Incorporated Untraditional Sources of Roughage in Growing New Zealand White, NZW) Rabbit Rations and Its Effects on Nutrient & Cell Wall Digestibility and Nutritive Values

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ABSTRACT

Seventy eight rabbits (4-5wks) divided into 13 groups that contained 6 were used in thirteen digestibility trials to study the availability of using rice straw (RS) or corn stalks (CS) as untraditional roughage sources as a partial or complete substitution or replacement for clover hay. Replacing clover hay (CH) that incorporated in control at 33% of ration formulation by RS treated with or without Pleurotus ostreatus and CS with or without Trichoderma reesei at levels (0, 11, 22 and 33%). Untreated RS (UBTRS) or biological treated (BTRS) with Pleurotus ostreatus caused an increasing in their contents of crude protein (CP), nitrogen free extract (NFE) and Ash while CF, OM, NDF, ADF, ADL and hemicellulose decreased in comparable with the raw rice straw. On the other hand, biological treatment of CS (BTCS) with Trichoderma reesei occurred a decreasing in their values of OM, crude fiber (CF), NFE, NDF, ADF, cellulose and hemicellulose, meanwhile, CP, ash and ADL contents of (BTCS) and untreated CS (UBTCS) were increased. All dietary treatments significantly increased OM digestibility. The best value of OM digestibility was recorded by rabbits fed 33% BTRS. Rabbits fed 22% and 33% BTRS or 22% UBTCS and 11% BTCS significantly (P<0.05) increased CP digestibility. Rabbits fed 33% (UBTRS or BTRS) and significantly increased CF digestibility. The best value of EE digestibility was recorded by rabbits that fed 33% BTCS. All dietary treatments significantly (P<0.05) increased NFE digestibility. All dietary treatments significantly (P<0.05) increased TDN value. Also, Rabbits received 22% and 33% BTCS and 22% UBTCS & 11% BTCS significantly (P<0.05) increased their value of DCP. The highest value of NDF digestibility was recorded by rabbits fed 11% BTCS, meanwhile the lowest value was observed with 33% UBTCS (P<0.05). Rabbits fed 11, 22 and 33% BTCS occurred significantly (P<0.05) increasing in hemicellulose digestibility.

Keywords: Rice straw, corn stalk, rabbit, Pleurotus ostreatus, Trichoderma reesei

1. Introduction

Several crops produced large amounts of stalks, cobs, straws…..etc, can be use as untraditional source of Berseem or Berseem hay. Field crops content largely present digestible nutrients (El-Shahat et al., 2006; Omer et al. 2012, Kholif et al., 2014).

In Egypt, amount of wheat straw, rice straw and corn stalks are completely used for feeding animals (Ministry of Agric and Land Reclamation 2008).

Sadek (2013) reported that agriculture by-products about 35 million tons annually, 23 million tons of which were plant wastes (7 million tons of them are used as fodders, 4 million tons were used as organic fertilizers and the rest of wastes which 12 million tons were left without any using).
Limiting factors of using by-products for feeding animals are low protein content (3-4%); high crude fiber (30-45%); Cellulose (30-40%); hemicellulose (5-35%) approximately; lignin (10-15%), approximately, poor palatability and low digestibility (Thander and Aman 1984).

Previous work mentioned that, crop residues contain 30-40% cellulose, 16-27 % hemicelluloses and 3-13 lignin, meanwhile the wood residues contain 45-56 % cellulose, 10-25 % hemicellulose and 18-30 % lignin, respectively (Chahal 1985).

Straws treated by white-rot fungi may be a good method to increase their nutritive quality (Fazaeli et al. 2002). Also fungi are responsive for lignocellulose degradation are fungi, and the most effective are basidomycetes (Rabinovich et al. 2004). Enzymes released from fungi break the polysaccharide-lignin and this improve degradation of straws, which may make straws more digestible. This would enhance the accessibility of enzymes to potentially digestible biomass resulting in higher degradation of the straw, which may create a more nutritious feed (Tawffek 2011).

Reducing indigestible cell wall and increasing the digestion coefficients of cell wall of straws may be due to role of action of *Pleurotus ostreatus* (Fazaeli et al. 2002).

Treated rice straw with *Pleurotus ostreatus* in sheep rations caused significantly increasing in digestibility of DM, OM, CP, CF, NDF, ADF, ADL, cellulose, hemicellulose, and nutritive values includes TDN and DCP (Abd-ElAziz and Ismail 2001).

Also, Deraz and Ismail (2001) noticed that all nutrients digestibility of cotton stalks and nutritive values as TDN and DCP were improved as a result of biological treatments, especially with *Coriolus versicolor* or *Pleurotus ostreatus*, followed by *Ph. chrysosporium*, compared with untreated cotton stalks.

