Use of Mushroom Spent Wheat Straw Compost as Animal Feed

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Abstract: Spent compost wheat straw (SPWS) is an available by-product, remaining from edible mushroom production, in a considerable amount, that creates an environmental problem and, economically, disposal of this mass residue will increase the mushroom production cost. This experiment was conducted to use SPWS from *Agaricus bisporus* mushroom, obtained from Sina mushroom production units, (Hamedan, Iran). In a completely randomised design, twenty five male lambs, with initial weight of 29 ± 1.14 kg were allocated to five experimental diets contained 0, 5, 10, 15 and 20 percent SPWS, respectively. During the 100 days experiment, daily voluntary feed intake was individually recorded and daily gain was determined by dividing the amount of body weight gain obtained from two consequently weighing into days of weighing interval. Feed conversion ratio was estimated, dividing the dry matter intake into body weight gain. At the end of the experiment, two lambs from each treatment were slaughtered and the internal organs were controlled and compared visually. The final live weight of the lambs receiving diets 1-5 were 46.1, 45.8, 48.4, 42.9 and 46.9 kg and the average daily gains were 178, 194, 213, 156 and 196 g per animal respectively, which were not significantly ($P>0.05$) varied among the treatments. The average daily dry matter intakes per animal were 1253, 1390, 1424, 1268 and 1175 g for the diets 1-5 respectively, and were significantly different. Feed conversion ratios were 7.19, 7.34, 6. 9, 7.33 and 5.96 for the diets 1-5, which were not statistically different among the treatments. No differences were observed in organs and carcasses of the lambs receiving the different diets. It can be concluded that SPWS separated from casing soil may be used up to 20% in the diet of finishing lambs.

Key words: Spent mushroom compost, *Agaricus bisporus*, animal feed

1 Introduction

For over five decades, production of edible mushroom has been industrially developed in more than 80 countries.[1] After growing and cropping of mushrooms, more than two tons of spent wheat straw (SPWS) remains from each ton of mushroom harvested.[2] This mass of SPWS produced every year constitutes a potential pollutant and, economically, disposal of the residues will increase the mushroom production cost. Therefore, wastes from the mushroom growing process (stumps and spent compost) will become an increasing problem, and disposal of the large volumes of material produced on a sizable farm can present considerable environmental concerns from nitrate leaching into ground water to filling up landfills. The compost is made by mixing wheat straw, animal manure, calcium and nitrogen supplements.[3, 4] This waste material could be rich of microorganisms and extracellular enzymes,[5] and contains relatively high levels of nitrogen, potassium, phosphorus, calcium and trace elements, notably iron and silicon[6, 7] that may be used as animal feed.

Several researchers have reorted the nutritive value of wheat straw that has been used to cultivate *Pleurotus* fungi.[8-12] According to Zadrazil,[9] the *in vitro* dry matter digestibility of spent wheat straw was increased from 4.4 to 8.9% after culture and harvesting of *Pleurotus ostreatus* mushrooms. Calzada et al.,[13] found that, during a 30 day period of solid-state fermentation of wheat straw by *P. ostreatus*, the lignin content decreased significantly and *in vitro* digestibility was increased from 14.3 to 29.5 percent. Fazaeli et al.,[14] reported that fungal treatment increased the digestibility of DM and OM by more than 10% 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 will result in degradation and increase the digestibility and availability of the carbohydrate.[12, 15] According to Langer et al.[6] and Durrant et al,[16] fungal cultivation resulted in considerable changes in the spent straw remaining after mushroom harvesting, leading to increases in crude protein and cell wall-soluble contents which might be more useful than the original straw when fed to ruminants. Meanwhile, inclusion of up to 25% spent wheat straw obtained from cultivation of *A. bisporus* mushroom in the diet of buffalo resulted in a similar nutrient digestibility but a lower dry matter intake compared to the control diet.[17] Spent mushroom harvested wheat straw could be more degradable in the rumen.[9] Based on recent and historical trends, it is expected that diversification of the mushroom industry will continue in many parts of the world. However, there is limited information regarding the nutritive value and utilization of mushroom spent wheat straw compost in animal nutrition. In Iran, the mushroom industry has expanded during the last two decades and currently more than 50,000 tons of mushroom compost is produced annually by this aerobic fermentation system.[18] These experiments were conducted to study the nutritive value and acceptability as a ruminant feed of spent *A. bisporus* mushroom wheat straw obtained from the bag system in Iran.

