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ORIGINAL RESEARCH

Recycling of mushroom compost wheat straw in the diet of feedlot calves with two physical forms

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Abstract
Background This experiment was conducted to study the effect of diet contained mushroom spent wheat straw (MSWS) remained from *Agaricus bisporus* mushroom as well as the physical form of the diet on the performance of the feedlot calves. At the end of mushroom harvesting period, MSWS was collected from production room and the casing soil was removed from the whole compost, then it was sun dried and sampled for chemical analysis. In a completely randomized design, 24 Holsteins male calves with initial weight of 201.9 ± 1.0 kg were allocated to four experimental diets containing (1) standard pellet diet; (2) pellet diet with 15 % MSWS; (3) standard mash diet and (4) mash diet contained 15 % of MSWS.
Results Average daily gain was 1,261, 1,146, 1,093 and 830 g; dry matter intake was 7.91, 6.51, 8.07 and 8.15 kg/animal/day and feed conversion ratio was 6.32, 5.69, 7.39 and 8.76 for the diets respectively that were significantly different ($P < 0.05$) among the treatments. Results of slaughtering observations showed that no differences could be detected in carcass and internal organs of the calves that received different diets.
Conclusions The spent compost straw could be included up to 15 % in finishing calve diet in the pellet form.

Keywords Mushroom compost straw · *Agaricus bisporus* · Fattening calves

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Introduction

Fungal growth on lignocellulosics has been known for several centuries producing edible mushroom. But industrially production of edible mushroom has been increased rapidly during the last decades where the button mushroom (*Agaricus bisporus*), accounted most amount of the world's production (Chiu et al. 2000; Ghang 2006). After mushroom cultivation, the waste residue is called the spent mushroom substrate. A large amount of these residues are currently produced every year constituting a potential pollutant, and economically, disposal of the residues will increase the mushroom production cost. The compost is made by mixing cereal straw, animal manure, calcium and nitrogen supplements and the some other additives (Konko et al. 2001; Kaul and Dhar 2007). The residual spent straw, from mushroom harvesting, could be rich of microorganisms, extra cellular enzymes and contained relatively a high level of nitrogen, potassium, phosphorus, calcium and trace elements notably iron and silicon (Ball and Jackson 1995).

Nutritive value of wheat straw cultured with *Pleurotus* fungi has been reported by some researchers (Jalc et al. 1998; Fazaeli et al. 2002). Fazaeli et al. (2004) reported that treatment of wheat straw with *Pleurotus* fungi, increased the digestibility by more than 10 % unit and resulted in a higher intake of dry matter (DM), organic matter (OM) and digestible organic matter (DOM), when fed to cattle.

Degradation of lignocelluloses is dependent to the depolymerization of its structural carbohydrates (Christian et al. 2005; Martinez et al. 2005). 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). Fazaeli and Talebian-Masoudi (2006) studied the effect of different levels (0, 10, 20 and 30 %) of *Agaricus bispuros* mushroom spent wheat straw in the maintenance diet of sheep and found that dry matter intake was 74.0, 73.8, 70.2 and 57.1 and organic matter intake was 62.7, 63.4, 58.0 and 44.4 g per kg $BW^{0.75}$ for the diets, respectively. Inclusion of spent compost straw up to 20 % of the diet did not affect the digestibility of DM, OM, crude fiber (CF), neutral detergent fiber (NDF) and acid detergent fiber (ADF), but the diet containing 30 % compost straw had significantly ($P < 0.05$) lower digestibility.

In addition, supplementation of poultry diets with *Agaricus bisporus* mushroom may have some positive effects on the performance and immunity. According to Giannenas et al. (2010) including of *Agaricus bisporus* in the diet of broiler chickens resulted in growth promotion and tissue antioxidant protective activity. In another study by Giannenas et al. (2010) dietary *Agaricus bisporus* mushroom supplementation positively affected the intestinal health of broiler chickens. Giannenas et al. (2010) also reported that inclusion of *Agaricus bisporus* mushroom in the diet of turkey poults improved the performance, intestinal integrity and antioxidant protective activity.

It is expected that diversification of the mushroom industry will continue in many parts of the world (Ghang 2006). However, there is limited information regarding the nutritive value and utilization of MSWS compost in animal nutrition. Therefore, this experiment was conducted to study the effect of different levels of spent *Agaricus bispuros* mushroom wheat straw, in the diet of fattening calves, where the feed intake, daily gain and feed conversion ratio were determined.