This study was carried to investigate the effect of incorporation untreated or treated biologically of both rice straw by *Pleurotus ostreatus* and corn stalks by *Trichoderma reesei* on nutrient and cell wall digestibility of rabbits.

2. Materials and Methods

2.1. Methods

The experimental work was carried out at El-Nubaria Experimental and Production Station, El-Imam Malik Village, Behira Governorate.

This work designed to study the effect of cultivation *Pleurotus ostreatus* on RS and *Trichoderma reesei* on CS and replacing clover hay by untreated and treated RS and CS at different levels (0, 33, 66 and 100%).

2.2. Biological treatments

2.2.1. Microorganisms:

*Trichoderma reesei* and *Pleurotus ostreatus* were obtained from Agriculture Microbiology Department, National Research Centre, Dokki, Cairo, Egypt.

2.2.2. Biological treatments of crop residues under study in large scale

A heap of 160 kg of the each tested chopped and crushed rice straw or corn stalks were moistened with medium contained, 2.5% molasses, 2.5% urea, 1.5% ammonium sulphate, 1.00% supper phosphate and 0.5% magnesium sulphate at solid: liquid (1:2). The treated crop residues were shuffled upside down daily for the prop 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. About 80 kg of rice straw or corn stalks were treated with above solution (without *Pleurotus ostreatus* or *Trichoderma reesei*).

2.3. Manufacturing the pelleted feed

The air dried compost have been transported to the forage manufacture for making the experimental pelleted feed by substituting of clover hay with biologically treated and untreated rice straw or corn stalks at the levels of (33% and 66% and 100%).
2.4. Animals and feeds

Seventy eight weaned New Zealand white rabbits (4-5 weeks) and about 565±13.57 g were randomly divided into thirteen experimental groups of 6 rabbits in each. Each group divided into three replicates of two rabbits in each.

All the experimental diets were approximately iso-nitrogenous and iso-caloric that meets requirements of growing rabbits according to (NRC, 1977) recommendation.

Each one of the thirteen experimental group rabbits received one of the following ration:

R1: Experimental ration contained 33% clover hay and considered as control.
R2: Experimental ration contained 11% rice straw (RS) without fungi (UBTRS).
R3: Experimental ration contained 22% rice straw (RS) without fungi (UBTRS).
R4: Experimental ration contained 33% rice straw (RS) without fungi (UBTRS).
R5: Experimental ration contained 11% rice straw (RS) treated by Pleurotus ostreatus fungi (BTRS).
R6: Experimental ration contained 22% rice straw (RS) treated by Pleurotus ostreatus fungi (BTRS).
R7: Experimental ration contained 33% rice straw (RS) treated by Pleurotus ostreatus fungi (BTRS).
R8: Experimental ration contained 11% corn stalks (CS) without fungi (UBTCS).
R9: Experimental ration contained 22% rice straw (RS) without fungi (UBTCS).
R10: Experimental ration contained 33% rice straw (RS) without fungi (UBTCS).
R11: Experimental ration contained 11% corn stalks (CS) treated by Trichoderma reesei fungi (BTCS).
R12: Experimental ration contained 22% corn stalks (CS) treated by Trichoderma reesei fungi (BTCS).
R13: Experimental ration contained 33% corn stalks (CS) treated by Trichoderma reesei fungi (BTCS).

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 rabbits were housed separately in metal cages and provide with feed and water ad libitum at 27-28°C ambient temperature with natural light and ventilation.

2.5. Digestibility trials

Thirteen digestibility trials were carried out using all rabbits (6 rabbits in three replicates of two rabbits) in each treatments were used from each treatment to determine the nutrient and cell wall digestibility and calculated nutritive value of (total digestible nutrient, TDN and digestible crude protein, DCP) of the experimental diets. All calculations of digestibility trials was carried out according to the classical method that described by Abou-Raya (1967). Feed and water were offered ad libitum.

Feed intake and excreted feces were daily recorded for 5 consecutive days before the end of experiment. Composite samples of dried feces (10%) were dried for 48 hrs (60), ground and stored for chemical analysis.

Chemical analysis of feeds and dried feces was determined according to AOAC (2005).

2.6. Analytical procedures

Samples of ingredients, diets and dried feces were analyzed according to AOAC (2005) methods for dry matter (DM), ether extract (EE). Crude protein (CP), Crude fiber (CF) and ash. The nitrogen free extract (NFE) and organic matter (OM) content were calculated. Fiber fractions includes (NDF, ADF and ADL) were determined according to Goering and Van Soest (1970) and Van Soest et al. (1991). Hemicellulose and cellulose contents were calculated by difference using the following equations:

\[ \text{Hemicellulose} = \text{NDF} - \text{ADF} \]
\[ \text{Cellulose} = \text{ADF} - \text{ADL} \]

2.7. Statistical analysis

Data were statistically analyzed as one way analysis of variance using the general linear model procedure of SPSS (2008). Meanwhile, Duncan’s Multiple Range Test was used to examine the significance between means, Duncan (1955).
3. Results

3.1. Chemical analysis of different ingredients

Untreated or BTRS caused an increasing in their level of crude protein, NFE and ash in comparison with the raw rice straw. The portion of improving values were recorded as the follows; crude protein increased by 178.75% and 224.5%; NFE 6.30% and 24.53% and ash 22.73% and 44.45%. Meanwhile, CF content depressed by 31.32% and 56.75%, but OM content reduced by 2.81% and 5.51%. BTCS cause an decrease in OM, CF, NFE, NDF, ADF, cellulose and hemicellulose while CP, ash and ADL were increased (Table 1).

