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Effect of Feeding Rations Containing Different Levels of Biologically Treated Rice Straw on Caecum Microbial Activity and Blood Parameters of Growing White New Zealand Rabbits

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Abstract: The aim of the present study was to investigate the effects of biological treatments of rice straw with or without *Pleurotus ostreatus* on caecum microbial activity and blood constituents of rabbits. A total number of 42 weaned New Zealand white rabbits; six weeks of age; were divided randomly into seven experimental groups of six rabbits in each. Each group divided into three replicates of two rabbits in each. The first group was fed on the control diet; the other six groups were fed diets containing rice straw which replaced clover hay at the levels of 0, 33, 66 and 100% biologically treated with or without *Pleurotus ostreatus.* The experimental period lasted for 13 weeks. At the end of the experimental period, the rabbits were slaughtered and blood samples were collected in heparinized tubes for biochemical analysis. Caecal microbial counts were estimated. Total bacteria, fungi, actinomyces and cellulolytic bacteria count tended to be higher when animals fed increasing level of biologically treated rice straw compared with those fed untreated rice straw and the control group. Blood analysis revealed significant ($p<0.05$) difference among treatments only in total proteins, aspartate transaminase (AST), urea, plasma alkaline phosphatase activity, creatinine, calcium, phosphorus, cholesterol and triglyceride concentrations besides catalase activity, total antioxidant capacity and lipid peroxide concentrations as indicator for oxidant/ antioxidant system. It could be concluded that replacement of 33% clover hay with biologically treated rice straw in growing rabbits rations caused an improvement in caecum microbiological activity and had no effective changes on the blood biochemical parameters.
Key words: Biological treatment - Rice Straw - Caecum Microbial -Blood- Parameters – Rabbits.

Introduction

In most of the undeveloped countries, such as in Egypt, animals suffer from shortage of feeds that are continuously increasing in the cost of feeding. However, at the same time many million tons of agricultural wastes and residues per year produced from processing of fruits and vegetables. However, in Egypt, there are about 25 million tons of plants residues produced annually. One of those residues is rice straw which is not utilized by many farmers either for bedding poultry farms or for livestock[1]. Such roughages are usually high in lignocellulose and low in available energy and also are generally low in readily available carbohydrate as well as nitrogen and certain minerals. Their utilization as bulky stuffs is also limited by the animals voluntary intake and their high cost of transport[2,3].

Hence due to the shortage of food in the world, several research projects were directed to increase the feeding values of low quality roughages and its utilization by physical, chemical and biological treatments[4-8]. Among those methods, biological treatments were considered to be the most effective one[9-11].

On the other hand, rabbit's production can contribute to solve the problem of meat shortage in Egypt. Since rabbits are characterized by rapid growth rate, short gestation period, high fertility rate, short generation intervals, high feed efficiency, and early marketing age moreover, it could be mentioned that rabbits meat has low cholesterol levels, high protein content and low total lipids[12] then The objective of the present trial were to investigate the effects of replacement clover hay with different levels (33, 66 and 100%) of biologically treated rice straw either treated or untreated with *Pleurotus ostreatus* on caecum microbial activity and blood parameters of growing rabbits.

Materials and Methods

The present study was carried out at the Nubaria Experimental Unit, Behira Governorate, and Laboratories of Animal Production, Agriculture Microbiology and Animal Reproduction and AI Departments, National Research Centre, Dokki, Giza, and Animal Production Dept., Faculty of Agriculture Mansoura University, Egypt.

1. Biological treatments

1.1. Microorganisms

Pleurotus ostreatus was obtained from Agriculture Microbiology Dept. National Research Centre, Dokki, Giza, Egypt.

1.2. Mycotoxin Determination

Thin layer chromatography for detection of mycotoxin of treated materials was applied according to the method described by[13, 14].

2. Degradation of rice straw by *Pleurotus ostreatus*

2.1. Preparation of substrate

Glass bottles of 120 ml capacity were used and thoroughly washed, dried for 10 min at 100°C and 25 g of the dried milled substrate was weighed into each bottle and 70 ml distilled water were added and each bottle was immediately covered with aluminum foil and sterilized in the autoclave at 121°C for 15 min. The treatment was run in triplicates.

2.2. Inoculation

Each bottle was inoculated at the center of the substrate with 2-10 mm mycelia disc and covered immediately. They were kept in the dark cupboard in the laboratory at 30°C and 100% relative humidity (RH). After 21 days of inoculation, the experimental bottles were harvested by autoclaving again to terminate the mycelia growth. Samples of the biodegraded samples were oven dried to constant weight and were kept for chemical analysis.

