelleted diets of rabbits[1-3].

Prebiotics are indigestible food ingredient(s) that beneficially affects host animal by selectively stimulating the growth and/or activity of one or a limited number of useful bacteria in the colon[4]. Most interest in the development of prebiotics has been focused on the use of indigestible oligosaccharides and polysaccharides which cannot be digested but are readily fermented by anaerobic colonic bacteria[5]. Prebiotics have shown considerable promise in promoting health and performance of rabbits[6,7]. There are few studies on the use of probiotics and prebiotics in rabbit nutrition. Therefore, this study was designed to investigate the growth performance, carcass traits and selected blood parameters of growing rabbits fed diets containing sugar beet tops hay without or with prebiotic.

MATERIALS AND METHODS

An experiment was carried out at the Rabbit Research Unit, Agricultural Research and Experiment Station, Faculty of Agriculture, Mansoura University. The chemical analysis of the tested materials and the experimental diets were undertaken at the Laboratory of Poultry Production Department, Faculty of Agriculture, Mansoura University, Egypt. The objective of the present study was to evaluate the effects of feeding three dietary levels (0.0, 20 and 30%) of dried sugar beet tops with or without a prebiotic (Perfect) on the growth performance of New Zealand White (NZW) rabbits from 6-12 weeks of age. The aim extended also to investigate the effects of feeding the sugar beet tops-containing diets in presence or absence of Perfect on carcass traits and certain blood plasma constituents of rabbits.

Processing of dried sugar beet tops: Sugar beet (*Beta vulgaris* L.) belongs to the family Chenopodiaceae which is grown in Egypt to get its fruits for sucrose extraction. Sugar Beet Tops (SBT) were manually harvested from a private farm (Dakahlia governorate), air-dried and ground before mixing with other feed components to formulate the experimental pelleted diets.

Experimental animals and diets: The chemical analysis of dried SBT and Alfalfa Hay (AH, the third cutting), using duplicate samples were done according to the official methods of analysis (AOAC)[8]. The nutrient composition of SBT was 88% Dry Matter (DM), 12.70% Crude Protein (CP), 21.02% Crude Fiber (CF), 0.57% Ether Extract (EE), 18.75% ash, 46.96% Nitrogen Free Extract (NFE), 0.34% calcium (Ca) and 0.045% total phosphorus (DM basis), the corresponding values for AH were 90.00, 15.30, 27.00, 2.40, 8.90, 46.40, 1.35 and 0.27%, respectively. In this study, 6 weeks old 54 unsexed NZW rabbits, with nearly similar initial live body weights were randomly distributed in a factorial arrangement of treatments to six equal experimental groups, each with three replications. Six experimental pelleted diets were formulated to meet the nutrient requirements of growing rabbits, as recommended by the NRC[9]. Alfalfa hay content of the control diet was replaced by 0.0, 20 or 30% of SBT (equivalent to replacement ratios of 0.0, 50 or 75% of AH) in presence (1.0 g kg^{-1}) or absence of perfect (a prebiotic) addition. As stated by the manufacturer, the prebiotic added (Perfect) is a buffered blend of specific carboxylic acids on a unique mineral carrier system combined with a fructo-oligosaccharide source. The ingredient composition and nutrient contents of the experimental diets are presented in Table 1.

Housing and management: Each replicate group of rabbits (3 animals) was kept in a galvanized wire-cage ($50\times50\times45$ cm) and provided with a feeder and a nipple drinker and fed their respective experimental diet from 6-12 weeks of age. All experimental rabbits were kept in a naturally ventilated building and subjected to similar environmental, managerial and hygienic conditions. Pelleted feed and fresh water were provided on an *ad libitum* basis.

Table 1: Composition and nutrient contents of the experimental diets of growing rabbits from 6-12 weeks of age