Table 1: Chemical analysis of different roughages used in ration formulations

| Item                  | Clover hay (CH) | Rice straw (RS) | Corn stalks (CS) |
|-----------------------|-----------------|-----------------|-----------------|
|                       | Raw UBTRS BTRS  | Raw UBTCs BTCS |                 |
| Moisture (%)          | 13.88 6.70 7.50| 8.00 7.00 8.50  | 8.20            |
| Chemical analysis on DM basis (%) |                |                 |                 |
| OM                    | 89.10 89.00 86.50| 84.10 88.50 87.01| 84.69          |
| CP                    | 17.03 5.27 14.69| 17.10 5.61 13.99| 16.68          |
| CF                    | 14.07 45.66 31.36| 19.75 37.78 32.96| 24.13          |
| EE                    | 2.50 1.10 1.15 1.21| 1.11 1.32 1.56  |                 |
| NFE                   | 55.50 36.97 39.30| 46.04 44.00 38.74| 42.32          |
| Ash                   | 10.90 11.00 13.50| 15.90 11.50 12.99| 15.31          |
| NDF                   | 33.84 68.75 65.75| 61.99 72.50 65.85| 60.00          |
| ADF                   | 18.17 47.50 45.15| 43.75 56.00 47.75| 45.25          |
| ADL                   | 12.89 14.85 13.56| 10.99 15.56 16.95| 18.75          |
| Hemicellulose         | 15.67 21.25 20.60| 18.24 16.50 18.10| 14.75          |
| Cellulose             | 5.28 32.65 31.59| 32.76 40.44 30.80| 26.50          |

UBTRS: Unbiological treated rice straw by *Pleurotus ostreatus* fungi.
BTRS: Biological treated rice straw by *Pleurotus ostreatus* fungi.
UBTCS: Unbiological treated corn stalks by *Trichoderma reesei* fungi.
BTCS: Biological treated corn stalks by *Trichoderma reesei* fungi.

Hemicellulose = NDF-ADF, Cellulose = ADF-ADL.

3.2. Chemical analysis of the experimental diets

R\(_{11}\) contains higher percent of CP and hemicellulose, however the highest value of cellulose was noticed with R\(_{10}\) meanwhile R\(_1\) recorded higher level of CF, ADF and ADL. Concerning about DE, R\(_9\) had the best value (Table 2).

3.3. Nutrient digestibility of the experimental groups

Data of Table (3) mentioned that DM digestibility was insignificantly increased when rabbits fed ration containing 11% BTCS (R\(_{11}\)), meanwhile rabbits fed 11 or 33% UBTRS (R\(_2\) and R\(_4\)) and 33% UBTCS (R\(_{10}\)) caused significant (P<0.05) decreasing in DM digestibility comparing to the control. On the other hand, rabbits fed (R\(_3\), R\(_5\) to R\(_9\), R\(_{12}\) and R\(_{13}\)) occurring insignificantly decreasing in their DM digestibility in comparison with the control. All dietary treatments significantly increased OM digestibility compared to control, the best value of OM digestibility (77.51%) was recorded by rabbits fed 33% BTRS (R\(_7\)). Rabbits fed rations containing 22% and 33% BTRS, 22% UBTCS or 11% BTCS (R\(_8\), R\(_{11}\), R\(_9\) and R\(_{11}\)) significantly increased CP digestibility compared to control. Rabbits fed 33% UBTRS (R\(_3\)) or 33% BTRS (R\(_7\)) significantly increased CF digestibility compared to control. The best value of EE digestibility was recorded by rabbits that fed 33% BTCS (R\(_{11}\)) in comparison with the control, the corresponding value of EE digestibility was (96.06 vs. 85.65%) for R\(_{13}\) and R\(_1\), respectively. All dietary treatments significantly (P<0.05) increased NFE digestibility in comparison with the control. The best value of NFE digestibility (85.11%) was recorded by rabbits that fed 22% BTRS (R\(_8\)) that fed 11% BTCS (R\(_{11}\)).
Chemical analysis of the experimental rations