Methods

A mushroom farm (Sina farm located in Hamedan area, Iran) was selected where the process of compost making and mushroom culturing was performed. In this experiment, the compost had been made by mixing wheat straw, poultry manure, calcium sulfate, sugar beet molasses and urea in amount of 590, 350, 40, 10 and 10 per metric ton, respectively. The mixture passed the composting process for 2 weeks then it was pasteurized and used as substrate after cooling. The spawn of *Agaricus bisporus* mushroom was prepared by inoculating at 200–250 g per square meter on wheat straw based compost. Production and harvesting of mushroom was completed after 8 weeks, then the bags of compost were removed from the growing room and the top layer of soil casing was separated and sun dried on a cement bed. The dried MSWS chopped and sampled for chemical analysis.

Twenty-four Holsteins male calves, with initial live weight of 201.9 ± 10.1 kg were allocated to the experiment for 170 days including 20 days adaptation to the feeding management and 150 days of data collection. Feeding was started with the control diet but it was steadily substituted for the experimental diets during the adaptation period. Animals were individually weighed, ear tagged, and vaccinated against parasites then were allocated in four experimental groups each with six replications. Animals were kept in individual stalls (0.80 × 0.50 m) equipped feed trough and water bunker with available fresh water at all times.

Two experimental diets containing 0.0 and 15 % MSWS were formulated, using the ingredients mentioned in

Table 1 Ingredients and chemical composition of the diets (% as DM basis)

Feed ingredients	Treatments			
	PSTD	PMSWSD	MSTD	MMSWSD
Wheat straw	10.00	0.00	10.00	0.00
MSWS	0.00	15.00	0.00	15.00
Alfalfa hay	20.0	15.00	20.00	15.00
Ground barley	34. 5	32.00	34.50	32.00
Wheat bran	14.00	14.00	14.00	14.00
Sugar beet pulp	4.00	11.00	4.00	11.00
Sugar beet molasses	3.00	4.00	3.00	4.00
Cotton seed meal	12.50	8.60	12.50	8.60
Calcium Carbonate	1.00	0.00	1.00	0.00
Sodium bicarbonate	0.50	0.20	0.50	0.20
Common salt	0.25	0.00	0.25	0.00
Vitamin supplement	0.25	0.20	0.25	0.20
Total (%)	100	100	100	100
Chemical composition (%) and ME (Mcal/kg) content				
ME	2.42	2.43	2.42	2.43
Ash	7.84	10.63	7.84	10.63
CP	14.11	14.10	14.11	14.10
RDP[a]	9.03	9.09	9.03	9.09
RUP[b]	5.08	5.01	5.08	5.01
NDF	39.06	34.21	39.06	34.21
ADF	21.82	19.01	21.82	19.01
Ca	0.74	1.10	0.74	1.10
P	0.43	0.53	0.43	0.53

PSTD pellet standard diet, *PMSWSD* pellet spent wheat straw diet, *MSTD* mash standard diet, *MMSWSD* mash spent wheat straw diet

[a] Rumen degradable protein

[b] Rumen un-degradable protein

Table 1. All feeds were sampled, before ration formulation and analyzed for dry matter (DM), ash, crude protein (CP), NDF, ADF, calcium (Ca) and phosphorous (P), using the standard method of AOAC (1990). The rations were formulated to meet the nutrient requirements of feedlot calves (NRC 2001) and to provide equal concentrations of protein and energy in both of the diets across the treatments. For each diet, roughage and concentrate were mixed and prepared as total mixed ration (TMR) where the half of it was prepared as mash form and the other half was prepared in pellet form (by press pelletizer machinery system) and offered to the animals ad libitum three times per day. The animals were kept in individual stall and allocated to one of the four experimental diets that were:

1. Standard diet in pellet form (PSTD).
2. Diet with 15 % MSWS, in pellet form (PMSWSD).
3. Standard diet in mash form (MSTD).
4. Diet with 15 % MSWS, in mash form (MMSWSD).

Diets offered and refusals were weighed daily in each stall prior to re-feeding at 08:30 h. Feed was not allowed to remain in the feed bunk for more than 1 day to prevent sorting. Stalls of calves never had their intake varied by more than 10 % of the previous day's intake. During the experiment, daily voluntary feed intake of each animal was individually recorded and dry matter intake was calculated.