		SBT	
Ingredients	Control	20%	30%
Soybean meal (44% CP)	12.00	14.00	14.50
Yellow corn	14.25	8.00	7.00
Wheat bran	3.00	7.00	10.50
Barley grain	26.20	26.20	23.20
Alfalfa hay	40.00	20.00	10.00
Sugar Beet Tops (SBT)	0.00	20.00	30.00
Molasses	2.00	2.00	2.00
Dicalcium phosphate	1.20	1.20	1.20
Limestone	0.60	0.80	0.75
Vit. Min. Premix[§]	0.40	0.40	0.40
Sodium chloride	0.20	0.20	0.20
DL-methionine	0.15	0.20	0.25
Total	100.00	100.00	100.00
Calculated analyses: As fed basis[9 ¶]			
Digestible energy (kcal kg^{-1})	2534.00	2542.00	2547.00
Crude protein (%)	16.20	16.34	16.32
Crude fiber (%)	13.67	12.43	11.85
Ether extract (%)	2.26	1.82	1.69
Lysine (%)	0.76	0.69	0.65
Meth. (%)	0.36	0.39	0.43
Meth.+Cyst. (%)	0.67	0.64	0.65
Calcium (%)	1.12	1.00	0.88
Total phosphorus (%)	0.57	0.57	0.58
Determined analyses: As DM basis[8]			
Dry matter (%)	92.00	91.11	91.05
Organic matter (%)	83.10	82.09	81.62
Crude protein (%)	17.61	17.93	17.92
Crude fiber (%)	14.86	13.64	13.02
NDF (%)	80.41	76.34	77.14
ADF (%)	18.19	14.54	15.72
ADL (%)	3.62	2.36	2.74
Ether extract (%)	2.75	2.00	1.86
Ash (%)	8.90	9.02	9.43
Nitrogen free extract (%)	55.85	57.41	57.77

[§]Each 3 kg premix contained 12,000,000 IU vitamin A, 2,500,000 IU vitamin D_3, 10,000 mg vitamin E, 2500 mg vitamin K_3, 1000 mg vitamin B_1, 4000 mg vitamin B_2, 1500 mg vitamin B_6, 10 mg vitamin B_{12}, 10,000 mg pantothenic acid, 20,000 mg nicotinic acid, 1000 mg folic acid, 50 mg biotin, 500 mg choline chloride, 60 mg manganese, 55 mg zinc, 100 mg selenium, 1000 mg Iodine, 35 mg Iron, 10 mg copper, 250 mg cobalt and carrier $CaCO_3$ to 3 kg. [¶]Calculated analyses are based on NRC[9], except for test materials on actual nutrient determination. NDF: Nutrient detergent fiber, ADF: Acid detergent fiber and ADL: Acid detergent lignin

Growth performance of rabbits: Individual Live Body Weights (LBW) of rabbits were recorded at the beginning of the experiment (6 weeks old) and on a weekly basis thereafter until the end of experiment (12 weeks of age). Weekly records on Feed Intake (FI) and Body Weight Gain (BWG) of rabbits were also maintained on a replicate group basis. Accordingly, Feed Conversion Ratio (FCR) was calculated as the amount of feed consumed per unit of BWG. Relative Growth Rate (RGR) for the entire experimental period was also calculated as BWG times 100 divided by the mean of initial and final LBW of rabbits. Mortality of rabbits was monitored and recorded daily throughout the duration of this study.

Carcass traits of rabbits: At the end of the experiment (12 weeks of age), three rabbits from each treatment were randomly chosen and slaughtered after fasting for 18 h. Just after estimating live body weight at slaughter (LBW), rabbits were carefully sacrificed, skinned and emptied. The individual weights of Fur Plus Legs (FPL), Carcass Yield (CY, including head), liver (LI), heart (HE), kidneys (KI), lungs (LU), spleen (SP) and Abdominal Fat (AF) were recorded. The Total Edible Parts (TEP) were calculated as EC plus total giblets (i.e., the sum of liver, heart and kidneys). Relative weights of EC, liver, heart, kidneys, lungs, spleen, fur plus legs and TEP were also calculated.

Blood parameters of rabbits: At 12 weeks of age, three blood samples per experimental group of rabbits were taken during slaughtering in heparinized test tubes. Blood samples were immediately centrifuged at 3000 rpm for 15 min in order to separate blood plasma. Plasma samples were frozen at -20°C until later analysis. The concentrations of glucose (GLU)[10], total protein (TPR)[11], albumin (ALB)[12], triglycerides (TRI)[13], total cholesterol (CHO)[14] and high density lipoprotein-cholesterol (HDL-C)[15] were determined in blood plasma using commercial kits. Blood plasma level of low density lipoprotein-cholesterol (LDL-C) was also estimated by using the equation of Friedewald[16], as follows:

$$\text{LDL-C} = \text{Total cholesterol-(HDL-C+VLDL)}$$

where, VLDL are very low-density lipoprotein which was calculated as concentration of plasma triglycerides divided by 5.