| Ingredients                      | Clover hay (CH) | Rice straw (RS) | Corn stalks (CS) |
|----------------------------------|-----------------|-----------------|------------------|
|                                  | Unbiological    | Biological      | Unbiological    | Biological      |
|                                  | treated rice    | treated rice    | treated corn    | treated corn    |
|                                  | straw by        | straw by        | stalks by       | stalks by       |
|                                  | Pleurotus       | Pleurotus       | Trichoderma     | Trichoderma     |
|                                  | ostreatus fungi | ostreatus fungi | reesei fungi    | reesei fungi    |
| Control                          | R1              | R2              | R4              | R7              |
| R2                               | 11%             | 22%             | 33%             | 11%             |
| R3                               | 33%             | 22%             | 33%             | 11%             |
| R4                               | 11%             | 22%             | 33%             | 11%             |
| R5                               | 33%             | 22%             | 33%             | 11%             |
| R6                               | 22%             | 11%             | 33%             | 11%             |
| R7                               | 33%             | 22%             | 33%             | 11%             |
| R8                               | 33%             | 22%             | 33%             | 11%             |
| R9                               | 22%             | 11%             | 33%             | 11%             |
| R10                              | 33%             | 22%             | 33%             | 11%             |
| R11                              | 22%             | 11%             | 33%             | 11%             |
| R12                              | 33%             | 22%             | 33%             | 11%             |
| R13                              | 11%             | 22%             | 33%             | 11%             |

Chemical analysis DM basis (%)

| Ingredient                        | Control | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 |
|-----------------------------------|---------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
| Moisture (%)                      | 13.88   | 10.05 | 9.78 | 90.83 | 7.38 | 9.17 | 7.52 | 8.79 | 8.90 | 8.89 | 8.46 | 8.57 | 9.03 |
| Digestible energy (DE)            | 2513    | 2496 | 2491 | 2453 | 2493 | 2445 | 2444 | 2503 | 2595 | 2412 | 2518 | 2501 | 2425 |
| Calcium (Ca) %                    | 1.08    | 1.03 | 0.98 | 1.02 | 0.90 | 0.92 | 0.97 | 1.04 | 1.01 | 1.03 | 0.97 | 0.92 | 0.96 |
| Tryptophane %                     | 0.80    | 0.82 | 0.79 | 0.80 | 0.85 | 0.80 | 0.82 | 0.80 | 0.79 | 0.80 | 0.82 | 0.79 | 0.83 |
| Lysine %                          | 0.89    | 0.83 | 0.77 | 0.72 | 0.86 | 0.40 | 0.71 | 0.85 | 0.80 | 0.74 | 0.85 | 0.71 | 0.63 |
| Methionine + Cystine %            | 0.55    | 0.55 | 0.56 | 0.57 | 0.55 | 0.53 | 0.57 | 0.57 | 0.57 | 0.58 | 0.56 | 0.46 | 0.54 |
| Sodium %                          | 0.20    | 0.19 | 0.18 | 0.17 | 0.19 | 0.79 | 0.18 | 0.19 | 0.18 | 0.17 | 0.17 | 0.18 | 0.17 |

Cell wall constituents (%)

| Ingredient                        | Control | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 |
|-----------------------------------|---------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
| Neutral detergent fiber (NDF)     | 33.84   | 30.32 | 28.49 | 25.29 | 24.02 | 28.60 | 26.28 | 30.46 | 32.12 | 28.49 | 37.97 | 35.24 | 31.68 |
| Acid detergent fiber (ADF)        | 18.17   | 14.42 | 15.83 | 14.18 | 13.95 | 13.32 | 13.49 | 14.74 | 17.72 | 14.73 | 17.54 | 15.38 | 16.90 |
| Acid detergent lignin (ADL)       | 12.89   | 10.83 | 5.40 | 3.63 | 11.59 | 6.12 | 2.81 | 3.84 | 7.22 | 2.99 | 6.52 | 8.56 | 5.88 |
| Hemicellulose**                   | 15.67   | 15.90 | 13.11 | 11.11 | 10.07 | 15.28 | 12.79 | 15.72 | 14.40 | 13.76 | 20.43 | 19.86 | 14.78 |
| Cellulose***                      | 5.28    | 3.59 | 10.43 | 10.50 | 2.36 | 7.20 | 10.68 | 10.90 | 10.50 | 11.74 | 11.02 | 6.82 | 11.02 |