Initial and final weights of the animals were determined using the average of weights taken on two consecutive days, and 30 days intermediate weights were taken prior to feeding at 08:00 h. Body weight changes of the calves were individually measured, daily gain and feed conversion ratio (kg feed intake/kg gain) were calculated.

Finally, three animals, from each treatment, were weighed after 16 h feed deprivation and slaughtered, at a commercial abattoir. The internal organs including heart, liver, kidneys, spleen, lungs, kidney and digestive tract were separated and visually evaluated for normal status and color (Terosky et al. 1997). The carcass quality was also visually compared among the treatments.

Statistical analysis was performed using the GLM procedure of SAS (1992) for a completely randomized design with a 2 × 2 factorial arrangement. The model included the effects of MSWS levels in the diet, physical form of diet and MSWS level × physical form interaction. For the periodically body weight changes and average daily gain, the effects represented repeated measurements on the same experimental scheme. Treatment means were compared with Duncan multiple range test. The residual mean square was used as the error term. The following model was used to describe the recorded parameters:

$$Y_{ijk} = \mu + Di + P_j + S_{(i)t} + DP_{ij} + E_{ijk},$$

where:

μ Overall sample mean,
D_i Diet i effect,
P_j Physical form j effect,
$S_{(i)t}$ Effect of periodical measures time (repeated measures) in treatments,
DP_{ij} Interaction of type with physical form of diets
E_{ijk} Ordinary least squares residual error

Results and discussions

Chemical composition of spent wheat straw

The chemical composition of spent wheat straw remained from mushroom harvesting was significantly ($P < 0.05$) different as compared to the initial wheat straw (Table 2). The MSWS contained considerably lower OM, CF, nitrogen free extract (NFE), NDF, ADF, cellulose and hemicellulose than the initial wheat straw whereas, concentration of ash, CP, Ca and P was much higher in MSWS compared to the initial wheat straw. These results are in accordance with the findings of other workers (Giovannozzi et al. 1989; Fazaeli and Talebian Masoudi 2006) who reported that fungal cultivation resulted in considerable increase in crude protein and soluble cell wall content. This by-product is also rich in Ca and P. The relatively higher amount of CP in MSWS (12.9 vs. 2.30 % in initial straw) could be due to addition of nitrogenous fertilizers to the substrate and increase in microbial and fungal biomass during the fermentation process (Konko et al. 2001; Kaul and Dhar 2007).

Table 2 Chemical composition of wheat straw (WS) and spent wheat straw (SWS)

Composition (% of DM basis)[A]	WS	MSWS
Organic matter	92.80[a]	65.00[b]
Ash	7.20[b]	35.00[a]
Crude fiber	42.90[a]	13.30[b]
Crude protein	2.30[b]	12.90[a]
Ether extract	0.89	1.26
Nitrogen free extract	46.71[a]	37.54[b]
Neutral detergent fiber	83.30[a]	27.84[b]
Acid detergent fiber	53.80[a]	20. 95[b]
Hemicelluloses	29.50[a]	6.89[b]
Cellulose	42.6[a]	5.85[b]
Non fiber carbohydrate	6.31[b]	23.0[a]
Calcium	0.22[b]	5.42[a]
Phosphorous	0. 04[b]	0.90[a]

Values with different letters in each row are different ($p < 0.05$)
[A] The values are average of three replicates

Table 3 Effect of treatments on the body weight changes and daily gains during the different months of the experiment