Statistical analysis: Data were statistically analyzed using two-way analysis of variance of SAS program[17]. Significant differences among means ($p \leq 0.05$) were separated using Duncan's multiple range test[18].

RESULTS AND DISCUSSION

Performance of growing rabbits: It was interesting to note that no morbidity or mortality of rabbits were observed during the course of this study.

Effect of dietary SBT level: The effects of replacing dietary alfalfa hay with dried Sugar Beet Tops (SBT) with or without a prebiotic on growth performance of rabbits are given in Table 2. These results showed that initial body weights of New Zealand White (NZW) rabbits were similar with no significant differences ($p > 0.05$) among the different experimental groups. Apart from dietary prebiotic addition, it was observed that final Live Body Weights (LBW) and Body Weight Gains (BWG) of rabbits were positively affected ($p \leq 0.05$) due to feeding the diets containing 20 or 30% SBT as compared to those of the control group (0% SBT). During the whole experimental period (6-12 weeks old), Feed Intake (FI) of rabbits fed the diets containing 20 or 30% SBT (50 or 75% replacement values of alfalfa hay) was significantly higher ($p \leq 0.05$) than that of the control group, irrespective of dietary prebiotic supplementation. However, it was interesting to note that rabbits fed the diets containing 20 or 30% SBT achieved superior Relative Growth Rate (RGR) and Feed Conversion Ratio (FCR) to those of the control group, regardless of dietary prebiotic addition.

The observed improvements in total BWG, FCR and RGR of rabbits fed the 20% SBT-diet, relative to those of the control group were estimated to be 18.0, 14.2 and 8.2%, respectively, the corresponding improvements for rabbits fed the 30% SBT-diet were 20.0, 14.7 and 9.0%, respectively. The estimated relative increases in FI of rabbits fed the diets containing 20 and 30% SBT were 1.95 and 2.85% compared with their control counterparts. This means that the improvements in BWG and RGR, observed herein are partly due to an increase in feed consumption of rabbits but other factors might played a major growth-promoting role. In this respect, Tag El-Din *et al.*[19] reported that feeding the SBT-diets caused positive effects on nutrient digestibility and the nutritive values of diets, as measured by percentages of total digestible nutrients and digestible crude protein and digestible energy. The superior FCR of rabbits fed the SBT-containing diets to that of the control rabbits is mainly attributable to the observed improvement in BWG of the former compared with the latter.

Table 2: Performance of growing NZW rabbits as affected by dietary level of sugar beet tops (SBT) and prebiotic supplementation from 6 to 12 weeks of age

Treatments	Initial LBW (kg)	Final LBW (kg)	Total BWG (kg)	RGR (%)	Total FI (kg)	FCR (kg:kg)
SBT level (A)						
0.00% A1	0.683	1.868^{c}	1.185^{b}	92.9^{c}	3.648^{b}	3.100^{b}
20.0% A2	0.685	2.084^{b}	1.399^{a}	101.1^{b}	3.719^{a}	2.660^{a}
30.0% A3	0.684	2.104^{a}	1.419^{a}	101.9^{a}	3.752^{a}	2.644^{a}
SEM	0.003	0.006	0.007	0.045	0.003	0.016
Significance	NS	*	*	*	*	*
Prebiotic (B)						
B1 (0.0 g kg^{-1})	0.683	1.910^{b}	1.227^{b}	94.6^{b}	3.633^{b}	2.961^{b}
B2 (1.0 g kg^{-1})	0.685	2.127^{a}	1.441^{a}	102.6^{a}	3.746^{a}	2.600^{a}
SEM	0.002	0.005	0.006	0.042	0.002	0.013
Significance	NS	*	*	*	*	*
AB interaction						
SEM	0.004	0.009	0.01	0.051	0.004	0.023
Significance	NS	NS	NS	NS	NS	NS

LBW: Live body weight, BWG: Body weight gain, RGR: Relative growth rate, FI: Feed intake, FCR: Feed conversion ratio, [a-c]Means in the same column bearing different superscripts are significantly different ($p \leq 0.05$), NS: Not significant, *Significant at $p \leq 0.05$

The improved growth performance, reported herein, harmonizes with the findings of Gaafar *et al.*[3], who found that replacing dietary berseem hay with ensiled sweet potato vines produced beneficial effects on LBW and BWG of rabbits as compared to their control counterparts. Similarly, Galal *et al.*[2] reported that rabbits fed diets containing dried strawberry vines up to 40% of clover hay displayed better LBW, daily BWG and daily FI while feed conversion was not affected compared with the control rabbits.