2.3. Biological treatments of rice straw

A heap of 160 kg of the tested chopped and crushed rice straw was moistened with medium contained, 2.5% molasses, 2.5% urea, 1.5% ammonium sulphate, 1.0% supper phosphate and 0.5% magnesium sulphate at solid: liquid (1:2). About 80 kg of each crop residues were used with the mixture of fermented fungal biomass

(6 kg *Pleurotus ostreatus*) and mixed well in mineral medium container, spread and mixed well on plastic sheet which contained the crop residues. The treated crop residues were shuffled upside down daily for the crop inoculation period (14 days). At the end of fermentation period, the treated crop residues were collected and exposed to sun-dry until the moisture content reached less than 10% then packed and stored until used in manufacturing the pelleted feed. In case of biologically treated rice straw, at the end of fermentation period (14 days), the *Pleurotus ostreatus* crop (mushroom) had been harvested before the traded rice straw was collected and sun dried. About 80 kg of rice straw was treated with above solution only (without *Pleuratus ostreatus* inoculants).

2.4. Manufacturing the pelleted feed

The air dried biologically treated or untreated crop residues have been transported to the forage manufacture for making the experimental pelleted feed by substitution of clover hay with biologically treated and untreated rice straw at the levels of 33%, 66% and 100% and mixing well with the other feed ingredients.

3. Experimental Diets

All the experimental diets were formulated to be approximately iso-nitrogenous and iso-caloric, to meet all the essential nutrient requirements of growing rabbits according to[15] recommendation.

The experimental diets were formulated as shown in (Table 1), the first diet represented the control without rice straw while in the other six diets, clover hay was replaced at the levels of 33, 66 and 100% by biologically treated rice straw with or without *Pleurotus ostreatus*.

Table (1): Composition and calculated chemical analysis of the experimental diets containing rice straw (on DM basis).

Ingredients	Experimental diets						
	Control CH	Without *Pleurotus ostreatus*			With *Pleurotus ostreatus*		
	0%	33%	66%	100%	33%	66%	100%
Clover hay	33.00	22.00	11.00	-	22.00	11.00	-
Yellow corn	15.71	21.25	28.85	39.25	21.16	28.75	38.75
Barley	14.50	14.50	13.50	2.50	14.50	13.50	2.50
Soybean meal	17.40	18.40	19.65	20.65	18.00	19.65	20.65
Wheat bran	16.50	9.50	1.25	0.60	10.00	1.25	0.60
Rice straw	-	11.00	22.00	33.00	11.00	22.00	33.00
Calcium Di-phos.,	2.05	2.50	2.85	3.05	2.50	2.85	3.05
Lime stone	0.10	0.10	0.10	0.10	0.10	0.20	0.60
Na Cl	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Premix *	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L.Meth	0.04	0.05	0.10	0.15	0.04	0.10	0.15
*Calculated***							
DE, Kcal/kg	2513	2496	2491	2453	2493	2445	2444
Ca, %	1.08	1.03	0.98	1.02	0.9	0.92	0.97
T.ph, %	0.80	0.82	0.79	0.80	0.85	0.80	0.82
Sodium, %	0.20	0.19	0.18	0.17	0.19	0.79	0.18
Lysin, %	0.89	0.83	0.77	0.72	0.86	0.4	0.71
Meth+, %	0.55	0.55	0.56	0.57	0.55	0.53	0.57

*Each kg of Vitamins and Minerals mixture contains Vit.A 2.000-000 IU, Vit. B, 0.33g, Vit B_2 1.09; Vit B_3 150.00 Iu , Vit E 8.33 g , Vit K 0.33 g, pantothenic acid, 3.33 g; Nicatonic acid 30.00g; Vit B_6 2.00 g; Vit. B_{12} 1.7 mg, Folic acid 0.039, Biotin 33 mg. Cu 0.50 g cholin chloride 200 mg, Mn 5.0 g; Fe 12.5 g, Mg 66.7 mg; Co 1.33 mg; Se 16.6 mg; Zn 11.9; Iodine 16.6 mg and Antioxidant 10.0 g.

** according to[15]. CH: Clover hay.

4. Experimental Animals

A total number of 42 weaned New Zealand white rabbits (6 weeks of age and about 500 g ± 90g average body weight) were randomly divided into 7 experimental groups of 6 rabbits in each. Each group divided into three replicates of two rabbits in each.

The first group was fed on the control diet. The other six groups were fed diets containing rice straw which replaced clover hay at the levels of 33%, 66% and 100% biologically treated with or without *Pleurotus ostreatus*.

All animals were kept under the same managerial and hygienic conditions and were housed in metal battery cages; two rabbits in each. Each replicate involved two and provide with feed and water *ad-lib*. at 27-28°C ambient temperature with natural light and ventilation. Feed troughs were nearly half full and were adjusted at a suitable height with special care taken to minimize feed scattering in front of rabbits. The experimental period lasted for 13 weeks (91 days).

