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THE NUTRITIVE VALUE OF SPENT CEREALS STRAW OF *Pleurotus ostreatus*

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ABSTRACT

This experiment was conducted to determine the nutritive value of spent wheat straw compost from *Pleruotus Ostreatus* mushroom production as ruminant feed. The compost was provided from mushroom unit production in the Khanasry station in Jordan ,then it was sun dried and sampled for chemical analysis ,*in vitro* digestion and *In vivo* digestion for untreated cereals straw and spent cereals straw was done. Fungal treatment increase CP from 3.7 in the untreated cereals straw to 13% in the spent cereals straw, ash increase in the spent cereals straw and OM,NFE, NDF,ADF,ADF,cellulose and hemicellulose were decreased in the spent cereals straw. *In vitro* digestion was lower for DM and OM in spent cereals straw. No significant differences in the *in vivo* digestion of DM, OM, NDF were found and ADF.CP digestion was significantly lower (P<0.0) in spent cereals straw. N-Balance was negative and significantly (P<0.01) lower for spent cereals straw.
Keywords: Spent cereals straw, *Pleurotus Ostreatus* and ruminant feed.

INTRODUCTION

Straw represent a major quantity of biomass from cereal production .However, most parts of its carbohydrates are in form of structural cell wall bonded with lignin, which reduce its degradability and limits the availability of nutrients from the straw.

In order to brake down the lignocellulossic bond of straw the various methods that could increase its nutritive values ,physically and chemically processing have been studied (Matsuzaki *et al*.,1994;Rahal *et al*.,1997).Although these methods have disadvantages, they are costly ,low in effectiveness, not environmentally friendly (Sharma *et al* .,1993).These factors limit their application, particularly at small farm level.

Straws characterized that contain high lignin, cellulose ,hemi cellulose and low digestibility, so its utilization by the animals is limited because of the low voluntary intake and their huge bulk (Balch,1976).

Cereals straw contain 30-40% cellulose,16-27% hemi cellulose and 3-13% lignin(Chahal,1991).In order to increase the digestibility of the these straws the attention was increased to use the white-rot fungi because its capacity to remove the lignin preferentially(Pilon *et al.*,1982).According to Durrant *et al*.(1991) fungal cultivation resulted in considerable changes in the spent straw remained after mushroom harvested ,leading to the increasing in the crude protein and cell-soluble contents which might be more useful than untreated straw ,fed to ruminants. Meanwhile, inclusion of spent wheat straw obtained from cultivation of *Agaricus bisporous* mushroom in the diet of

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buffalo, up to 25%, resulted in a similar nutrient digestibility but a lower dry matter intake, comparing to the control diet(Langer *et al.*,1982).

Nutritive value of cereals straw cultured with *pleurotus* fungi has been reported by some researcher (Dehanda *et al*.,1996;Zadrazil,1997;Jalc *et al* .,1997 and fazaeli *et al* .,2004).Khorshed,(2000) reported that biological treatment (*T.viridi,S.cerevisae* or *T.viridi+S.cerevisae*)decreased significantly (P<0.05)DM,OM,CF and NFE(P<0.01) and increased the contant of ash and CP for wheat straw.He also found that NDF, cellulose and ADF contents decreased (P<0.01).Bakshi *et al* .,(1985) reported that treating wheat straw by (*Pleurotus* sp.) produse lower CF,NDF,ADF,cellulose and hemicellulose content than untreated wheat straw.