However, Gaafar *et al.*[20] observed no significant differences in final LBW or BWG of rabbits fed diets in which sugar beet tops hay completely replaced berseem hay but feed intake was reduced while feed conversion was improved compared with the control group. Similar results were also obtained by Abo El-Maaty *et al.*[1], who evaluated the effects of partial or complete substitution of Cucumber Vines Straw (CVS) for dietary clover hay on growth performance of rabbits. They reported that rabbits fed the diets containing up to 22.5% CVS (equivalent to a replacement value of 75% of clover hay) achieved comparable growth performance to those of the control group. In an early study, Tag El-Din *et al.*[19] also observed that partial or complete replacement of dietary clover hay with SBT had no significant effect on final LBW, daily BWG or daily FI but feed conversion was negatively affected.

Effect of prebiotic supplementation: Apart from dietary SBT level, added dietary prebiotic had a positive effect ($p \leq 0.05$) on final LBW, BWG, FCR and RGR of NZW rabbits, although FI of rabbits fed the prebiotic-supplemented diets was significantly higher ($p \leq 0.05$) than that of the control ones (Table 2). In harmony with the present results, Abo El-Maaty *et al.*[1] reported that dietary supplementation with a prebiotic (mannan oligosaccharide) exerted a beneficial effect on growth performance of rabbits fed the diet in which cucumber vines straw completely replaced clover hay. The present results concur also with those of Amber *et al.*[21], who found that growth performance of rabbits was positively affected in response to dietary supplementation with prebiotic. In rabbits, however, prebiotics should create unfavorable conditions for pathogenic microorganisms in the caecum[22], such a role seems to be depended mainly on type and dose of the added prebiotic, diet composition and hygienic conditions of the animals.

It is generally accepted that prebiotics, as indigestible feed components can have a beneficial action because of selective stimulation of the growth or metabolic activity of a limited number of intestinal microbiota species, such as bifidobacteria and *Lactobacillus* spp. Gibson and Roberfroid[23], thus they may have a similar mechanism of action as probiotics[24]. However, Kocher[25] indicated that mannan oligosaccharide-based prebiotic (MOS) is thought to act mainly by preventing colonization more than by stimulating beneficial microorganisms[26]. In this regard, Falcao-e-Cunha *et al.*[22] clarified that many pathogens have fimbriae which specifically attach to the mannose residues of the enterocyte receptors and by connecting to MOS instead will not attach to the mucosa. In poultry, the proposed mechanism by which prebiotics produce their effects are: (1) Growth inhibition of harmful intestinal microbes, (2) Increased intestinal acidity, (3) Growth stimulation of intestinal absorptive cells and (4) Stimulation of the enteric immune system, thus facilitating better performance and health status of the birds[6,27]. Dietary SBT by added prebiotic interactions were not significant ($p > 0.05$) for all growth performance criteria investigated herein.

Carcass traits of rabbits

Effect of dietary SBT level: Data on carcass traits of rabbits fed diets containing 20 or 30% SBT (to replace 50 or 75% of alfalfa hay) with or without prebiotic supplementation are presented in Table 3. Irrespective of prebiotic addition, feeding the diets containing 20 or 30% SBT significantly increased CY and TEP ($p \leq 0.05$) but significantly decreased the relative weights of FPL ($p \leq 0.01$), KI ($p \leq 0.01$) and LU ($p \leq 0.05$), as well as the absolute weight of AF ($p \leq 0.01$), however, other carcass traits investigated here were not affected.

The improvement in CY and TEP of rabbits, reported in the present study, due to feeding the SBT-containing diets agrees with the findings of Galal *et al.*[2], who reported that rabbits fed diets containing dried strawberry vines instead of clover hay achieved significantly higher slaughter weight (hot carcass weight plus edible organs) while other carcass traits were not affected compared with the control rabbits. The present results are in line also with those of Abo Egla *et al.*[28], who evaluated the effects of partial or complete substitution of Cucumber Vines Straw (CVS) for dietary clover hay on carcass characteristics of rabbits and found that carcass traits of rabbits fed the diets containing up to 22.5% CVS (equivalent to a replacement value of 75% of clover hay) were comparable to those of the control group but when the dietary level of CVS reached 30% (completely replaced clover hay) the relative weights of empty carcass and total edible parts were negatively affected. However, Gaafar *et al.*[20] observed no significant differences in carcass traits of rabbits fed diets in which sugar beet tops hay completely replaced berseem hay compared with the control group. Similar results were obtained by Gaafar *et al.*[3], who reported that replacing dietary