5. Total counts of bacteria, fungi and actinomyces in caecum of rabbit

Immediately after slaughter, caecum of three rabbits per treatment were separated carefully to estimate the caecal microbial count. The serial dilution plate count procedure was used to estimate the total number of different groups of micro-organisms, namely, bacteria; fungi and actinomycetes. Three selective media were used for plate count. These were nutrient agar[16] for bacteria, Martin's medium[17] for fungi and glucose asparagine agar for actinomycetes. Plates were incubated at 28°C for mesophilic.

Fungal colonies were counted after 3 days; bacteria (7 days) and actinomyces colonies after 10 days and colonies of actinomyces have been distinguished by their characteristic growth, and by the use of straight needle and microscopic examination. Counts were presented per 1 g /oven dry weight of material.

5.1. Aerobic cellulose decomposers

The dilution method was used. Five tubes containing the different selective media were inoculated with 1.0 ml from each dilution. The most probable numbers of bacteria were obtained from the positive tubes using methods of[18].

Dubos' cellulose medium[17] was used for aerobic cellulose-decomposing organisms. In the positive tubes, the filter paper showed a yellowish brown colour and gradually lost its con chancy.

5.2. Utilization of carbon sources

Each of the following carbon sources was added to the glucose asparagine medium instead of glucose for testing the efficiencies of the isolates to utilize those carbon sources: glucose, xylose, arabinose, rhamliose, mannose, galactose, fructose, sucrose, lactose, raffinose, marvutol, inositol and salicil at the rate of 1 %. Agar plates were streaked and incubated for 4 days at 28°C for mesophilic.

Media

The media were used in the present investigation as described by[16, 17, 19, 20].

6. Blood samples and blood plasma analysis

At the end of the experimental period, the rabbits were fasted for 12 hours, before sacrificing according to the Islamic rules. The animals were weighed individually to the weight nearest gram, and then three rabbits from each group were slaughtered by cutting the neck at jugular vein with a sharp knife to obtain blood samples free from any tracheal exudates.

Individual blood samples from each sacrificed animals were collected in heparinized dry clean centrifuge tubes. Blood was centrifuged at 3000 rpm for 15 minutes. The clear plasma was transferred and stored in deep freeze (-20ºC) for the subsequent biochemical analysis assays.

Total protein was measured using Biuret method as described by[21]. Albumin determined according to[22]**.** Globulin calculated by difference between total protein and albumin. Cholesterol and triglycerides were determined according to[23]. Aspartic transaminase (AST or GOT) and Alanine transaminase (ALT or GPT) were assayed in the plasma using the method of[24]. Urea was measured according to[25]. Creatinine was determined according to[26]. Alkaline phosphatase was determined according to[27]. Calcium was assessed according to[28]. Inorganic phosphorus present in plasma as phosphate forms was determined using the method adopted by[29]. Lipid Peroxide (LPO) determined according to[30, 31]. The determination of the total antioxidant capacity (TAC) was performed by the reaction of antioxidants in the sample with a defined amount of exogenously provide hydrogen peroxide[32]. Catalase (CAT) reacts with a known quantity of H_2O_2. The reaction is stopped after exactly one minute with catalase inhibitor[33, 34].

7. Statistical Analysis

The collected data were subjected to statistical analysis as two factors-factorial analysis of variance using the general linear model procedure of[35]**.** Duncan's Multiple Range Test[36] was used to separate means when the dietary treatment effect was significant.

The following model was used:

$Y_{ijk} = \mu + T_i + L_j + (TL)_{ij} + e_{ijk}$

Where:

Y_{ijk} = Observation,

μ = the overall mean,

Ti=the effect of biologically treated rice straw for i= 1 to 2, 1 = untreated rice straw without *Pleuratus ostreatus* (UTRS) and 2 = biologically treated rice straw with *Pleuratus ostreatus* (BTRS).

L_j= the effect of rice straw levels used for j =1-4, 1=0 % clover hay, 2 = 33% rice straw, 3= % rice straw and 4=100 % rice straw.

$(TL)_{ij}$ = the interaction of untreated and biologically treated rice straw and rice straw levels.

e_{ijk} = the experimental error.

This model was used to analyse data of caecum microbial activity and different blood components.

Results and Discussion

Caecum microbiology:

Rabbit is a small non-ruminant herbivore. Rabbit feeding is more similar to ruminants feeding than to poultry feeding, as rabbit digestive physiology shows some similarity to ruminants, particularly caecal processing of fiber[37]. The caecum plays a key role in the digestive physiology as the major sit of fermentation (fiber degradation, etc…).

Fermentation pattern in rabbit caecum resemble that of the rumen, however it shows low fibrocystic microbial activity and relatively high analytic and proteolytic microbial activity[38].

