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Influence of *Pleurotus ostreatus* spent corn straw on performance and carcass characteristics of feedlot Pelibuey lambs

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ABSTRACT

The present study was conducted in lambs fed diets including the corn straw post-grow of the mushroom, *Pleurotus ostreatus*, to evaluate growth performance and carcass characteristics of feedlot lambs. Thirty two Pelibuey lambs (29 kg) were divided in two treatments and blocked by weight. Dietary straw treatments were: (i) 9% of pasteurized straw as control (CS); and (ii) 9% of pro-farming straw from *Pleurotus ostreatus* (CSP). *Pleurotus* treatment increased crude (39.5%) and soluble protein (165%), soluble carbohydrates (621%), and decreased neutral detergent fiber (14.5 units). Average daily gain (ADG) was increased up 56 d (31%) and total trial duration (1 to 56 d) to 17.5%. DMI was increased up to 13% and 4.6% to period 28 to 56 d and total trial duration, respectively. Carcass weight, dressing percentage, fat thickness, and KPH were not influenced by dietary treatments. In conclusion, corn straw treated with *P. ostreatus* improved chemical composition of straws and growth performance of feedlot lambs, without negative effects on carcass characteristics.

Key words: Carcass characteristics, Lambs, *Pleurotus ostreatus*, *Plurotus srotinus*, Spent corn straw

The lignocellulose complex in straw is degraded slowly by ruminants because of the physical barrier imposed by lignin polymers, which prevent free access of hydrolytic enzymes such as cellulases and hemicellulases to their substrates. Biological delignification of straw would seem a possible method for improving the digestibility of crop residue (Zadrazil and Reinger 1988) without the use of toxic chemical.

Particularity, in México the bulk of wastes post-grow of *Pleurotus ostreatus* is about 70 million tonnes/year. However, the substrate used to cultivate *Pleurotus ostreatus* is biodegraded and enrich with cellular components of the mushroom. It presents the ability to degrade ligninocelulosics compounds, which are presents on farming leftovers, reason why it contributes to the productive use of this substrate as well as in recycling in the nature (Martínez-Carrera *et al*. 1999).

A significant increase *in-vitro* dry matter digestibility of wheat straw by *Pleurotus* was reported by Lindenfelser *et al*. (1979), who used commercial cellulase to compare the release of glucose from untreated straw to that of straw following *Pleurotus* fermentation. They found that lignin content decreased by 51% during incubation period (90 days). Similar results were reported by Zadrazil (1985), who showed an increase of 23 to 32% *in-vitro* digestibility following fermentation by *Pleurotus ostreatus* and *Pleurotus serotinus*. The present study was conducted in lambs fed diets including the corn straw post-grow of the mushroom previously conserved in anaerobic conditions to evaluate the digestibility and influence on growth performance.

MATERIALS AND METHODS

Forage material: Stabilized corn straw was produced on a farm located 5 km north from Ixtacuixtla, Tlaxcala, Mexico. After the harvest, corn straw was baled into standard 36 cm × 46 cm × 91 cm bales. During this study we used the *Pleurotus ostreatus* UAT-PO7 stump registered at American Type Culture Collection as ATCC-201218. The *Pleurotus ostreatus*

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stump was seeded on chopped corn straw with a particle size of 5 to 7 cm. The corn straw was pasteurized by water at 85ºC for 1hr. It was planted in nylon bags, alternating layer of inoculated (0.5 kg) and pure corn straw (5 kg). They were compacted slightly and got incubated in total absence of light for 15 days. After this period, the bags were moved to the production room and they were exposed to light. Only a cut was done and the post-farming of stump was removed from the production room, to ferment them in a future process. After pasteurized straw (CS) and pro-farming straw from *Pleurotus* (CSP) were introduced in metallic fermenters of 37 cm diameter and 53 cm height. In each fermenter, the content of 6 bags was compacted @ 40 kg/in^2 pressure, which promoted anaerobic fermentation, specially the heterolactic type, given by the native flora (Bolsen 1995).

Feedlot performance: Pelibuey lambs originated from south of Mexico were transported to the Mexican plateau, Tlaxcala State. The average daily minimum and maximum air temperature during the 56-day trial was 5.0 and 17.5°C, respectively. Upon arrival, lambs were vaccinated for clostridials treated for parasites (Closantel), and adapted to high grain diet by 14 days.