Body weight (kg)	Treatments				SEM	P values		
	PSTD	PMSWSD	MSTD	MMSWSD		Diet	Ph[A]	Diet × Ph[B]
Initial weight	200.0	199.0	199.7	209.0	10.1	0.876	0.943	0.703
End of 1st month	240.9	220.8	230.7	233.5	10.5	0.426	0.426	0.571
End of 2nd month	280.4[a]	248.0[b]	272.5[a]	259.5[ab]	11.7	0.167	0.254	0.808
End of 3rd month	318.3[a]	282.2[b]	309.3[a]	281.9[b]	12.5	0.042	0.102	0.963
End of 4th month	354.8[ab]	328.6[a]	338.5[ab]	308.8[a]	14.5	0.051	0.044	0.714
End of 5th month	389.2[ab]	371.0[a]	363.7[ab]	333.7[a]	10.9	0.050	0.015	0.692
Total weight gain	189.9[a]	172.0[a]	164.0[ab]	124.7[b]	6.54	0.005	0.004	0.337
Daily gain (g/animal)								
1st month	1,363[a]	727[c]	1,033[b]	817[bc]	67	0.004	0.002	0.320
2nd month	1,317[a]	907[b]	1,393[a]	867[b]	89	0.002	0.045	0.183
3rd month	1,263[a]	1,140[a]	1,227[a]	747[b]	155	0.001	0.001	0.136
4th weight	1,217[b]	1,547[a]	973[c]	897[c]	123	0.090	0.001	0.066
5th month	1,147[b]	1,413[a]	840[c]	830[c]	100	0.070	0.001	0.670
Total means	1,266[a]	1147[ab]	1,093[b]	831[c]	42	0.005	0.001	0.336

Means with different superscript within a row are significantly different ($P \leq 0.05$)

Values with different letters in each row are different ($p < 0.05$)

PSTD pellet standard diet, *PMSWSD* pellet spent wheat straw diet, *MSTD* mash standard diet, *MMSWSD* mash spent wheat straw diet, *SEM* standard error of mean

[A] Physical form of diet

[B] Interaction of diet with physical form of diet

The concentration of NDF and ADF was much lower in the MSWS compared to the normal wheat straw that could be as a result of decrease in OM content of MSWS. However, this waste material contains a low level of organic matter and its utilization is limited because of very high level of ash content (35/100 g DM). Similar results reported by the other workers (Fazaeli and Talebian Masoudi 2006). The high level of ash is due to the depletion of OM of straw by the fungi (Martinez et al. 2005). Moreover, in *Agaricus bisporus* production system, the straw is covered by a layer of soil and at the end of process the soil is removed. Although much attention is paid to prevent contamination of straw with soil, but such contamination exists to some extent (Sharma et al. 1999). The ash content of MSWS has been reported from 38 to 53 % (Langar et al. 1980; Bakshi and Langar 1991) that is affected by the substrates components, cultivation period and mushroom harvesting.

Effects of diets on the performance of animals

The initial live weight of calves was not significantly different between the experimental groups (Table 3), whereas after the first month of the experiment, significant variations in live weight were found among the treatments ($P < 0.05$). The PSDT and PMSWSD showed higher ($P < 0.05$) body weight gain compared to MSTD and MMSWSD. When the body weight changes were calculated as daily gain, it was found that the highest value was related to the PSDT, followed by the PMSWSD, however the differences between these diets were not significant (Table 3).

Inclusion of MSWS in the diets resulted lower ($P < 0.05$) daily gains during the first and second month of the experiment, but at third month, MMSWS diet had the lowest amount of daily gain. During the fourth and fifth month, MSTD and MMSWSD ranked the lowest but PMSWSD the highest amount of daily gain. In general, the total means of daily gain, during the 150 days of experiment were increased with the pellet diets, whereas the daily gain was negatively affected by inclusion of MSWS in non-pellet diet. The total means of daily gain were 1,266, 1,147, 1,093 and 831 g per animals received experimental diets, respectively, indicated that the physical form of the diet improved ($P < 0.05$) the daily gain, particularly for MSWS diet.

Regardless of the diet components, pelletizing of the ration increased the daily gain during the last 3 months of the experiment (Fig. 1) resulted in a higher total means of daily gain during the experiment (1,207 vs. 967 g). Such results are not far from expectation, because the experimental diets were similar in concentration of energy and protein content and also in most of the other nutrients (Table 1). The nutrient digestibility and availability may be improved by pelletizing the complete ration particularly for the roughage portion. Reddy et al. (2002) compared the pellet with mash form of diet contained 40 % sugarcane bagasse as sole source of roughage in growing bulls and reported that average daily gain and feed efficiency were significantly higher in the pelletized diet group. They concluded that digestibility and nitrogen balance were increased by pelletizing the ration due to the expander-extruder processing. Yaylak et al. (2003) found higher live weight when fed fattening lambs with pelletized feed than the mash feed with lower feed to gain ratio.