The obtained results of the total bacteria ($x10^5$), fungi ($x10^3$), actinomyses ($x10^3$) and cellulolytic bacteria ($x10^3$) are shown in Table (2) and illustrated in Figures (1, 2, 2a, 2b, 2c and 2d). The recorded values being: 47.49, 4.73, 4.25 and 26.71 with (UTRS) compared to 55.07, 8.39, 5.07 and 29.73 with (BTRS), respectively. It was cleared that rabbits fed UTRS in their diet, significantly ($p<0.05$) recorded lower bacteria, fungi, actinomyces and cellulolytic bacteria count than that of BTRS.

Analysis of variance revealed that feeding rabbits on diets which included 33% of rice straw (regardless of treatment) instead of clover hay were significantly ($P<0.05$) higher in bacteria and cellulolytic numbers compared with the control group, while, fungi and actinomyces were insignificantly decreased compared with the control group.

On the other hand, results with level of 66 and 100% recorded significantly higher values of bacteria, fungi and cellulolytic bacteria than those of control group, while actinomyces recorded insignificantly higher values compared to control group.

Table (2): Effects of biological treatments and substituting levels of rice straw on caecum microbiology of treated rabbits.

Item	Experimental diets							SEM
	Treatments		SEM	Levels of rice straw				
	Without *Pleurotus ostreatus*	With *Pleurotus ostreatus*		0%	33%	66%	100%	
Bacteria $x10^5$	47.49^{b}	55.07^{a}	1.73	40.33^{c}	50.67^{b}	56.45^{a}	57.67^{a}	1.73
Fungi $x10^3$	4.73^{b}	8.39^{a}	0.56	5.93^{c}	5.33^{c}	6.98^{b}	8.00^{a}	0.56
Actinomyces $x10^3$	4.25^{a}	5.07^{a}	0.18	4.67^{a}	4.50^{a}	4.98^{a}	4.48^{a}	0.18
Cellulolytic bacteria $x10^3$	26.71^{b}	29.73^{a}	0.57	25.40^{c}	27.22^{b}	30.27^{a}	30.00^{a}	0.57

Different letter superscripts (a, b and c) means within row (treatments or levels) differ significantly at $p<0.05$).

SEM : Standard error of the means.

Table (3): Effect of interactions between biological treatments and substituting levels of rice straw on caecum microbiology of the treated rabbits.

Item	Experimental diets								SEM
	Without *Pleuratus ostreatus*				With *Pleuratus ostreatus*				
	0%	33%	66%	100%	0%	33%	66%	100%	
Bacteria $x10^5$	40.33^{e}	45.33^{d}	51.63^{c}	52.67^{bc}	40.33^{e}	56.00^{b}	61.27^{a}	62.67^{a}	1.73
Fungi $x10^3$	5.93^{c}	4.67^{d}	4.33^{d}	4.00^{d}	5.93^{c}	6.00^{c}	9.63^{b}	12.00^{a}	0.56
Actinomyces $x10^3$	4.67^{ab}	4.00^{b}	4.00^{b}	4.33^{b}	4.67^{ab}	5.00^{ab}	5.97^{a}	4.63^{ab}	0.18
Cellulolytic bacteria $x10^3$	25.40^{d}	25.47^{d}	28.37^{bc}	27.60^{c}	25.40^{d}	28.97^{b}	32.17^{a}	32.40^{a}	0.57

Different letter superscrits (a, b, c, d and e) means in the same row differ significantly at $P<0.05$

SEM : Standard error of the means

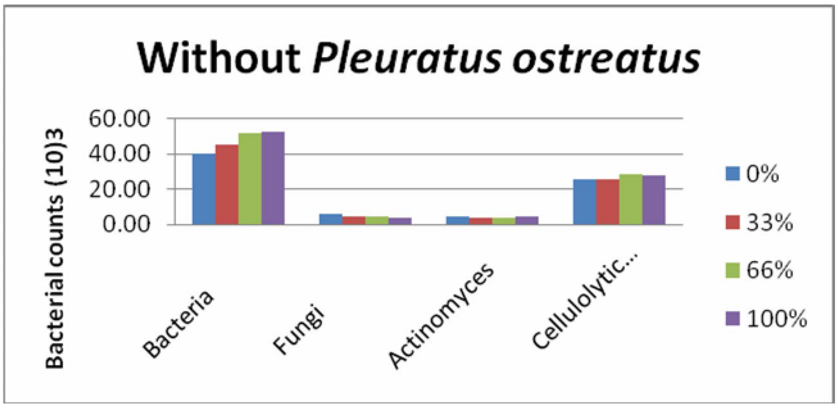

Figure (1): Effects of treatment without *Pleurotus ostreatus* and substituting levels of rice straw on caecum microbiology of the treated rabbits.