Table 3: Carcass traits of 12 weeks old NZW rabbits as affected by dietary level of Sugar Beet Tops (SBT) and prebiotic supplementation

Treatments	LBW (kg)	CY (%)	LI (%)	HE (%)	KI (%)	TEP (%)	FPL (%)	SP (%)	LU (%)	AF (g)
SBT level (A)										
0.00% A1	1.884[c]	55.09[b]	3.52	0.237	0.745[a]	67.59[b]	16.99[a]	0.077	0.816[a]	18.65[a]
20.0% A2	2.079[b]	56.53[a]	3.26	0.238	0.590[b]	70.62[a]	14.12[b]	0.082	0.721[a]	15.30[b]
30.0% A3	2.100[a]	56.94[a]	2.86	0.203	0.599[b]	70.60[a]	13.35[b]	0.076	0.571[b]	15.12[b]
SEM	0.005	0.241	0.22	0.025	0.039	0.262	0.464	0.02	0.044	0.385
Significance	*	*	NS	NS	**	*	**	NS	*	**
Prebiotic (B)										
(0.0 g kg^{-1}) B1	1.915[b]	55.14[b]	3.4	0.239	0.695_a	69.47[b]	15.26	0.093	0.71	19.00[a]
(1.0 g kg^{-1}) B2	2.126[a]	57.23[a]	3.03	0.213	0.595[b]	71.07[a]	14.38	0.063	0.695	13.71[b]
SEM	0.004	0.197	0.18	0.021	0.032	0.201	0.379	0.016	0.036	0.315
Significance	*	*	NS	NS	**	*	NS	NS	NS	**
AB interaction										
SEM	0.007	0.341	0.311	0.036	0.055	0.352	0.657	0.029	0.062	0.545
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SY: Carcass yield, LI: Liver, HI: Heart, KI: Kidneys, TEP: Total edible parts, FPL: Fur plus legs, SP: Spleen, LU: Lungs, AF: Abdominal fat weight, NS: Not significant, *Significant at $p \leq 0.05$, **Significant at $p \leq 0.01$, [a-c]Means in the same column bearing different superscripts are significantly different ($p \leq 0.05$)

berseem hay with ensiled sweet potato vines had no significant effects on carcass traits of rabbits as compared to their control counterparts.

Effect of prebiotic supplementation: Dietary prebiotic supplementation produced positive effects on the percentages of CY and TEP and AF weight ($p \leq 0.01$) of rabbits but significantly reduced ($p \leq 0.01$) the KI percentage, regardless of the effects of dietary SBT level (Table 3). However, added dietary prebiotic did not affect the relative weights of FPL, LI, SP, LU or HE of rabbits. The positive effect of added dietary prebiotic on CY, TEP and AF, found in this study, harmonizes with the results of Attia *et al.*[29], who reported that intermittently administered mannan oligosaccharides (MOS) produced a significant increase in dressing percentage of rabbits while its continuous administration caused a significant reduction in the fat content of rabbit meat. They also found that MOS administration by the two protocols led to significant increases in tenderness and water holding capacity of rabbit meat as compared to the control group. The present results are in harmony also with the findings of Amber *et al.*[21], who reported that carcass percentage of rabbits was positively affected by dietary supplementation with prebiotic but the relative weight of giblets was not affected. However, other researchers failed to detect any positive effect of dietary prebiotic supplementation on carcass characteristics of rabbits[30-33]. The responsiveness of rabbits to added dietary prebiotic can depend on many factors such as nature and dose of the prebiotic, experimental protocol, age and gut health status of rabbits and the hygienic conditions of animals as well as diet composition, particularly dietary fiber constituents[22]. The interactions between dietary level of SBT and prebiotic were not significant for all carcass traits examined in this study.