Apart from the physical form, inclusion of MSWS in the diet reduced the average daily gain during the first 3 months of the experiment (Fig. 2) which significantly affected overall daily weight gain between the standard and

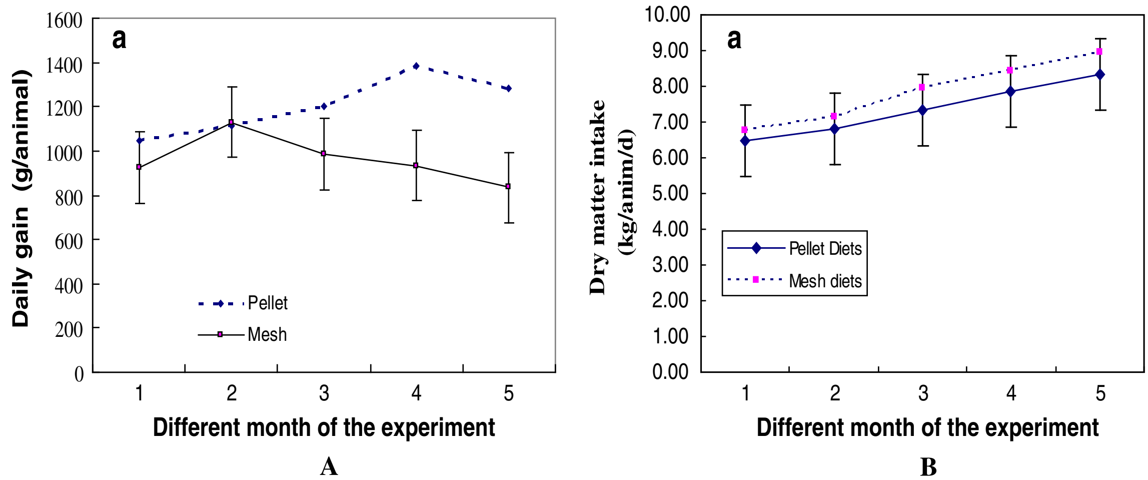

Fig. 1 Effect of physical form of the diet on the daily gain (**a**) and DMI (**b**) across the experiment. The differences of daily gain was significant ($P < 0.05$) during the months 3, 4 and 5

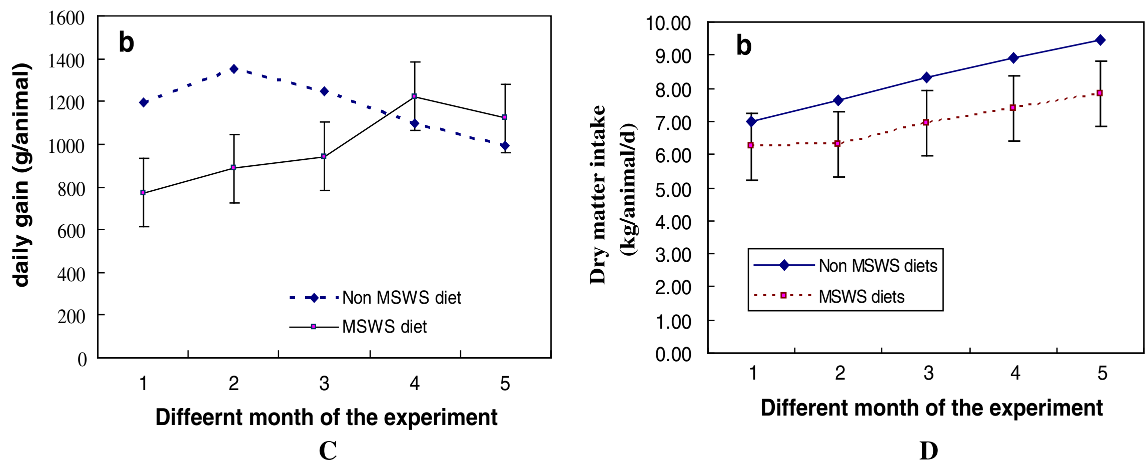

Fig. 2 Effect of diets on the daily gain (**a**) and DMI (**b**) across the experiment. The differences of daily gain was significant ($P < 0.05$) during the months 1, 2 and 3. The differences of DMI was significant ($P < 0.05$) during the months 2, 3, 4 and 5