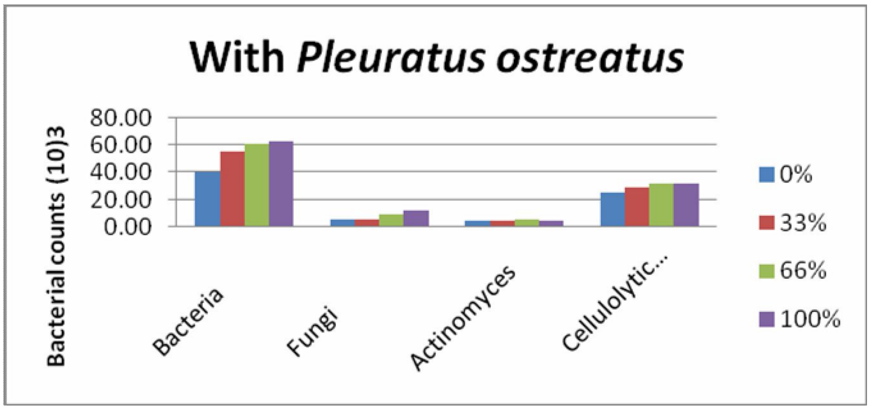

Figure (2): Effects of biological treatments and substituting levels of rice straw on caecum microbiology of the treated rabbits.

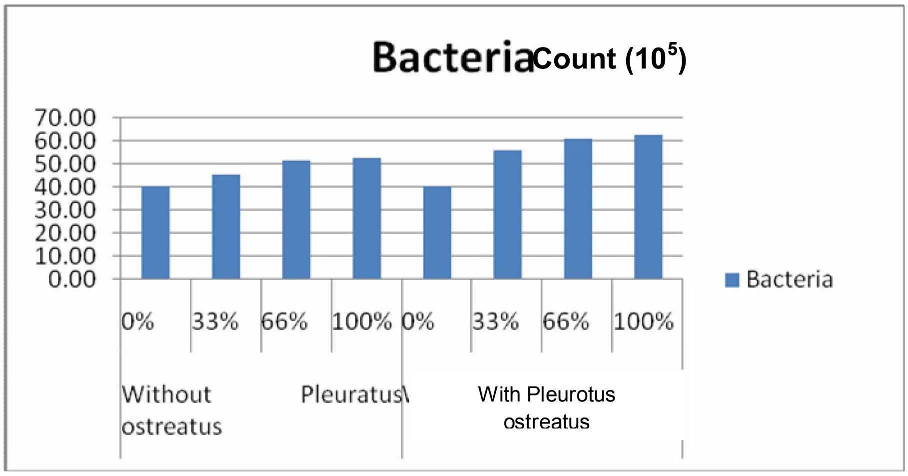

Figure (2a): Effects of biological treatments and substituting levels of rice straw on bacteria counts ($x10^5$) of the treated rabbits.

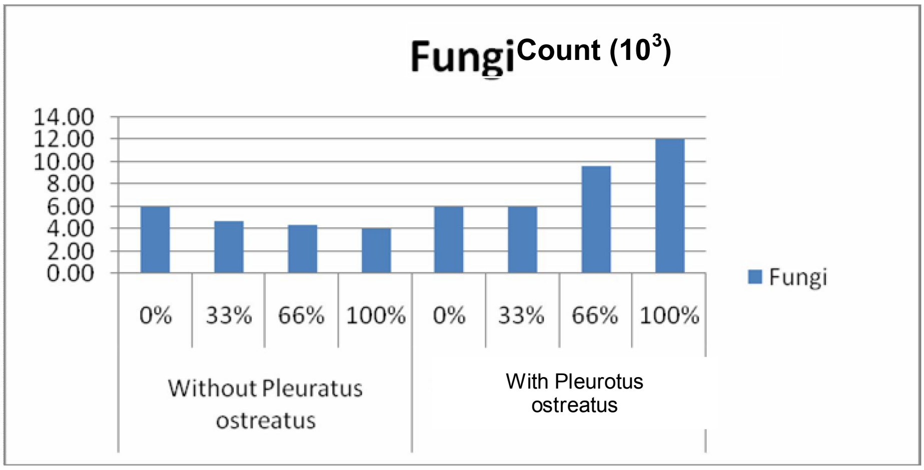

Figure (2b): Effects of biological treatments and substituting levels of rice straw on fungi counts ($x10^3$) of the treated rabbits.