Blood parameters of rabbits

Effect of dietary SBT level: The effects of feeding diets containing 20 or 30% SBH to replace 50 or 75% of dietary alfalfa hay) on blood plasma parameters of NZW rabbits are illustrated in Table 4. It was observed that feeding the SBT-containing diets did not alter plasma concentrations of total protein, albumin, triglycerides, total cholesterol, HDL-C or LDL-C of 12 weeks old NZW rabbits compared with the control group, irrespective of added dietary prebiotic. But rabbits fed the diet containing the highest level of SBT (30%) exhibited significantly higher ($p \leq 0.05$) blood plasma level of globulin than that of their control counterparts. These results may indicate that complete replacement of dietary alfalfa hay with SBT is safe and had no adverse effect on the metabolic functions or the health status of rabbits, since no morbidity or mortality were observed during the course of this study.

The absence of significant differences in most blood plasma parameters of rabbits, observed in the present study, in harmony with the findings of Galal *et al.*[2], who reported that replacing dietary clover hay with dried strawberry vines did not significantly affect the plasma concentrations of total protein, albumin, globulin, glucose, total lipids, cholesterol or creatinine. Similar results were obtained by Elgohary and Abo El-Maaty[33], who found that replacing the clover hay in rabbit diets with *Phaseolus vulgaris* straw had no significant effect on blood plasma constituents (total protein, albumin, total lipids, cholesterol and creatinine).

Effect of prebiotic supplementation: The results presented in Table 4 indicated that dietary supplementation with prebiotic caused significant increases ($p \leq 0.05$) in blood plasma concentrations of total protein and globulin of rabbits but had no significant effect ($p > 0.05$) on plasma levels of albumin, triglycerides, total cholesterol, HDL-C or LDL-C,

Table 4: Blood plasma constituents of 12 weeks old NZW rabbits as affected by dietary level of Sugar Beet Tops (SBT) and prebiotic supplementation

Treatments	TPR (g dL^{-1})	ALB (g dL^{-1})	GLO (g dL^{-1})	TRI (mg dL^{-1})	CHO (mg dL^{-1})	HDL-C (mg dL^{-1})	LDL-C (mg dL^{-1})
SBT level (A)							
0.00% A1	5.37	3.08	2.29[b]	44.28	63.5	22.48	32.16
20.0% A2	5.62	3.32	2.30[b]	43.43	62.63	21.77	32.18
30.0% A3	5.94	3.21	2.73[a]	45.13	64.17	22.43	32.71
SEM	0.05	0.07	0.08	1.02	1.11	0.5	0.34
Significance	NS	NS	*	NS	NS	NS	NS
Prebiotic (B)							
(0.0 g kg^{-1}) B1	5.14[a]	3.22	1.92[b]	43.67	63.39	22.19	32.47
(1.0 g kg^{-1}) B2	5.81[b]	3.18	2.63[a]	44.9	63.48	22.27	32.23
SEM	0.04	0.06	0.069	0.83	0.91	0.4	0.27
Significance	*	NS	*	NS	NS	NS	NS
AB interaction							
SEM	0.07	0.1	0.12	1.44	1.57	0.7	0.47
Significance	NS	NS	NS	NS	NS	NS	NS

TPR: Total protein, ALB: Albumin, GLO: Globulin, TRI: Triglycerides, CHO: Total cholesterol, HDL-C: High density lipoprotein-cholesterol, LDL-C: Low density lipoprotein-cholesterol, NS: Not significant, *Significant at $p \leq 0.05$, [a-b]Means in the same column bearing different superscripts are significantly different ($p \leq 0.05$)

regardless of dietary SBT level. The increased level of plasma globulin of rabbits fed the prebiotic-supplemented diets in this study is in line with the perspective of Attia *et al.*[29] that the increased total antioxidant capacity of rabbits induced by administration of MOS is an indication to a reduced oxidative stress in rabbits and an improvement in the general health status of the animals. In this regard, Abdelhady and El-Abasy[34] concluded that dietary supplementation of prebiotic, probiotic and their mixture the cell-mediated immune response of rabbits.

The lack of a significant effect of dietary prebiotic supplementation on most blood plasma constituents of rabbits, noticed in this study is in agreement with the results obtained by Elgohary and Abo El-Maaty[33], who found that blood plasma constituents of rabbits were not influenced by feeding prebiotic-supplement diets. The present results are also in partial agreement with those obtained by Attia *et al.*[29], who reported that MOS administration to rabbits did not significantly affect plasma concentrations of total protein, albumin, globulin, glucose, total cholesterol and total lipids. Apart from the effect of dietary treatments, the reported means of blood constituents of rabbits in the present study fell within the normal physiological range[35]. The interactions between added prebiotic and dietary level of SBT were not significant for all blood plasma parameters measured in this study.