The study was based on selection of 36 lambs with average live weight of 29 kg ± 1.13 kg and 4-month-old. All animals were dived in two treatments and they were blocked by weight and assigned within blocks to one of 8 pens (four lambs per pen). All animals received a diet of 59.5% corn grain, 16.4% soybean meal, 9% corn straw, 5.8% wheat bran, 5% sugarcane molasses, 2% mineral (premix), 1.5% vegetable oil and 0.8% urea to meet the requirement of growing lambs (NRC-2007). Dietary corn straw included in the diet was the treatment effect: (i) 9% of pasteurized-straw as control (CS); and (ii) 9% of pro-farming straw from *Pleurotus ostreatus* (CSP). Diets were prepared weekly and stored in wood-boxes, and feed was added twice daily so that lambs had *ad lib.* access to their diet. During the slaughter of animals was obtained a sample of ruminal fluid to determine the pH and volatile fatty acids concentration. Hot carcass weights were obtained from all lambs at time of slaughter. After the carcasses were chilled for 24 hr the following measurements were obtained: (i) subcutaneous fat thickness over the eye muscle at the twelfth rib taken at a location 3/4 the lateral length from the chine bone end; (ii) kidney, pelvic and heart fat (KPH) as a percentage of carcass weight, and KPH according to Mexican Norm Official (2006).

Laboratory analysis: Samples were subjected to all or part of the following analyses: DM (oven drying at 100°C until no further weight loss), ash, total and soluble protein (AOAC 2003), neutral detergent fiber (NDF) (Weizhong and Udén 1998), soluble carbohydrates (Trevelyan and Harrison 1956) and volatile fatty acids (gas chromatography; Erwin *et al.* 1961).

Statistics: A completely randomized design was used where lambs were stratified by weight within each pen and treatments. Pen was used as the experimental unit. All data were compared using the parametric Student's test (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Chemical composition: *Pleurotus* treatment increased crude (39.5%) and soluble protein (165%), soluble carbohydrates (621%), ash (188%), and decreased neutral detergent fiber (14.5 units). The improvements on nutritive value through chemical composition (Table 1) of straws or byproducts through solid fermentation using *Pleurotus ostreatus* is consistent with Hamza *et al.* (2003) who found that strains *Pleurotus florida* and *Pleurotus* sp. were the best effective strains for cellulose and hemicellulose degradation. The protein increase over the untreated corn stalks was 90% by *Pleurotus* sp. Also the *in-vitro* dry matter digestibility (IVDMD) was improved by biological treatment. Villas-Boas *et al.* (2003) reported that the bioconversion of apple pomace by *Candida utilis* and *Pleurotus ostreatus* increased protein level as well as a mineral level. Also, free sugars increased after the fermentation with *P. ostreatus* alone due to pectin and hemicellulose degradation. Kutlu *et al.* (2000) showed that *Pleurotus florida* inoculation increased digestibility in sheep (22%), crude protein (60%), crude oil (20%), nitrogen-free extract about (5%), while reducing crude fibre content about 16%. Fonseca *et al.* (2009) using rice byproducts as substrate in *P. sajor-caju*- and *P. ostreatus* found an protein enrichments, also a higher digestible protein increase was

Table 1. Chemical composition of corn straw (CS) and corn straw with *Pleurotus ostreatus* (CSP) using in the composition diets to feedlot lambs

Chemical composition	Dry matter basis g/100 g of DM	
	CS	CSP
Crude protein	3.44 ± 0.17	4.80 ± 0.02
Soluble protein	0.69 ± 0.01	1.83 ± 0.08
Soluble carbohydrates	0.37 ± 0.03	2.77 ± 0.06
Neutral detergent fibre	70.64 ± 2.58	60.37 ± 1.99
Ash	2.74 ± 0.86	7.90 ± 0.42

Table 2. Treatment effect on rumen fermentation characteristics in Pelibuey lambs

Characterstics	CS	CSP	SE
Rumen parameters			
pH	6.1	6.3	0.1
Volatile fatty acids (mol/100 mol)			
Acetate	66.6	68.9	1.8
Propionate	18.5	19.3	1.3
Butyrate	14.8	11.7	.99

SE, standard error, P > 0.05 Nonsignificant.

obtained for both species in media with 70% moisture and 25% soft rush. Montañez-Valdez (2008) concluded that growing *P. pulmonarius* in wheat straw improves the chemical composition of the straw by increasing its organic matter content and modifies the fiber structure, which increases the soluble carbohydrates content. Rumen parameters pH and VFA (acetate, propionate and butirate) were not influenced by dietary treatments (Table 2).