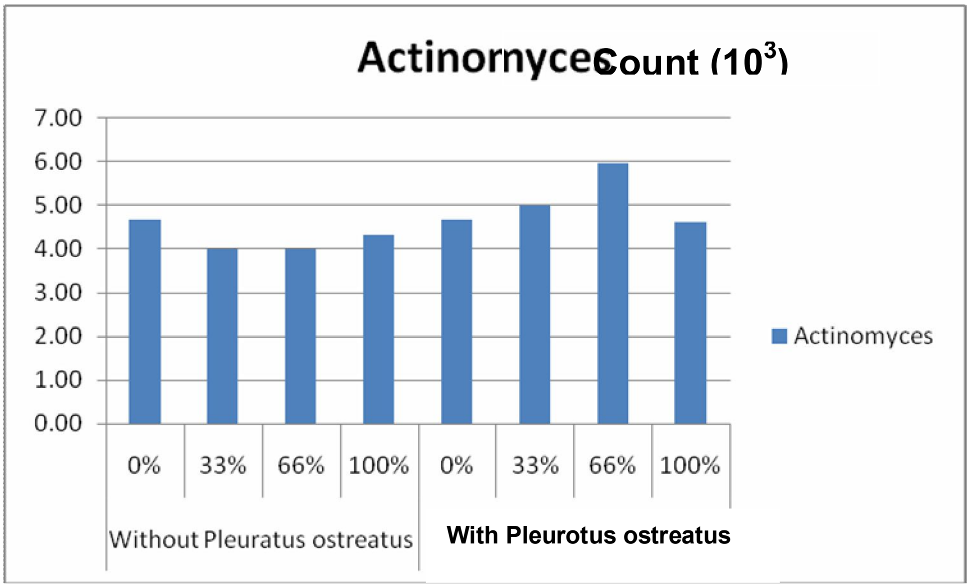

Figure (2c): Effects of biological treatments and substituting levels of rice straw on actinomyces counts ($x10^3$) of the treated rabbits.

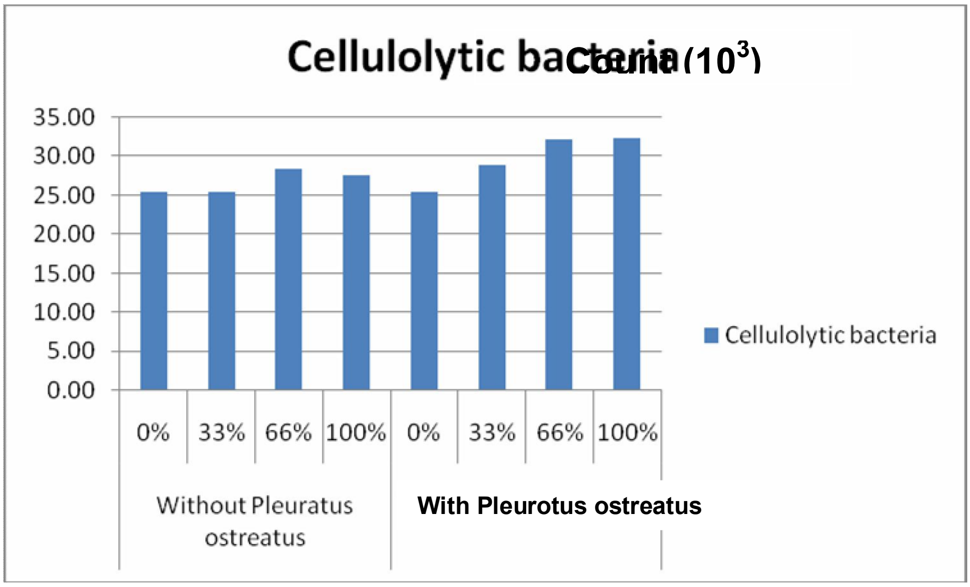

Figure (2d): Effects of biological treatments and substituting levels of rice straw on cellulolytic bacteria count ($x10^3$) of the treated rabbits.

In general, total bacteria, fungi, actinomyces and cellulolytic bacterial counts tended clearly to be higher when rabbits fed with increasing level of biologically treated rice straw compared to the control group. The increase of bacterial count and cellulolytic bacteria concentration was attributed to the higher crude fiber digestibility and higher celluloytic count for the experimental diets, compared to the control group. On the other hand, biological treatments are alternative treatments to modify digestion of fibrous material, by ruminants. The mode of fungal action on roughages by white rot fungi was found to improve *in vitro* dry matter digestibility of the decayed substrate[39]. So, rabbit can convert dietary by-product to meat band skin due to their high feeding efficiency. They had a large caecum containing varied species of microflora and they were cecotrop lager[40].

Interaction between treatments and levels on microbiology of caecum of the experimental groups are shown in Table (3). Results revealed that rabbits fed diets containing BTRS had the higher total bacteria, fungi, actinomyces and cellulolytic bacteria than that of UTRS. In general, total count of bacteria, fungi, actinomyces and cellulolytic bacteria tended clearly to be higher when rabbits fed with increasing levels of biologically treated rice straw than those of untreated in rabbit diets. Similar results obtained by[41] who, studied the effect of partial and completely replacement of clover hay biologically treated rice straw by fungi in growing rabbit diets. Data of total bacterial count showed significantly ($p<0.05$) higher values for rabbit fed 35% rice straw treated with fungi than those of control group. The cellulolytic bacteria count increased in rabbits fed diet contained 35% rice straw treated with bacteria plus fungi than the groups fed the control diet[41]**.**

The obtained results are in agreement with those found by[42] who showed that colonization of the caecum with organisms favorable for cellulose digestion requires large number of bacteria and found that *cellulomonace* bacteria increased with increasing cellulose in the diet.