CONCLUSION

In conclusion, SBT can completely replace alfalfa hay in growing rabbits' diets with better performance and carcass traits; prebiotic performs further improvements in rabbit growth, feed conversion and dressing-out percentage.

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REFERENCES

1. Abo El-Maaty, H.M.A., E.S.H.A. Abo Egla, E.M. Qota and S.M. El-Desouky, 2014. Performance and economical efficiency of growing New Zealand white rabbit fed cucumber (*Cucumis sativus* L.) vines straw without or with some feed additives under Egyptian conditions. Egypt. Poult. Sci., 34: 413-431.
2. Galal, H.M.F., M.A. El Menniawy, M.H. Abo-Fadel, A.A. Khir and S.N. Abdel-Azeam, 2014. Some nutritional studies on using strawberry (Fragaria × Ananas) vine as hay in rabbit ration. J. Anim. Poult. Prod. Mansoura Univ., 5: 635-647.
3. Gaafar, H.M.A., A.I.A. Abd El-Lateif and S.B. Abd El-Hady, 2014. Effect of partial replacement of berseem hay by ensiled and dried sweet potato vines on performance of growing rabbits. Rep. Opin., 6: 60-66.
4. Gibson, G.R., H.M. Probert, J. van Loo, R.A. Rastall and M.B. Roberfroid, 2004. Dietary modulation of the human colonic microbiota: Updating the concept of prebiotics. Nutr. Res. Rev., 17: 259-275.
5. Mussatto, S.I. and I.M. Mancilha, 2007. Non-digestible oligosaccharides: A review. Carbohydr. Polym., 68: 587-597.
6. Fonseca, A.P., L. Falcao, A. Kocher and P. Spring, 2004. Effect of dietary mannan oligosaccharide in comparison to oxytetracyclin on performance of growing rabbits. Proceedings of the 8th World Rabbit Congress, September 7-10, 2004, Puebla, Mexico, pp: 829-833.