*Calculated according to NRC 1977. ** Hemicellulose = NDF – ADF *** Cellulose = ADF – ADL. DE = kcal/kg feed
Table 3: Effect of incorporating different roughage sources on nutrient & cell wall constituents digestibility and nutritive values of the experimental groups

| Item                        | Clover hay (CH) | Rice straw (RS) | Corn stalks (CS) |
|-----------------------------|-----------------|-----------------|------------------|
|                             | Control         | Unbiological treated rice straw | Biological treated rice straw | Unbiological treated corn stalks | Biological treated corn stalks |
|                             |                 | by *Pleurotus ostreatus* fungi (UBTRS) | by *Pleurotus ostreatus* fungi (BTRS) | by *Trichoderma reesei* fungi (UBTCS) | by *Trichoderma reesei* fungi (BTCS) |
|                             | SEM             | %               | %               | %               | %               | %               | %               | %               |
| Dry matter (DM)             | 83.99<sup>a</sup> | 76.51<sup>b</sup> | 78.41<sup>abc</sup> | 78.11<sup>b</sup> | 80.54<sup>ab</sup> | 81.21<sup>ab</sup> | 80.73<sup>ab</sup> | 80.18<sup>ab</sup> | 76.80<sup>b</sup> | 84.03<sup>a</sup> | 79.30<sup>ab</sup> | 80.94<sup>ab</sup> | 0.54          |
| Organic matter (OM)         | 65.11<sup>b</sup> | 67.11<sup>f</sup> | 72.27<sup>bcde</sup> | 73.91<sup>b</sup> | 72.61<sup>b</sup> | 76.85<sup>a</sup> | 77.51<sup>a</sup> | 70.93<sup>de</sup> | 71.76<sup>de</sup> | 70.57<sup>c</sup> | 76.23<sup>a</sup> | 72.99<sup>bc</sup> | 72.79<sup>de</sup> | 0.57          |
| Crude protein (CP)          | 64.52<sup>bc</sup> | 63.92<sup>d</sup> | 69.50<sup>bc</sup> | 68.13<sup>abcde</sup> | 69.56<sup>bc</sup> | 72.49<sup>bc</sup> | 72.23<sup>a</sup> | 68.12<sup>bcde</sup> | 72.88<sup>a</sup> | 68.73<sup>abc</sup> | 75.06<sup>a</sup> | 61.14<sup>d</sup> | 71.81<sup>ab</sup> | 0.81          |
| Crude fiber (CF)            | 32.15<sup>b</sup> | 21.38<sup>de</sup> | 34.80<sup>b</sup> | 44.46<sup>a</sup> | 25.49<sup>cd</sup> | 38.59<sup>bc</sup> | 44.67<sup>a</sup> | 23.40<sup>de</sup> | 21.59<sup>de</sup> | 37.54<sup>bc</sup> | 35.82<sup>b</sup> | 27.05<sup>cd</sup> | 16.05<sup>e</sup> | 1.54          |
| Ether extract (EE)          | 85.65<sup>b</sup> | 85.71<sup>b</sup> | 88.25<sup>abc</sup> | 89.44<sup>ab</sup> | 86.65<sup>ab</sup> | 88.26<sup>bc</sup> | 90.53<sup>ab</sup> | 89.70<sup>ab</sup> | 83.99<sup>bc</sup> | 91.32<sup>ab</sup> | 93.52<sup>ab</sup> | 92.40<sup>ab</sup> | 96.06<sup>a</sup> | 0.88          |
| Nitrogen free extract (NFE) | 75.51<sup>c</sup> | 78.37<sup>d</sup> | 80.96<sup>b</sup> | 81.64<sup>bc</sup> | 82.99<sup>bc</sup> | 85.11<sup>c</sup> | 83.73<sup>ab</sup> | 82.04<sup>de</sup> | 81.69<sup>bc</sup> | 77.64<sup>de</sup> | 84.00<sup>ab</sup> | 81.75<sup>bc</sup> | 81.47<sup>bc</sup> | 0.46          |

Nutrient digestibility (%)

| Item                        | Control         | Unbiological treated corn stalks by *Trichoderma reesei* fungi (UBTCS) | Biological treated corn stalks by *Trichoderma reesei* fungi (BTCS) |
|-----------------------------|-----------------|---------------------------------------------------------------|---------------------------------------------------------------|
|                             | SEM             | %               | %               | %               | %               | %               | %               | %               |
| Total digestible nutrients (TDN) | 51.02<sup>c</sup> | 61.66<sup>e</sup> | 65.77<sup>cd</sup> | 66.42<sup>bed</sup> | 67.36<sup>bc</sup> | 68.53<sup>bc</sup> | 67.50<sup>bc</sup> | 66.82<sup>bed</sup> | 66.93<sup>bc</sup> | 65.03<sup>d</sup> | 70.89<sup>a</sup> | 66.23<sup>cd</sup> | 66.81<sup>bed</sup> | 0.76          |
| Digestible crude protein (DCP) | 10.99<sup>d</sup> | 10.90<sup>d</sup> | 11.83<sup>bc</sup> | 11.60<sup>bc</sup> | 11.97<sup>bc</sup> | 12.48<sup>ab</sup> | 12.83<sup>ab</sup> | 11.58<sup>bc</sup> | 12.41<sup>ab</sup> | 11.75<sup>bc</sup> | 13.59<sup>a</sup> | 10.36<sup>d</sup> | 11.90<sup>bc</sup> | 0.16          |