Blood Constituents

Blood constituents as affected by feeding growing New Zealand white rabbits on UTRS, BTRS diets and levels of 0.0, 33, 66 and 100% of rice straw are presented in Table (4). Effect of interaction between treatments and their levels on blood parameter of the experimental groups are shown in Table (5). Results indicated that all measured blood parameters were within the normal range according to[43].

Statistical analysis showed significant differences ($p<0.05$) between treatments only in urea, alkaline phosphatase, calcium, cholesterol and triglyceride concentration. Results showed that groups fed (UTRS) were significantly higher in blood urea compared with (BTRS); also, level 33% was significantly higher in urea than that of control. While, there was insignificant increase in creatinine for (UTRS) than that of (BTRS). In this respect, when[44] added 0.5% dried yeast to rabbit diets no significant effect on creatinine was observed, compared to the control diets. These results are in agreement with[45] who found that addition of enzyme (Bentonite Co-supplementation) to rabbit diets decreased urea concentration, compared with control group. It was clearly to notice that, feeding growing rabbits on BTRS significantly ($p<0.05$) increased the alkaline phosphatase, compared with that of UTRS.

In this respect, when[46] used treated rice straw *P. ostreatus* in diets of sheep, the highest alkaline phosphatase concentration was obtained with treated material. Also, feeding growing rabbits on BTRS significantly ($p<0.05$) increased the concentration of calcium compared with that of UTRS.

It was clearly to notice that (Table 4) feeding growing rabbits on (BTRS) significantly ($p<0.05$) decreased the concentration of cholesterol and triglyceride than that of control diet. These declines may be due to the presence of *P. osteratus* which have the capability to reduce cholesterol and triglyceride synthesis[45]. Also, the same authors found that addition of enzyme (Bentonite Co- supplementation) to rabbit rations decreased catalase concentration.

Concerning total protein, albumin, creatinine, GOT, GPT, phosphorus, catalase (CAT), total antioxidant capacity (TAC) and lipid peroxide (LPO) results showed that there were no significant differences between UTRS and BTRS was observed. Similar results were obtained by[46, 47] when rams or sheep were fed ration containing rice straw treated with *P. osteratus*, compared with those fed ration of untreated rice straw. While, the highest alkaline phosphatase was obtained when rabbit fed rice straw treated with *P. osteratus* in their rations.

However, [48] fed female of New Zealand rabbits on diets contained rice straw untreated, 4% urea-treated or urea treated and inoculated with fungus coprinus. They showed that no histopathological changes in organs and mortality rate was low, indicating that fungus was not toxic.

Finally, it could be concluded that replacement of 33% clover hay with biologically treated rice straw in growing rabbits rations caused an improvement in caecum microbiological activity and had no effective changes on the blood biochemical parameters.

Table (4): Effects of biological treatments substituting levels of rice straw on blood parameters of the treated rabbits.

Item	Experimental diets							SEM ±
	Treatments		SEM	Levels of rice straw				
	Without *Pleurotus ostreatus*	With *Pleurotus ostreatus*		0%	33%	66%	100%	
Total protein(g/dl)	6.23^{a}	5.85^{a}	0.14	6.43^{a}	6.01^{ab}	6.19^{ab}	5.53^{b}	0.14
Abumin (g/dl)	3.65^{a}	3.72^{a}	0.09	3.94^{a}	3.44^{a}	3.86^{a}	3.49^{a}	0.09
Globulin (g/dl)	2.58^{a}	2.13^{a}	0.05	2.49^{a}	2.57^{a}	2.33^{a}	2.04^{a}	0.5
A/G ratio	1.41^{a}	1.75^{a}	0.01	1.58^{a}	1.34^{a}	1.66^{a}	1.71^{a}	0.01
Urea (mg/dl)	39.67^{a}	30.75^{b}	2.11	29.67^{b}	39.67^{a}	38.33^{ab}	33.17^{ab}	2.11
Creatinine (mg/dl)	0.47^{a}	0.37^{a}	0.07	0.29^{a}	0.60^{a}	0.36^{a}	0.45^{a}	0.07
AST (U/L)	21.88^{a}	23.64^{a}	3.64	38.96^{a}	29.51^{ab}	15.96^{b}	12.85^{b}	3.64
ALT (U/L)	54.20^{a}	56.15^{a}	2.03	53.90^{a}	58.55^{a}	54.35^{a}	53.91^{a}	2.03
Alkaline phosphatase (U/L)	497.2^{b}	612.7^{a}	38.93	363.3^{b}	554.7^{a}	644.2^{a}	657.5^{a}	38.93
Cholesterol(mg/dl)	64.42^{a}	41.08^{b}	5.55	33.33^{c}	72.00^{a}	49.50^{b}	56.17^{b}	5.55
Triglycerides(mg/dl)	86.33^{a}	47.25^{b}	7.85	34.67^{b}	89.33^{a}	64.67^{a}	78.50^{a}	7.85
Calcium (mg/dl)	13.67^{b}	14.92^{a}	0.27	15.33^{a}	15.00^{a}	13.50^{b}	13.50^{b}	0.28
Phosphorus (mg/dl)	6.25^{a}	6.33^{a}	0.27	5.33^{b}	6.33^{ab}	7.33^{a}	6.17^{b}	0.27
CAT (U/L)	169.0^{a}	172.8^{a}	13.70	128.4^{a}	146.8^{a}	201.8^{a}	206.4^{a}	13.70
TAC (mmol/L)	0.24^{a}	0.25^{a}	0.006	0.28^{a}	0.25^{ab}	0.23^{b}	0.23^{b}	0.001
LPO(nmol/ml)	5.92^{a}	6.42^{a}	0.70	5.67^{b}	5.00^{b}	9.33^{a}	4.67^{b}	0.70

