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Effects of feeding yeast *(Saccharomyces cerevisiae),* organic selenium and chromium mixed on growth performance and carcass traits of hair lambs

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Abstract

Yeasts and organic minerals are used in diets to improve health, productive performance and some carcass characteristics of ruminants and non-ruminants. Thirty-two lambs (Pelibuey×Katahdin; BW=(30.55±1.67) kg; *n*=8) were used in a 56-d feeding experiment to study the effects of different levels of live yeast (*Saccharomyces cerevisiae*; yeast), selenium (Se) and chromium (Cr) mixed (Se-Cr), and a mixture of yeast-Se-Cr on growth performance and carcass traits. Animals were stratified by body weight (BW) and randomly assigned to one of four treatments: 1) control group (0.0 g kg^{-1} yeast); 2) yeast (1.50 g kg^{-1} dry matter intake (DMI) d^{-1}); 3) Se-Cr premix (1.5 mg kg^{-1} DMI d^{-1} for each mineral); and 4) yeast-Se-Cr mixture. There were no treatment effects on final BW; whereas lambs fed Se-Cr or yeast-Se-Cr had higher (P<0.05) DMI than animals supplemented with only yeast. Average daily gain (ADG), gain:feed ratio, chop area, dorsal fat and carcass yield were similar (P>0.05) among treatment groups. In conclusion, supplementation with yeast, Se-Cr mixed or yeast-Se Cr did notimprove ADG, final BW, back fat content and carcass yield of growing of Pelibuey×Katahdin lambs. Supplementation with Se-Cr and yeast-Se-Cr increased DMI, and approximately 250 g ADG $animal^{-1}$ d^{-1} was produced with no negative effects on growth and health of the animals.

Keywords: yeast, organic selenium and chromium, Pelibuey×Katahdin sheep.

1. Introduction

Yeasts are used in diets to improve health, productive performance and some carcass characteristics of ruminants (Desnoyers *et al.* 2009; Chaucheyras-Durant and Durant 2010; Khalid *et al.* 2011; Elghandour *et al.* 2014a, b, 2015; Puniya *et al.* 2015). Beneficial effects of *Saccharomyces cerevisiae* supplementation on ruminant productive performance have been widely studied, but results are inconsistent. Supplementation with yeast can stimulate cellulolytic activity of fibrolytic bacteria in the rumen (Thrune *et al.* 2009; Fereli *et al.* 2010; Zeoula *et al.* 2011; Jurkovich *et al.* 2014), improve feed intake (Payandeh and Kafilzadeh 2007; Tripathi and Karim 2011; Vosooghi-Poostindoz *et al.* 2014), average daily gain (ADG; Haddad and Goussous 2005; Ding *et al.* 2008; Khalid *et al.* 2011; Tripathi and Karim 2011), and carcass characteristics (Abdelrahman and Hunaiti 2008; Valdés-García *et al.* 2011; Estrada-Angulo *et al.* 2013).

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It also has been observed that yeast can act as a modulator of immune responses (Stephens *et al.* 2007; Tabe *et al.* 2008; Ng *et al.* 2009; Girardin and Seidman 2011). However, no effects of yeast supplementation were reported in other cases (Hristov *et al.* 2010; Sales 2011; Issakowicz *et al.* 2013). In Mexico, mineral supplementation for growing lambs is rare even though selenium (Se) and chromium (Cr) are essential micronutrients for growing lambs (NRC 2007). Se is involved in glutathione peroxidase formation and membrane
cell maintenance and, in conjunction with vitamin E acts as an antioxidant in the balance of free radicals; whereas Cr acts directly on the sensitivity of cells to insulin and glucose metabolism (NRC 2007). Both Se and Cr have been associated with increased carcass yield, hot carcass weight and *longissimuss dorsi* area in finishing feedlot lambs (Domínguez-Vara *et al.* 2009; Estrada-Angulo *et al.* 2013). Association of yeast with minerals such as Se or Cr or Se-Cr mixed has been studied in some particular areas of Mexico. However, studies that used Se chelated with yeast in ruminant diets showed inconsistent results regarding its effects on carcass characteristics. This scenario is quite similar to Cr functions relative to growing hair lambs. For growing hair lambs, National Research Council, USA (NRC 2007) has recommended a Se requirement, but for the same animals, National Research Council only suggests that Cr should be added to the diet as an essential element, with no indication of the amount required for growing animals. Based on the above on the inconsistency of Se and Cr supplementation results and on the unknown Cr levels required for growing hair lambs, the objective of this study was to determine the effect of yeast supplementation, Seand Cr mixed, or a combination of yeast-Se-Cr on dry matter intake (DMI), ADG, back fat and carcass yield in growing hair lambs.