7. Pinheiro, V., C.M. Guedes, D. Outor-Monteiro and J.L. Mourao, 2009. Effects of fibre level and dietary mannanoligosaccharides on digestibility, caecal volatile fatty acids and performances of growing rabbits. Anim. Feed Sci. Technol., 148: 288-300.
8. AOAC., 2000. Official Methods of Analysis. 17th Edn., Association of Official Analytical Chemistry, Arlington, Virginia, USA.
9. NRC., 1977. Nutrient Requirement of Rabbits. 2nd Edn., National Research Council, Washington, DC., USA.
10. Trinder, P., 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann. Clin. Biochem., 6: 24-27.
11. Doumas, B.T., D.D. Bayse, R.J. Carter, T. Peters Jr. and R. Schaffer, 1981. A candidate reference method for determination of total protein in serum. I. Development and validation. Clin. Chem., 27: 1642-1650.
12. Doumas, B.T., W.A. Watson and H.G. Biggs, 1971. Albumin standards and the measurement of serum albumin with bromcresol green. Clinica Chimica Acta, 31: 87-96.
13. Fossati, P. and L. Prencipe, 1982. Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. Clin. Chem., 28: 2077-2080.
14. Allain, C.C., L.S. Poon, C.S.G. Chan, W. Richmond and P.C. Fu, 1974. Enzymatic determination of total serum cholesterol. Clin. Chem., 20: 470-475.
15. Sawle, A., M.K. Higgins, M.P. Olivant and J.A. Higgins, 2002. A rapid single-step centrifugation method for determination of HDL, LDL and VLDL cholesterol and TG and identification of predominant LDL subclass. J. Lipid Res., 43: 335-343.
16. Friedewald, W.T., R.I. Levy and D.S. Fredrickson, 1972. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin. Chem., 18: 499-502.
17. SAS., 2004. SAS® User's Guide for Personal Computer. SAS Institute Inc., Cary, NC., USA.
18. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
19. Tag El-Din, H.T., A.S.H. Abo-Egla, F.S.A. Ismail and S.S. Samy, 2000. Utilization of sugar beet tops in feeding rabbits. Egypt. J. Rabbit Sci., 10: 223-228.
20. Gaafar, H.M.A., A.I.A. Abd El-Lateif and S.B. Abd El-Hady, 2010. Effect of partial replacement of berseem hay by ensiled and dried sugar beet tops on performance of growing rabbits. Researcher, 2: 10-15.
21. Amber, K., F.M. Abd El-Nabi, W.A. Morsy and S.H.A. Morsy, 2014. Effect of dietary supplementation of probiotic and prebiotic on preventing post weaning digestive disorders and productive performance of growing rabbits. Egypt. Poult. Sci., 34: 19-38.
22. Falcao-e-Cunha, L., L. Castro-Solla, L. Maertens, M. Marounek, V. Pinheiro, J. Freire and J.L. Moura, 2007. Alternatives to antibiotic growth promoters in rabbit feeding: A review. World Rabbit Sci., 15: 127-140.
23. Gibson, G.R. and M.B. Roberfroid, 1995. Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotics. J. Nutr., 125: 1401-1412.
24. Huyghebaert, G., R. Ducatelle and F. van Immerseel, 2011. An update on alternatives to antimicrobial growth promoters for broilers. Vet. J., 187: 182-188.
25. Kocher, A., 2006. Interfacing Gut Health and Nutrition: The Use of Dietary Prebiotics and Probiotics to Maximise Growth Performance in Pigs and Poultry. In: Antimicrobial Growth Promoters: Where Do We Go From Here? Barug, D., J. de Long, A.K. Kies and M.W.A. Verstegen (Eds.). Wageningen Acad. Publ., Wageningen, The Netherlands, pp: 289-310.
26. Chen, W.L., J.B. Liang, M.F. Jahromi, N. Abdullah, Y.W. Ho and V. Tufarelli, 2015. Enzyme treatment enhances release of prebiotic oligosaccharides from palm kernel expeller. BioResources, 10: 196-209.
27. Sethiya, N.K., 2016. Review on natural growth promoters available for improving gut health of poultry: An alternative to antibiotic growth promoters. Asian J. Poult. Sci., 10: 1-29.
28. Abo Egla, E.S.H.A., H.M.A. Abo El-Maaty, E.M. Qota, S.M. El-Desouky, 2013. Effects of replecing clover hay by cucumber (*Cucumis sativus* L.) vines straw without or with natuzyme or prebiotic contaning manan oligosaccharide in NZW rabbit diets on nutrient digestibility, caecal, carcass characteristies and some blood constituents. J. Anim. Poult. Prod. Mansoura Univ., 4: 79-96.
29. Attia, Y.A., R.S. Hamed, A.E. Abd Al-Hamid, M.A. Al-Harthi, H.A. Shahba and F. Bovera, 2015. Performance, blood profile, carcass and meat traits and tissue morphology in growing rabbits fed mannanoligosaccharides and zinc-bacitracin continuously or intermittently. Anim. Sci. Pap. Rep., 33: 85-101.
30. Ewuola, E.O., C.U. Amadi and T.K. Imam, 2011. Performance evaluation and nutrient digestibility of rabbits fed dietary prebiotics, probiotics and symbiotics. Int. J. Applied Agric. Apicult. Res., 7: 107-117.
31. Bovera, F., A. Lestingi, F. Iannaccone, A. Tateo and A. Nizza, 2012. Use of dietary mannanoligosaccharides during rabbit fattening period: Effects on growth performance, feed nutrient digestibility, carcass traits and meat quality. J. Anim. Sci., 90: 3858-3866.
32. Tazzoli, M., G. Xiccato, A. Trocino, D. Majolini and N. El Abed *et al*., 2012. Dietary supplementation with mannan oligosaccharides and B-glucans in growing rabbits. 1. Growth performance, health status and carcass traits. Proceedings of the 10th World Rabbit Congress, September 3-6, 2012, Sharm El-Sheikh, Egypt, pp: 547-551.

33. Elgohary, F.A. and H.M.A. Abo El-Maaty, 2014. *Phaseolus vulgaris* straw as a substitute for clover hay in rabbit diets with prebiotic supplementation and feed restriction interaction: Influence on nutrient utilization, caecal activity, carcass yield and blood plasma constituents. Global Veterinaria, 13: 1010-1021.
34. Abdelhady, D.H. and M.A. El-Abasy, 2015. Effect of prebiotic and probiotic on growth, immuno-hematological responses and biochemical parameters of infected rabbits with *Pasteurella multocida*. Benha Vet. Med. J., 28: 40-51.
35. Ozkan, C., A. Kaya and Y. Akgul, 2012. Normal values of haematological and some biochemical parameters in serum and urine of New Zealand White rabbits. World Rabbit Sci., 20: 253-259.