Different letter superscripts (a, b and c) means within row (treatment or levels) differ significantly at $p<0.05$.SEM : Standard error of the mean

Table (5): Effect of interactions between biological treatments and substituting levels of rice straw on blood parameters of the treated rabbits.

Item	Experimental diets								SEM
	Without *Pleurotus ostreatus*				With *Pleurotus ostreatus*				
	0%	33%	66%	100%	0%	33%	66%	100%	
Total protein (g/dl)	6.43^{ab}	6.72^{a}	6.20^{abc}	5.59^{bc}	6.43^{ab}	5.31^{c}	6.18^{abc}	5.47^{c}	0.14
Abumin (g/dl)	3.94^{a}	3.36^{a}	3.70^{a}	3.60^{a}	3.94^{a}	3.53^{a}	4.02^{a}	3.37^{a}	0.09
Globulin (g/dl)	0.49^{a}	3.36^{a}	2.50^{a}	1.99^{a}	2.49^{a}	1.78^{a}	2.16^{a}	2.10^{a}	0.05
A/G ratio	1.58^{a}	1.00^{a}	1.48^{a}	1.81^{a}	1.58^{a}	1.98^{a}	1.86^{a}	1.60^{a}	0.01
Urea (mg/dl)	29.67^{bc}	51.67^{a}	43.00^{ab}	34.33^{bc}	29.67^{bc}	27.67^{c}	33.67^{bc}	32.00^{bc}	2.11
Creatinine (mg/dl)	0.29^{ab}	0.82^{a}	0.22^{b}	0.55^{ab}	0.29^{ab}	0.37^{ab}	0.49^{ab}	0.34^{ab}	0.07
AST (U/L)	38.96^{a}	23.20^{a}	14.83^{a}	10.53^{a}	38.96^{a}	35.82^{a}	17.09^{a}	15.16^{a}	3.64
ALT (U/L)	53.90^{a}	58.84^{a}	57.44^{a}	46.61^{a}	53.90^{a}	58.25^{a}	51.25^{a}	61.20^{a}	2.03
Alkaline phosphatase (U/L)	363.3^{c}	431.5^{bc}	534.5^{abc}	659.4^{ab}	363.3^{c}	677.9^{ab}	753.8^{a}	655.7^{ab}	38.93
Cholesterol (mg/dl)	33.33^{d}	113.00^{a}	60.00^{b}	51.33^{bc}	33.33^{d}	31.00^{d}	39.00^{cd}	61.00^{b}	5.55
Triglycerides (mg/dl)	34.67^{d}	103.70^{ab}	79.00^{bc}	128.00^{a}	34.67^{d}	75.00^{bc}	$50.33c^{d}$	29.00^{d}	7.85
Calcium (mg/dl)	15.33^{ab}	14.33^{ab}	12.33^{d}	12.67^{c}	15.33^{ab}	15.67^{a}	14.67^{ab}	14.00^{bc}	0.28
Phosphorus (mg/dl)	5.33^{cd}	5.67^{bcd}	6.67^{abc}	7.33^{a}	5.33^{cd}	7.00^{ab}	8.00^{a}	5.00^{d}	0.27
CAT (U/L)	128.4^{ab}	125.4^{b}	183.5^{ab}	238.5^{a}	128.4^{ab}	168.2^{ab}	220.2^{ab}	174.3^{ab}	13.70
TAC (mmol/L)	0.28^{a}	0.25^{ab}	0.23^{b}	0.22^{b}	0.28^{a}	0.26^{ab}	0.22^{b}	0.24^{ab}	0.006
LPO (nmol/ml)	5.67^{b}	4.67^{b}	7.00^{ab}	6.33^{b}	5.67^{b}	5.33^{b}	11.67	3.00^{b}	0.70

Different letter superscripts (a, b and c) means in the same row having different super scripts differ significantly ($p<0.05$)

SEM : Standard error of the mean

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