MSWS diet (989 vs. 1,180 g) throughout the experiment. Although spent straw has some advantages over the original straw (Fazaeli et al. 2007), it may contain components with limiting effect on growth and daily gain of growing calves. Fazaeli and Talebian-Masoudi (2006) studied the digestibility of spent *Agaricus bispuros* mushroom wheat straw, from the bag system of mushroom production, in sheep and reported that it could be included up to 20 % of ruminant diet. But the results do not agree with the above recommendation for the case of growing calves where the 15 % of MSWS reduced daily gain and disagree with findings of Fazaeli and Shaffeyee-VA (2005) who reported that no significant variation was found in daily gain where they used 15 % of *Agaricus bisporus* spent wheat straw in the diet of finishing lambs. It may be related to the susceptibility of Holstein male calves used in this experiment to the MSWS diet. Additionally, duration of this experiment should be taken into account which was longer (5 vs. 3 months) than that of the mentioned trial.

Voluntary feed intakes were higher ($P < 0.05$) by the calves received MSTD or PSTD during all periods with exception for the PSTD that had lower intake during the last month of the experiment (Table 4). However, the total means of daily feed intake during the total period of experiment were similar for the animals received MSTD or PSTD, but it was reduced ($P < 0.05$) when the MSWS was included in the diets, either pellet or mash form. Between the two diets contained 15 % MSWS, the pelleted diet resulted in a lower ($P < 0.05$) feed intake. Physical form of diet could affect the voluntary intake (Fluharty 1999). It seems that palletizing concentrates the ration which in turn, causes a higher intake potential (Miron et al. 2004). However, numerically lower dry matter intake was calculated based on the g/kg $BW^{0.75}$ when the animals received

Table 4 Effect of treatments on the feed intake and feed conversion ratio during the different months of the experiment

Items	Treatments				SEM	P values		
	PSTD	PMSWSD	MSTD	MMSWSD		Diet	Ph^{A}	Diet × Ph^{B}
Feed intake (kg/animal/day)								
1st month	7.15^{a}	5.8$^{0\ b}$	6.86^{a}	6.68^{a}	0.25	0.762	0.008	0.762
2nd month	7.78^{a}	5.81^{c}	7.47^{a}	6.80^{b}	0.24	0.865	0.002	0.866
3rd month	8.01^{a}	6.69^{c}	8.68^{a}	7.19^{b}	0.19	0.842	0.013	0.842
4th weight	8.48^{a}	7.21^{b}	9.31^{a}	7.56^{a}	0.22	0.032	0.001	0.021
5th month	8.94^{b}	7.73^{c}	9.94^{a}	7.92^{c}	0.26	0.023	0.001	0.013
Total means	7.79^{a}	6.51^{c}	8.07^{a}	7.15^{b}	0.27	0.254	0.001	0.346
Feed conversion ratio								
1st month	5.25^{b}	7.98^{a}	6.64^{ab}	8.18^{a}	0.54	0.032	0.022	0.477
2nd month	5.91^{bc}	6.41^{b}	5.36^{c}	7.84^{a}	0.66	0.007	0.503	0.213
3rd month	6.34^{bc}	5.87^{c}	7.07^{b}	9.63^{a}	0.77	0.001	0.002	0.052
4th weight	6.97^{c}	4.66^{d}	9.57^{a}	8.43^{b}	0.67	0.011	0.034	0.117
5th month	7.79^{c}	5.47^{d}	11.83^{a}	9.54^{b}	0.71	0.009	0.006	0.459
Total means	6.15^{c}	5.68^{c}	7.38^{b}	8.60^{a}	0.30	0.002	0.015	0.317

Means with different superscript within a row are significantly different ($P \leq 0.05$)

Values with different letters in each row are different ($p < 0.05$)

PSTD pellet standard diet, *PMSWSD* pellet spent wheat straw diet, *MSTD* mash standard diet, *MMSWSD* mash spent wheat straw diet, SEM: standard error of mean