According to Zadrazil (1997) the *in vitro* dry matter digestibility of wheat straw,cultured with *Pleruotus ostreatus* ,after harvesting of mushroom(spent cereals straw) was increased by 4.4 to 8.9 %units.Calzada *et al* .,(1987) found that during the solid-state fermentation of wheat straw by *P.sajor-caju* lignin content decreased significantly and in vitro digestibility was increased by 14.3 to 29.5 %.Fazaeli *et al* .,(2002) reported that the fungal treatment increased the digestibility of DM and OM by more than 10% units and resulted in a higher intake of DM,OM and DOM,when fed to cattle.. Digestibility of the straw is dependent on the depolymerization of its structural carbohydrates. Enzymatic degradation of these macromolecules in the straw would result in degradation and increase the digestibility and availability of the carbohydrate (Giovannozzi *et al* .,1989;Fazaeli *et al* .,2004).According to Lange*r et al .,(1980)* and Durrant *et al.,(1991)* fungal cultivation resulted in considerable changes in the spent straw ,remaining after mushroom harvesting ,leading to increase crude protein and soluble cell wall content which might be more useful than the original straw when fed to ruminants. The bio-conversion of lignocellulosic materials is circumscribed to the group of white-rot fungi, of which some species of *Pleurotus* are capable of producing upgraded spent straw as ruminant feed. The fungi are able to colonize on cereals straw and liberate water soluble substrates from polymers during soiled state fermented(SSF)and thus improve the *in vitro* digestibility (Fazaeli *et al* .,2003;Zadrazil ,1997;Yamakawa *et al* .,1992).During the SSF of wheat straw by fungi ,its organics matter and detergent fiber content could be reduced and the lignin selectively removed from the lignocellulose's complex (Singh *et al.*,1990;Kunda,1994)).The crude protein and ash were also increased in the spent wheat straw(Moysen and Verachtert,1991).Such changes were depend on the strain of fungi and the culture conditions(Tripathi and Yadav,1992).Some strain of *P.ostreatus* increased the in vitro digestibility of wheat straw up to 25.5 % unit, while some others decreased the digestibility by 13.8 % unit(Zadrazil ,1997).The aim of this experiment is to study the chemical composition ,*in vitro* and *in vivo* digestibility of the spent *Pleruotus Ostreatus* mushroom cereals straw used in Jordan for sheep feeding.

MATERIALS AND METHODS

Substrate preparation:

The first substrate was a mixture of cereals straw 90%, wheat bran 5% and gypsum 5% , .After preparation of substrate placed in a sieved clothes bag then completely submerged in a water bath inside a large tank at 100c° for 1.5 hr ,then removed from the water bath, allowed to drain ,cold to about 30-40 c° ,then placed in a large plastic sheet in order to mix the spawn with the substrate by mixing manually ,then it was inoculated with *Pleurotus ostreatus* at rate of 5% of the dry matter basis .Then the bags were punched and tied, the temp. was 25 c° ,humidity 80%,with completely darkness until the compost was completely colonized by the mycelium ,then exposed to cold chock around 5 c° for 1 day .During the fruiting period ventilation is very important. Mushroom was harvested from the substrate when the caps were fully mature ,harvested period was one and half month ,then the compost bags were removed and sun dried after that samples were taken, then stored to use them in the trial.

Chemicals analysis and in vitro digestion:

Samples were taken to the veterinary labs in the veterinary department in Jordan to examine for harmful fungi and bacteria (*A. Flavus, Alafoxicose , Ovine salmonellosis* and *brucella abrtus*).

Chemical analysis were performed on untreated cereals straw and spent cereals straw.The substrates were dried in oven at 60 c and ground .Crude protein (NX6.25) and ash were determined according to A.O.A.C.(1990).

Samples of different used rations ,feces and urine were analyzed for moisture ,crude protein(CP) ,crude fiber (CF), ether extract (EE), and ash according to (A.O.A.C.,1990).Nitrogen free extract was obtained by differences .Neutral detergent fiber (NDF),acid detergent fiber (ADF),were determined according to Van Soest *et al*,(1991).Hemicellulose was calculated as the difference between NDF and ADF,cellulose was calculated between ADF and ADF. *In vitro* digestibility was determined by using the method of Tilley and Terry,(1963).

In vivo digestibility:

Two digestible trials were carried out for the untreated cereals straw and spent cereals straw to determine the nutrient digestibility coefficient ,feeding value of experimental untrated and treated cereals straw.

A one week pre-test was considered to understand the acceptability and voluntary intake of the experiment diet as below .The animals were divided into two similar groups(1. Untreated cereals straw and Spent cereals straw) on the basis of average live body weight , one control and the other is treatment group, using 6 mature Awssi rams with average live body weight of 56.5±2.2 kg.The animals were individually housed in metabolic cages.During trails the animals were fed 3% of their live body weight untreated cereals straw (UCS)or spent cereals straw(SCS).

The experiment was completed in three weeks, two weeks for adaptation and one week for collection. Feed intake were recording and samples of feed

and residues were collected during the collection period, and frozen at -20 until processed for the analysis .Feces from individual animals were collected every morning and weighing then 10% was kept. The samples from feed residues and feces were dried at 65 c for 48 hr. The dried samples were ground through awiley mill with 1-mm screen, and then composted for analysis. Using plastic containers, urine was collected measured and recorded, then 5% was kept to evaluate N retention, each bottle had 50 ml of 1N HCL to prevent ammonia losses.