2 Materials and Methods

Compost of spent wheat straw (SPWS) was obtained from a mushroom production unit (Sina in Hamedan) of Iran. The compost was made by mixing wheat straw (6,000 kg), poultry manure (3,500 kg), urea (100 kg), molasses (100 kg) and calcium sulfate (400 kg). *A. bisporus* spawn had been inoculated in an amount of 200-250g per square meter of the wheat straw based compost. After mushroom harvesting (3 times), which was completed within 6 to 8 weeks post spawning, the bags of compost were removed from the growing room, the top layer of soil casing was separated and the composted straw left in a cement yard for sun-drying. The air dried SPWS, as well as the initial wheat straw, was then chopped into 3-6 cm lengths and sampled for chemical analyses.

Twenty-five male lambs from local sheep, with initial weight of 29 ± 1.14 kg, were allocated to the experiment. The animals were housed in individual boxes and randomly assigned to one of the five experimental diets (five lambs per diet). The feeding trial lasted for 100 days, consisted of 10 days adaptation and 90 days for the measurements. Five experimental diets containing 0.0, 5, 10, 15 and 20 percent SPWS were formulated using wheat straw, mushroom spent wheat straw, alfalfa hay ground barley, wheat bran, soya bean meal and sugar beet molasses (Table 2). Roughage and concentrate were mixed and offered as total mixed ration (TMR) three times per day. The animals had continuous to fresh water and salt stone. The rations where prepared every two weeks and samples of prepared feeds were collected for chemical analyses.

During the experiment, the daily voluntary feed intake of each lamb was individually recorded and daily residues were collected, weighed and sampled weekly and the daily feed intakes were calculated. The dry matter intake was estimated by subtracting the amount of residues from the amount of feed offered (based on dry matter). Body weight changes of the animals were individually measured during the experiment using a special balance designed for small ruminant weighing, and daily gain was obtained by dividing the amount of body weight gain obtained from two consequently weighing into days of weighing interval. The feed conversion ratio was estimated by dividing the dry matter intake into body weight gain. The experiment was carried out for a 10 days adaptation and 90 days measurements, after which two lambs from each treatment, were slaughtered and the internal organs were controlled and compared visually. Data were statistically analysed according the completely randomised design using the SAS GLM procedure.

3 Results and Discussion

Chemical composition analyses (Table 1) revealed that the SPWS remaining after *A. bisporus* cultivation con

tained a considerable amount of CP and is a rich source of Ca and P that could be used in the diet of ruminants. The relatively higher amount of CP in SPWS (11% vs. 3.1% in initial straw) could result from the use of nitrogenous fertilizers during the composting period, and the remains of fungal residues.[3, 4, 18] Ball and Jackson[5] reported that this type of waste material could be rich with microorganisms and extracellular enzymes, and contained relatively high levels of nitrogen, potassium, phosphorus, calcium and trace elements. The concentration of CF, NDF and ADF were much lower in the SPWS compared to normal wheat straw. However, this waste material contained a low level of OM and its utilization is limited because of very high level of ash content (35g/100gDM). The lower amount of ADF and NDF could be the result of OM decreasing in the SPWS, which is similar to other reported results.[3, 19, 20] The high level of ash is due to the depletion and consumption of OM of straw by the fungi. Moreover, in the case of the *Agaricus* production system, the straw is contaminated with soil, which is one of the bed components for fungal cultivation. Although the soil was used on the surface parts, and was separated from the straw before use, it was not possible to separate it completely from the straw. The ash content of SPWS has been reported to range from 38-53%.[3, 17]

Table 1. Chemical composition of wheat straw and spent wheat straw compost (DM basis)

SPWS	IWS	Composition
64.95	90.8	Organic matter
35.05	9.9	Ash
17.8	42.9	Crude fibre
11.0	3.1	Crude protein
1.26	0.89	Ether extract
34.9	43.2	Nitrogen free extract
27.8	78.2	Neutral detergent fibre
21.0	53.8	Acid detergent fibre
20.8	9.5	Acid detergent lignin
7.0	42.3	Cellulose
6.8	24.4	Hemicellulose
	0.8	Calcium