^{A} Physical form of diet

^{B} Interaction of diet with physical form of diet

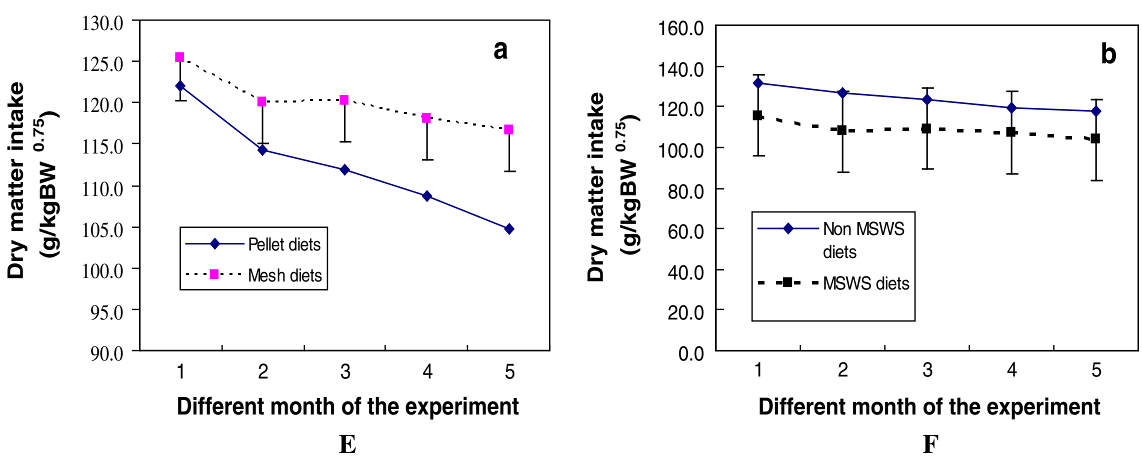

Fig. 3 Comparing of the physical form (**a**) and treatment diets (**b**) on the DMI (g/kg BW$^{0.75}$) across the experiment. The DMI was significantly ($P < 0.05$) affected by the physical form of the diets from the month 3 up to the end of the experiment

PSTD and PMSWSD (Fig. 3). Voluntary intake depends on the nutrient composition, palatability and physical form of the diet. In this experiment, the feed ingredients were similar for the treatment diets, except for the MSWS that was used in diet 2 and 4; hence there were no significant differences between the diets for nutrient (particularly energy and protein) contents. This means that differences between physical forms of the diets as well as between the diets with or without MSWS are related to the physical form that caused a lower intake in pelletized diets. This reduction may be due to degree of hardness of the palletized diet that limited the voluntary intake. Meanwhile, the amount of feed waste could be higher when the feed offered in mash form that will be shown a higher feed intake. In fact, no feed waste was observed during daily feeding practice by the animals that received pelletized feed, whereas some feed waste was observed on the stall of animals fed mash feed that could not be recorded.

As it is shown in Table 2, the ash content in MSWS was much higher than that of original straw (35.05 vs. 9.9 %) that in turn caused a higher concentration of ash in diets containing MSWS (10.58 vs. 5.26 %). The high concentration of ash and acid insoluble ash would have a negative effect on the voluntary feed intake. According to Kakkar et al. (1990), that used mushroom harvested spent straw as feed for buffaloes, the voluntary intake decreased due to the relatively high content of ash in the diet. In addition to the high concentration of ash, presence of inhibitor substances such as phenolic compounds in MSWS, produced as a result of degradation of lignocelluloses by fungi, could negatively affect intake (Langar et al. 1980; Bonnen et al. 1994). According to previous studies mushroom spent