Statistical analysis:

The collected data were analyzed using the GLM of SAS soft ware (1996).Least squire were calculated for all measured variables and the protected LSD test was used to determine significant differences .The following model was use:

$$YiJK=\mu + Ti+e\ ijk$$

YiJK=represent observations.
μ=Overall means.
Ti=Treatments
e ijk=Experiment error.

RESULTS AND DISCUSSION

Chemicals analysis and in vitro digestion:

The veterinary labs reported that all the samples were free from any foreign fungi, harmful bacteria and can be used in animals feed.

Results of chemical composition showed (table 1) that the SCS remained after *Plerurotus ostreatus* cultivated contained a considerable amount of crude protein (CP).The relatively higher amount of CP in SCS (12.87%) could be because SCS rich with microorganism .extra cellular enzymes and contained relatively a high level of nitrogen(Ball and Jackson,1995).

Table (1) The chemical analysis , fiber fractions and in vitro digestibility of treated and untreated cereals straw.

	SCS	UCS
Dry Matter	90.9	92.2
Organic Matter	74.49	76.90
Crude Protein	12.87	3.69
Crude Fiber	28.30	25.73
Ether Extract	0.41	0.37
Nitrogen free Extract	32.91	47.11
Ash	25.41	23.10
NDF	60.22	77.55
ADF	39.15	52.18
ADL	14.57	15.97
Cellulose	24.58	36.21
Hemi cellulose	21.07	25.37
Lignin	12.48	12.74
In Vitro DMD	31.35	41.15
In Vitro OMD	38.35	49.78

SCS=Spent cereals straw
UCS=Untreated cereals straw

The concentration of crude fiber (CF),neutral detergent fiber (NDF) and acid detergent fiber (ADF) were lower in the UCS comparing to the SCS ,however cereals straw contained a low level of organic matter (OM) and its utilization is limited because of high level of ash .The lower amount of NDF and ADF could be as a result of OM decreased in the UCS, which similar to the result reported by (Fazaeli and Shafey,2005;El-tahan *et al* .,2003 ; Mahrous and Abo Ammuo,(2005) .

Table (2) N- balance and nutrients digestibility of untreated and treated cereals straw.

Item	Treatments		
N balance	**treated**	**untreated**	**signification**
N output in feces	6.4±1.1	4.7±0.9	NS
N output in urine	4.7±1.2	3.0±0.9	NS
N intake	10.5±2.2	9.0±1.8	NS
N retained	-0.60±1.3[a]	1.30±1.1 [b]	*

[a,b,c]**Means within the same row with different superscripts differ according to the indicated level of significance**
NS = non significant; * = P<0.01;

The high level of ash is due to the depletion and consumption of OM of straw by the fungi. The ash content of UCS increase form 23.10 to 25.41%,this result agreed with Adamovic *et al*.(1998), Fazaeli and Shafey(,2005)and El-tahan *et al* .,(2003).Also
Bakshi *et al* .,(1985) reported that treating wheat straw by (*Pleurotus* sp.) produse lower CF,NDF,ADF,cellulose and hemicellulose content than untreated wheat straw, this agreed with herein obtained results.

DM *in vitro* digestibility was decreased in UCS and SCS from 41.15 to 31.55, respectively , also *in vitro* OMD decrease from 49.87 to 38.35,respectively.These results are not in accordance with the result Zadrazil ,(1997) and Calazada *et al* .,(1987).It could be because of the culturing condition, the ability of various strains of white-rot fungi in cell wall degradation and the different digestibility of the by product used is (Tripathi andYadav,1997;Jalc *et al* .,(1997).The result in this study agreed with Han and Anderson (1975) was found that the white-rot fungus *poyporus sp*. decreased the *in vitro* digestibility of rygrass straw.At the same time disagreed with Kaneshiro (1976) who concluded that it might be possible to fermented fields lot waste fiber giving a products depleted in lignin ,enriched in *Pleruotus* mycelial protein and more digestible in the rumen. In vitro digestibility of fungal substrates decreased at the beginning of colonization by white rot fungi and increased after (Zadrazil,1977; Zadrazil and Brunnrt,1982).The digestibility of substrate degraded by white-rot fungi depends on the relative rates of utilization of lignin and cellulose and other substances accessible for microbial attack. Also they reported that the increase of in vitro digestibility of lignocellulose materials depends on the fungal species, cultivation time ,temperature ,the water/air ratio and gas composition (O2,Co2 and N2 in the substrate), bulk density and composition of the substrate (Zadrazil and Brunnrt,1980; Zadrazil and Brunnrt,1981).In general *the in vitro* digestibility of colonized substrate was decreased when

the incubation period increase. This is the reason of low *in vitro* digestibility in this study.