Growth performance: Average daily gain (ADG) increased 17.5% (P<0.10). DMI increased from 28 to 56 d (13%; P<0.01) and total trial duration with 4.6% (P<0.05). FE was not influenced (P>0.10) by dietary treatments (Table 3). Inclusion of corn straw treatment with *Pleurotus ostreatus* improved growth performance of feedlot lambs. In agreement, Hüttermann *et al.* (2000) reported that rams fed fungus-treated straw exhibited increased body-weight, as result of the improvement in nutritive value by the fungal treatment of rice straw or corn stalk. However, different results were reported by Aceves *et al.* (1997) in feeding lambs with 70% of wheat straw non-treated (WS) and treated with *Pleurotus ostreatus* (WSP). Feed intake was similar in both treatments and ADG was 80 g for WSP, and 101 g WS. Growth performance of lambs was not improved by *P. ostreatus* treatment. Similarly, Malik *et al.* (1999) in fat-tailed ram lambs fed four diets containing cardboard-based protein-enriched fermented feed with *Phanerochaete chrysosporium* and *Pleurotus ostreatus* fungi (PEFF), which increased the crude protein (CP) of the cardboard from 7 to 96 g/kg dry matter (DM) and ADG was 279, 224, 146 g, for control, 25, 50 and 75 PEFF diets, respectively. Consistently, Adamovic *et al*. (1998) studied the influence of *Pleurotus ostreatus* enzymes on wheat straw degradation; after that, straws were used in a feeding trial with 0% (control), 10% (group 1) and 17% (group 2) of dietary dry matter. Average daily gains were 1150, 1140 and 990 g/day respectively. The utilization of dry matter per kg of gain had a tendency to decrease with the increased amount of compost in the diet. The difference between the results for growth performance of lambs in present research and previously mentioned studies, may be due to the substrates used for *Pleurotus* growth; the present research used corn straw, while other used wheat straw which could be of lower nutritive value. In addition, the level of forage in diet also is different; in this study a dense energy diet was used and included 9% of straws (DM basis). Other studies included higher forage levels and showed a diminution in growth of lambs fed greater forage levels in diet (Adamovic *et al.* 1998). Although, treated straws showed improvement in chemical composition and digestibility, however higher levels of treated straws might reduce the energy content of diets. The increase in ADG was not reflected in F: G efficiency because DMI also increased in animals consuming diets with treated corn straws.

Table 3. Treatment effect on growth performance in Pelibuey lambs

	CS	CSP	SE
Pen replicates	4	4	
Days on test	56	56	
Weight, kg			
Initial	29.24	28.29	2
Final	40.5	41.5	5
ADG, kg			
1–28 d	0.205	0.220	.017
28–56 d*	0.190	0.249	.019
DM intake, kg/d			
1–28 d	1.139	1.196	.046
28–56 d**	1.096	1.138	.026
Feed efficiency			
1–28 d	5.51	5.44	.406
28–56 d	5.77	5.0	.390
Carcass traits			
Carcass weight, kg	20.2	20.8	1.66
Dressing percentage	49.9	50.1	0.72
Fat thickness, mm	2.11	2.25	0.43
KPH,%	1.42	1.2	0.14

SE, standard error; *P < 0.05, **P < 0.01.

Carcass characteristics: Carcass weight, dressing percentage, fat thickness, and KPH were not influenced (P>0.05) by dietary treatments (Table 3). The use of corn straws treated with *Pleurotus ostreatus* did not have negative effects on carcass characteristics. Information in this aspect is limited, however, Malik *et al.* (1999) fed ram lambs with four diets containing cardboard-based protein-enriched fermented feed (PEFF) and concentrates in ratios of 0 (control), 25, 50 and 75 of PEFF. Higher PEFF decreased dressing percentage, and side weights. Increasing the proportion of PEFF in the diet from 250 to 750 g/kg feed, did not change the proportion of lean in the lamb carcasses. The difference between these results for carcass characteristics of lambs and present research may have similar explanation to the mentioned for growth performance. Corn straw treated with *Pleurotus ostreatus* improved chemical composition of straw and growth performance of feedlot lambs, without negative effects on carcass characteristics.

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