Cell wall constituents digestibility (%)

| Item                        | Control         | Unbiological treated corn stalks by *Trichoderma reesei* fungi (UBTCS) | Biological treated corn stalks by *Trichoderma reesei* fungi (BTCS) |
|-----------------------------|-----------------|---------------------------------------------------------------|---------------------------------------------------------------|
|                             | SEM             | %               | %               | %               | %               | %               | %               | %               |
| Neutral detergent fiber (NDF) | 60.99<sup>ab</sup> | 42.71<sup>de</sup> | 45.98<sup>d</sup> | 47.27<sup>d</sup> | 43.14<sup>de</sup> | 55.87<sup>bc</sup> | 54.22<sup>c</sup> | 48.39<sup>de</sup> | 47.17<sup>de</sup> | 38.55<sup>e</sup> | 66.03<sup>c</sup> | 61.63<sup>ab</sup> | 56.72<sup>bc</sup> | 1.38          |
| Acid detergent fiber (ADF)   | 72.87<sup>a</sup> | 54.83<sup>cd</sup> | 49.30<sup>de</sup> | 55.94<sup>bed</sup> | 54.84<sup>ed</sup> | 57.62<sup>bcd</sup> | 63.66<sup>de</sup> | 41.96<sup>de</sup> | 51.34<sup>bc</sup> | 42.15<sup>c</sup> | 64.37<sup>c</sup> | 52.34<sup>d</sup> | 53.90<sup>d</sup> | 1.49          |
| Hemicellulose               | 47.22<sup>bed</sup> | 31.68<sup>de</sup> | 42.57<sup>cde</sup> | 36.20<sup>de</sup> | 26.92<sup>c</sup> | 54.35<sup>bc</sup> | 44.26<sup>bed</sup> | 54.42<sup>bc</sup> | 42.04<sup>cde</sup> | 34.69<sup>c</sup> | 67.45<sup>c</sup> | 68.78<sup>d</sup> | 59.95<sup>bc</sup> | 2.37          |
| Cellulose                   | 69.45<sup>bcde</sup> | 20.02<sup>d</sup> | 64.96<sup>bcde</sup> | 82.41<sup>a</sup> | 23.25<sup>d</sup> | 74.12<sup>d</sup> | 82.41<sup>a</sup> | 53.37<sup>def</sup> | 49.84<sup>de</sup> | 56.11<sup>cdef</sup> | 71.23<sup>b</sup> | 40.12<sup>f</sup> | 59.51<sup>bcd</sup> | 3.38          |

a, b, c, d, e, f and g: Means in the same row having different superscripts differ significantly (P<0.05).

SEM: Standard error of the mean.
3.4. Nutritive values of the experimental groups

All dietary treatments significantly (P<0.05) increased TDN value comparing to the control. The best value of TDN (70.89%) was recorded by rabbits fed 11% BTRS (R₁₁) meanwhile the lowest value (51.02%) was recorded by those rabbits that fed on the control (R₁). On the other hand, the other treatments recorded the intermediate values of TDN that ranged from 61.66 to 68.53% (Table 3).

Also, Rabbits received 22% and 33% BTRS (R₆ and R₇); 22% UBTRS (R₈) and 11% BTRS (R₁₁) significantly (P<0.05) increased their value of DCP in comparison with that fed the control (R₁)

The corresponding values of DCP were 12.48, 12.83, 12.41 and 13.59% for R₆, R₇, R₈ and R₁₁, respectively. Meanwhile, DCP value of control (R₁) was 10.99%. The best value of DCP (13.59%) was observed when rabbits received 11% BTRS (R₁₁).

3.5. Cell wall constituents digestibility of the experimental groups

Data illustrated in Table (3) showed that the highest value of NDF digestibility (66.63%) was recorded by rabbits fed 11% BTRS (R₁₁), meanwhile the lowest value (38.55%) was observed when rabbit fed 33% UBTRS (R₁₀). Furthermore, all dietary treatments significantly (P<0.05) decreased ADF digestibility among the 12 treatments compared to the control (72.87%).

Rabbits fed ration containing 11% BTRS (R₃) caused significantly (P<0.05) decreasing in hemicellulose digestibility (26.92%) in comparison with the control (47.22%). Rabbits fed rations containing 11 and 22 % BTRS (R₁₁ and R₁₂) occurred significantly (P<0.05) increasing in their value of hemicellulose digestibility (67.45 and 68.78%) for R₁₁ and R₁₂, respectively. However, it was noticed that, rabbits fed ration containing 22 and 33% BTRS (R₆ and R₇) or that fed 11% UBTRS containing ration (R₁₁) recorded insignificantly (P>0.05) increasing in their values of hemicellulose digestibility compared to control (R₁). The corresponding value of were (54.35, 44.26 and 54.42 vs. 47.22 % for R₆, R₇, R₈ and R₁₁), respectively. Rabbits fed 33% UBTRS (R₈) and 33% BTRS (R₁₁) recorded the highest values (82.41 and 82.41%) of cellulose digestibility, followed by rabbits fed 22% BTRS (R₆) and 11% BTCS (R₁₁) that recorded 74.12% and 71.23%. On the other hand rabbits that fed ration containing 11% UBTRS (R₈) or 11% BTRS (R₁₁) recorded the lowest value of cellulose digestibility (20.02 and 23.25% for R₆ and R₈, respectively).