In vivo digestibility:

Table (3) shows no significant difference in DM digestibility and OM digestibility among all the groups. This result agree with Bader,(2001);Langer *et al*.,(1982) and El-Marakby,(2003),but it in accordance with Fazaeli and Masood ,(2006) and Calzad *et al.*, (1987).This result may be due to the high level of ash and may contain relatively high amount of silica that limits the digestibility (Bakshi and Langar,1985;Sharma *et al* .,1993),other reporters(Tamong *et al* .,1992;) illustrate that the digestibility decrease because of high level of acid insoluble ash and lignin. It shows also that no significantly differences in NDF and ADF digestibility between UCS and SCS, but there is significantly differences in CP digestibility, these findings agreed with Fazaeli and Masood ,(2006) who reported that inclusion of spent wheat straw up to 20kg/100kg of the diet did not affect the digestibility of NDF and ADF ,also he reported that digestibility of CP was significantly lower ($p<0.05$) when he fed 20 and 30 % of spent wheat straw in sheep diets. These result agreed also with Langar *et al.,*(1982) and with Fazaeli *et al* .,(2002) who reported that inclusion of the treated straw at different level in the diet did not affect the digestibility of nutrient(DM,OM,CP and NDF) except the ADF was significantly ($p<0.05$) reduced in the diet contained 30% treated straw. El-tahan ,(2003) found that CP digestibility decrease significantly ($p<0.01$) when he fed 50% control ration with 50% spent wheat straw to buffaloes. This low digestibility may also led to low palatability of the SCS .

Table (3) Digestibility of untreated and treated cereals straw.

Item	**Treatments**		
Digestibility (%)	**treated**	**untreated**	**signification**
Dry matter	56.3±4.9	57.6±4.0	NS
Organic matter	61.5±5.3	59.3±4.3	NS
Crude protein	38.9±3.9[a]	47.9±3.2 [b]	*
NDF	60±7	58±5	NS
ADF	58±6	53±5	NS

[a,b,c]Means within the same row with different superscripts differ according to the indicated level of significance

NS = non significant; * = P<0.01;

It well established that nitrogen retention depend on the intake of nitrogen, amount of fermentable energy source are urinary and faecel excretion .The result in table (3) showed negative N-retained in the SCS group, this result agreed with Fazaeli and Masood,(2006), when they fed 30 % of the total ration spent wheat straw, this reduction is due to that, the nitrogen retention depends on the fermentable carbohydrate of the diet(Sarwr *et al*.,2003) .Therefore ,reduction of intake and decreased of metabolism may have resulted to negative balance.

CONCOLUTION

I t can be conclude that *Pleruotus Ostreatus* harvested spent cereals straw ,contained considerable amount of nitrogen and may be used as a roughage in sheep feeding. Although its utilization in the diets of ruminants is limited because of high mineral content .which may reduce its acceptability and nutrient balance.

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القيم الغذائية لاتبان المحاصيل الحقلية المزروع عليها فطر عيش الغراب ألمحاري.

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أجريت هذه الدراسة في محطة الخناصري التابعة للمركز الوطني للبحوث ألزراعيه بهدف دراسة القيم الغذائية و معامل الهضم لاتبان المحاصيل الحقلية،حيث استخدمت هذه ألمخلفات لزراعة فطر عيش الغراب ألمحاري (*Pleurotus ostreatus*) ،استمرت ألزراعه ثمانية أسابيع،تم حصاد للفطر عدة مرات، أخذت عينات قبل ألزراعه وبعد الحصاد لدراسة التحليل الكيميائي ومعامل الهضم.بينت الدراسة ارتفاعا بنسبة البروتين في المعامله حيث ارتفع من ٣,٦٩الى ١٣% في حين انخفضت ألماده ألعضويه ،ألأليياف الخام،المستخلص ألدهني والمستخلص خالي ألأزوت،أما معامل الهضم للمادة الجافة والمادة ألعضويه لم يتأثر معنويا ،بينما انخفض معامل هضم البروتين معنويا ($P<0.01$) .وكذلك بالنسبه لكمية الازوت المحتجز فقد كان الفرق معنويا($P<0.01$) حيث كانت ٠,٦-في التبن المعامل في حين وصلت ١,٣٠ في التبن غير المعامل.

تبين هذه الدراسة أنه يمكن استخدام هذه المخلفات بعد حصاد الفطر كعلف مالئ فقط.