IWS: initial wheat straw; SPWS: spent wheat straw

With regard to the animal performance, results showed that the final live weight of the lambs receiving diets I-V were 46.1, 45.8, 48.4, 46.9 and 42.9 kg, and the mean daily gains were 178, 194, 213, 196 and 156 g per animal, respectively. Values were significantly ($P<0.05$) lower in treatment V. This could be the result of the lower dry matter intake by the animals receiving diet V. The average daily dry matter intake per animal was 1253, 1390, 1424, 1268 and 1175 g for the diets I-V, respectively. There was a significant ($P<0.05$) different among the treatments. As shown in Table 2, inclusion of SPWS in the diet of sheep (up to 15 percent of the total diet) did not affect feed intake, but when it was increased up to 20 percent of the diet, the intake were significantly ($P<0.05$) reduced. Such a reduction in voluntary intake could be mostly the result of a higher ash content in diet IV.

As shown in Table 3, the ash content is 13.5 percent in diet IV. The high concentration of ash and acid insoluble ash could be in accordance with limiting minerals in feeds would have a negative effect on the voluntary feed intake.[15, 21-23] According to Kakkar et al.,[22] who used mushroom harvested spent straw as feed for buffaloes, the voluntary intake decreased was due to the relatively high content of ash in the diet. Reports indicated that mushroom spent straw obtained from *Coprinus fimetarius* or *Pleurotus* fungi resulted in no such limitation of intake when fed to ruminants.[14, 24] These types of fungi are cultured on cereal straws without using any soils and the remaining compost straw contained much lower ash than the spent straw that remained from button mushroom cultivation.[4, 9, 14] The feed conversion ratio was 7.19, 7.34, 6.9, 5.96 and 7.33, respectively for the diets 1-5, values that were not statistically different among the treatments. No differences were observed in organs and carcasses after slaughtering lambs receivng different diets.

Table 2. Effect of treatments on the performance of the animals

Parameters	Treatments					SEM
	I	II	III	IV	V	
Initial weight (kg)	30.1	28.3	29.3	28.8	29.1	5.81
Final weight (kg)	46.1^{ab}	45.8^{ab}	48.4^{a}	46.9^{ab}	42.9^{b}	2.47
Total body weight gain (kg)	16.1^{ab}	17.5^{ab}	19.2^{a}	17.8^{ab}	14.1^{b}	1.65
Average daily gain (g)	178.3^{ab}	194.0^{ab}	212.8^{a}	197.5^{ab}	156.3^{b}	18.19
Dry mater intake (g/d/animal)	1253^{ab}	1390^{ab}	1424^{a}	1268^{ab}	1175^{b}	19.4
Feed conversion ratio	7.19	7.34	6.90	5.96	7.33	1.35

Means with different superscripts within a row are significantly ($P<0.05$) different.
SEM = standard error of means.

Table 3. Formulation and chemical composition of the experimental diets (DM basis)

Feed stuffs (%)	Treatments				
	I	II	III	IV	V
IWS	14.5	5	6	0	0
SPWS	0.0	5	10	15	20
Alfalfa hay	17.5	20	15	12	6
Barley	57	57	58	62.5	68
Wheat bran	5	8.5	9	5	0
Soya bean meal	4.5	1.5	1.5	1.0	2
Molasses	1.5	3	0.5	4.5	4
Total	100	100	100	100	100
Chemical composition (%)					
Organic matter	93.4	90.7	89.3	87.8	86.5
Ash	6.6	9.3	10.7	12.2	13.5
Crude protein	12.1	12.1	12.1	12.1	12.1
Crude fibre	13	11	11	9.1	8.3
Calcium	0.5	0.76	0.93	1.14	1.36
Phosphorous	0.32	0.38	0.43	0.45	0.46

4 Conclusions

It can be concluded that *A. bisporus* harvested spend wheat straw, obtained from bag cultivation system, contained considerable amount of nitrogen and may be used as a ruminant feed. However, its utilisation in the diets of ruminants is limited because of high mineral content, which may reduce its acceptability and nutrient balances. This experiment showed that spent compost straw could be included up to 15kg/100kg of the diet for finishing lambs.

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