4. Discussion

Values of chemical analysis of different roughage (Table 1) were in agreement with El-Shahat et al. (2006) who noted that biologically treated corn stalks with Trichoderma viride cause an improvement in both CP and NFE percentages and decreasing in CF content. Also, Durand and Chereau (1988) showed that, Trichoderma viride is characterized by high protein content wide spectrum amino acids composition, low nucleic acids contents, no toxicity, no antibiotic production and its ability to consume different substrates. However, the increase in protein content in biologically treated corn stalks may be due to the release of water soluble sugar from polysaccharides might have led to faster growth of fungus which in turn resulted in higher CP content, or may be related to the addition of basal mineral media containing nitrogen salts as has been suggested by (Grajek 1988 and Garcia et al. 1993). On the other hand, the decreasing in crude fiber content of biologically treated corn stalks in comparison with untreated may be due to the utilization of CF by the fungi for their growth since fungi among the microorganisms which have capability in decomposing different agricultural by- products as had been suggested by (Kim et al. 1985). El-Tahan et al. (2003) and El-Tahan and Mohamedi (2005) observed that cultivating mushroom, Agaricus basiporius on wheat straw increased its contents of CP and ash, while, DM, OM and CF contents decreased by 231.8, 139.4, 1.2, 20.8 and 63.5% compared with untreated one, respectively. However, Shakweer (2003) noticed that when rice straw and sugarcane bagasse were treated with either yeast, S. cerevisiae plus bacterium, Cellulomonas cellulans, yeast plus fungus, Ph. chrysosporium or with the three organisms together, an increase in CP content and a decrease in CF content.

Meanwhile, data of Table (1) cleared that biological treatment of rice straw caused a decreasing in their values of NDF, ADF, ADL and hemicellulose contents. These results in harmony with those recorded by Bassuny et al. (2005) and Al-Barakel et al. (2007). Furthermore, Fazaeli et al. (2004) found that fungal treatments (five species of Pleurotus fungi, coded P-21, P-30, P-41, P-60 and P-90) significantly increased CP and decreased NDF and ADF contents of wheat straw. However, culture, P-21f significantly showed lower ability than others to degrade the NDF and ADF content. Meanwhile,
NFE content of corn stalks was decreased as a result of treatment without or with *Trichoderma reesei* by control (Table 1). This reduction in NFE may be as a result of using it by microorganism for their growth and reproduction. And these results in agreement with those found by Martin (1977) who recorded that many bacterial genera are capable its utilizing steroids as a sole carbon and energy source, there by degrading steroids completely to CO₂ and H₂O. Also, our results in agreement with those found by Abd-Allah (2007) and Abd El-Wahed (2007) who noticed an increasing in CP and ash contents; a decreasing in OM, CF, NDF, ADF and ADL contents when corn cobs and stalks, banana wastes and rice & wheat straws were treated with *T. viride, or S. cerevisiae* or both or corn stover that biologically treated with *T. harzianum*, or *S. cerevisiae* or both. Meanwhile, Ashour *et al.* (1991) examined the applicability of chemical, biological and/or a combination of both on rice straw, they indicated that, the biological treatment with *Humicola fuscoatra* induced higher increase in protein content (17.54 %) and decreased the cellulose content by about (40.29%), while ash content was almost consistent (18.98 %) compared with the untreated rice straw (6.48, 45.38 and 18.87 %, respectively). The biological treatment of rice straw pretreated with Ca (OH)₂ caused a high increase in protein and cellulose contents (16.31 and 68.18 %, respectively) but ash content was decreased (11.21%).