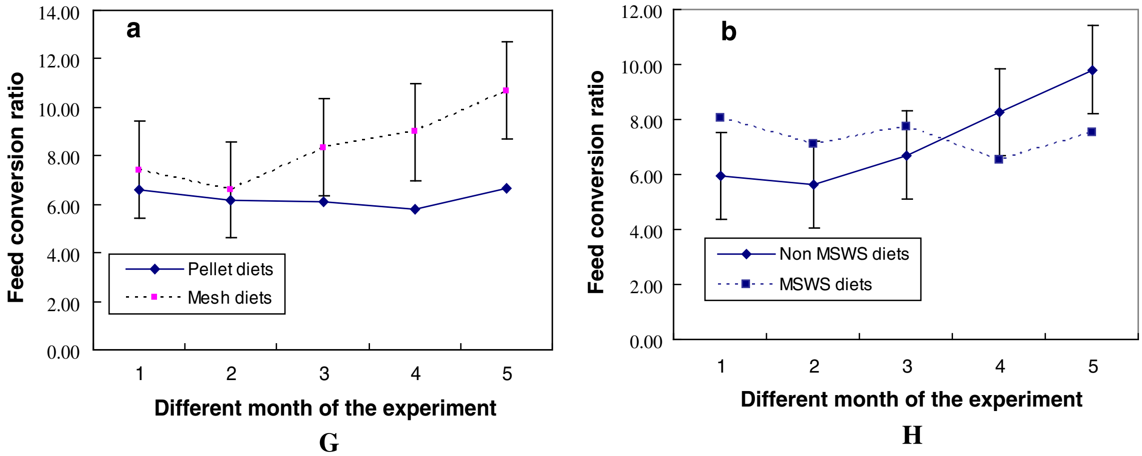

Fig. 4 Effect of physical form (**a**) and treatment diets (**b**) on the feed conversion ratio (FCR) across the experiment. The FCR was significantly ($P < 0.05$) affected by the physical form of the diet during the months 3, 4 and 5

straw obtained from *Coprinus fimetarius* or *Pleurotus* fungi did not have such limitation effect on intake (Walli et al. 1991; Fazaeli et al. 2002). These types of fungi are cultured on cereal straws where no soils are added to the substrate and the remaining compost contained much lower ash than that of the spent straw from button mushrooms (Zadrazil 1997; Fazaeli et al. 2007).

Fazaeli and Talebian-masoudi (2006) reported that inclusion of MSWS up to 20 % in the diet of mature sheep, did not affect the intake and digestibility that is somehow different from the present work. It may be due to the animals and type of the diets. The mentioned authors provided MSWS for maintenance diet of mature sheep that could have less effect on intake. According to Fazaeli and Shaffeyee-VA (2005), inclusion of 15 % MSWS, remained form *Agaricu bisporos,* to the diet of fattening lambs, did not affect the feed intake, but the feed intake was reduced when the amount of MSWS was increased to 20 % of the diet. Langar et al. (1980) that used *Agaricu bisporos* MSWS in the diet of buffalo, reported that dry matter intake was reduced when the spent straw used at 25 % of the diet.

As it is shown in Table 4, feed conversion ratio (kg of DM intake by the animals per kg of body weight gain) was affected ($P < 0.05$) by the treatments during the different months of the experiment and the total feeding period.

Although some fluctuations were found across the different months for the treatments nevertheless, pelletized diets resulted in lower ($P < 0.05$) feed conversion ratio (FCR) compared to the mash form. No significant difference was found in total means of FCR between the PSTD or PMSWS diets whereas, using of MMSWS negatively affected the FCR.

Physical form of the diets affected the FCR which resulted in a lower dry matter intake per kg of body weight gain during the last 3 months of the experiment (Fig. 4) but a crisscross trend was found for FCR between the animals fed standard or MSWS, regardless the physical form of the diets. Meanwhile, a better trend of FCR could be expected in non MSWS diets in this experiment.

Particle size of forage may increase the gut capacity which results in greater maintenance energy requirements that in turn could affect the feed conversion ratio (Fluharty 1999). Therefore, by using the mash ration, animals received long particle size roughage, whereas in case of pelletized ration, animals received ground pellet roughage more closely resembles a concentrate feed in terms of particle size that may resulted in a greater feed efficiency. Yaylak et al. (2003) found more live weight when fed fattening lambs with pelletized than the mash feed with lower feed to gain ratio. Complete feed pellet provides ruminants with higher nutrient density and homogenize nutrients available, which can result in a better rumen manipulation and a subsequent rise in animal performance. Thus preparing of feed in pellet form prevents it from sorting that keeps the optimum balance between grain and roughage in the diet throughout consumption. Results of carcass evaluation showed that the apparent conditions and colors of carcass and internal organs including heart, liver, kidneys, spleen, lungs, kidney and digestive tract were not different among the calves in different treatments.

Conclusion

It can be concluded that *Agaricus bisporus* harvested spent wheat straw, obtained from bag cultivation system, has considerable amount of nitrogen and may be used as a ruminant feed. However, utilization of this byproduct in the diet of finishing calves negatively affected the feed intake and daily gain when the feed offered as total mixed ration in mash form. But it may be used in complete pellet ration to prevent its negative effect on the feed intake and body weight gain. Pelletizing of the diet improved fattening performance of the calves but no interaction effects of diet with pelletizing were detected in this study. Finally, this experiment showed that spent compost straw could be included in the diet of finishing calves produced in pellet form.

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Conflict of interest The authors declare that they have no conflict of interest

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