Our results (Table 3) are closed with Abd El-Hakim *et al.* (2006) who noted that partial and completely replacement of clover hay by rice straw biologically treated by fungi in growing rabbits diets recorded higher values of all nutrients digestion coefficient. Also, Abd El-Aziz and Ismail (2001) noted that when sheep fed ration contained rice straw treated with *Pleurotus ostreatus*, the digestibility of DM, OM, CP, CF were significantly increased by 20.9, 20.3, 96.4, 33.0% compared to control. However Deraz and Ismail (2001) observed that all nutrients digestibility of cotton stalks were improved as a result of biological treatments, especially with *Pleurotous ostreatus*, compared with untreated cotton stalks. Furthermore, Fazaeli *et al.* (2004) showed that when bulls fed on wheat straw treated with *pleurotus* fungi significantly increased digestibility of DM and OM, compared with those fed untreated wheat straw spent rice straw. Fayed *et al.* (2012) noted a significantly higher (P<0.05) digestion coefficients of DM, OM and NFE when rams fed potato vines treated with fungi, bacteria (*Thermonospora funeae* or (*Cellulomonace cellulose*) in comparison with those fed the control ration. Also, present results in agreement with those obtained by Abd-El-Aziz and Ismail (2001) who reported that when sheep received rations contained rice straw treated with *Pleurotus ostreatus*, the digestibility of NDF, ADF, cellulose, hemicellulose were significantly increased by 20.9, 36.3, 21.0, 47.5% comparing to the control. Our results seemed to be near from that obtained by Abd-Allah (2007) who observed that treatment with *T. reesei* and *S. cerevisiae* had no effect on digestibility of DM, OM and CP of corn stalks or rice straw.

The effect of incorporation different sources of roughage (rice straw or corn stalks) that untreated or treated biologically with *Pleurotus ostreatus* fungi for rice straw or by *Trichoderma reesei* for corn stalks on nutrient & cell wall constituents digestibility and nutritive values (Table 3) were in agreement with many studies that carried out by Hammouda (1996); Kholif (2001); El-Sayed *et al.* (2001 and 2002); Abd El-Gawad *et al.* (2002); Abd El-Malik *et al.* (2003); El-Ashry *et al.* (2003); Shakwear (2003); El-Manlawi *et al.* (2005); Kholif *et al.* (2005) and Abd El-Hakim *et al.* (2006) who mentioned that the digestion coefficient tended clearly to be higher when rabbits fed biologically treated rice straw at different levels than that fed untreated rice straw, crop residues or banana wastes. In contrast our results disagreement with those found by Owens and Bergen (1983) and Kholif *et al.* (2014) who reported that the decreasing occurred in CP digestibility when lactating goats fed rations contained spent rice straw (SRS) of *Pleurotus ostreatus* basidiomycete at 0.25 (SRS25) or 0.45 (SRS45) (w/w, DM basis) as instead of Egyptian Berseem clover (BC, *Trifolium alexandrinum*) may be because Berseem clover (BC) contains higher levels of soluble CP compared to SRS, and/or because some of the nitrogen in SRS originates from mycelium and the mushroom fruit body. Mycelium nitrogen may be partly complexes with chitin that would not be easily digested (Fazaai and Talebian Masoodi 2006). Also, our results near from the results obtained by Singh *et al.* (1990); Abd-Allah (2007); Fayed *et al.* (2012) and Kholif *et al.* (2014) who reported that cell wall digestibility tended clearly to be improved with biologically treatment compared to that untreated substrate wastes.

Our results of biologically treatments on nutritive values were in agreement with those obtained by Abd-El-Aziz and Ismail (2001) who reported that when sheep offered ration contained rice straw treated with Pleurotus ostreatus, the nutritive values as TDN and DCP were significantly increased by 9.0, 17.6 and 16.4% in comparison with the control. Meanwhile, Deraz and Ismail (2001) noted nutritive
values as TDN and DCP of cotton stalks were improved as a result of biological treatments, especially with *Pleurotus ostreatus*, compared with untreated cotton stalks. Also, Abd El-Hakim et al. (2006) noted that partial and completely replacement of clover hay by rice straw biologically treated by fungi in growing rabbits diets recorded higher values of nutritive values as TDN and DCP than that recorded by control. Furthermore, Fayed et al. (2012) showed that rams that fed rations contained potato vines treated with fungi had higher (p<0.05) TDN and DCP values in comparison with that fed the control ration.

Results concerning with nutritive value of man effect of roughage source disagreement with those obtained by Abd-Allah (2007) who observed that biologically treatments with *T. reesei* and *S. carevisiae* increased DCP value, but TDN was not affected for corn stalks, meanwhile, treated rice straw resulted an decreased in TDN and did not affect DCP compared to the untreated crop residues.

Also, Hammouda (1996); Kholif (2001); El-Sayed et al., 2001 and 2002; Abd El-Gawad et al. (2002); Abd El-Malik et al. (2003); El-Ashry et al. (2003); Shakwear (2003); El-Manlawi et al. (2005); Kholif et al. (2005) and Abd El-Hakim et al. (2006) mentioned that the nutritive values tended clearly to be improved when rabbits and other livestock fed biologically treated rice straw at different levels than that fed untreated rice straw, crop residues or banana wastes.

**Conclusion:**

Rice straw treated by *Pleurotus ostreatus* and corn stalks by *Trichoderma reesei* were safety and improved their chemical analysis, nutrient digestibility and nutritive values.

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