2. Results

2.1. Yeast supplementation on dry matter intake

Table 1 shows initial and final body weight (BW), DMI, ADG, feed efficiency, chop area, back fat and carcass yield, observed in Pelibuey×Katahdin growing lambs during 56 d. During this period, no effect of yeast on DMI ($P>0.05$) was observed; however, the effect of the Se-Cr supplementation and the combination of yeast-Se-Cr did affect DMI ($P<0.05$).

2.2. Growth performance

Initial and final BW, ADG and feed efficiency (Table 1) were not different among treatment groups ($P>0.05$). Decreased DMI (approximately 10.0%) in response to the inclusion of Se-Cr mixed, compared with other treatment groups, did not affect growth performance of Pelibuey×Katahdin lambs.

2.3. Back fat content and carcass yield

Chop area, back fat and carcass yield in growing lambs (Pelibuey×Katahdin) supplemented with yeast, Se-Cr and a combination of yeast-Se-Cr are shown in Table 1. After 56 d of feeding, growing lambs in confined conditions showed no differences ($P>0.05$) in chop area, back fat or carcass yield.

3. Discussion

3.1. Dry matter intake

Several reports (Zerby *et al.* 2011; Issakowicz *et al.* 2013) have indicated that supplementation with yeast, Se-Cr mixed or the combination of both have increased DMI, ADG and carcass yield of growing lambs, and steers (Chang and Mowat 1992; Cole *et al.* 1992; Zinn *et al.* 1999). In the present study, *S. cerevisiae* supplementation (1.5 g d^{-1}) did not influence DMI (Table 1), which is consistent with the study of Mutsvangwa *et al.* (1992), who reported similar effects of yeast supplementation on finishing bulls. The increase in DMI observed in the current study can be explained by addition of yeast, which stimulated the rumen fermentation. Wiedmeier *et al.* (1987) observed an increase in digestibility of crude protein (CP) and hemicellulose of
a diet fed to lactating cows supplemented with 90 g d^{-1} of yeast, suggesting that adding yeast could have stimulated rumen fermentation. They also suggested that this stimulation is related to an increase in fermentation activity of bacteria, especially cellulolytic strains, which are associated with neutral detergent fiber (NDF) and dry matter (DM) diet digestibility.

Table 1 Effect of *Saccharomyces cerevisiae* (yeast) supplemented, organic selenium and chromium (Se-Cr) mixed or a combination of yeast-Se-Cr on productive performance and some carcass characteristics of Pelibuey×Katahdin fattening lamb in experimental period of 56 d in confinement

Item	Treatments[1)]				Contrast (*P*-value)		
	Control	Yeast	Se-Cr	Yeast-Se-Cr	Yeast	Se-Cr	Yeast-Se-Cr
Initial body weight (kg)	31.12±3.60	30.62±4.59	29.65±5.46	30.80±5.09	0.84	0.70	0.62
Final body weight (kg)	43.25±4.16	41.50±3.74	40.75±6.27	43.00±4.34	0.88	0.76	0.24
Dry matter intake (kg)	1.38±0.14a	1.30±0.08 ab	1.24b±0.06	1.32±0.02 ab	0.89	0.02	0.05
Average daily gain (kg d^{-1})	0.216±0.05	0.194±0.04	0.198±0.04	0.217±0.03	0.92	0.80	0.19
Gain:feed ratio	6.65±1.48	7.20±2.24	6.43±1.09	6.16±0.88	0.79	0.25	0.44
Chop area (mm^2)	1081.13±91	1045.88±127	1089.63±111	1044.13±100	0.30	0.93	0.89
Dorsal fat (mm)	2.75±0.46	2.62±0.51	2.87±0.35	2.62±0.51	0.26	0.70	0.70
Carcass yield (%)	48.67±1.11	50.03±1.75	49.35±1.70	49.35±1.49	0.48	0.91	0.37

1) Yeast, *Saccharomyces cerevisiae* (1.5 g kg^{-1} DMI); Se-Cr, organic selenium and chromium mixed (1.5 mg kg^{-1}); yeast-Se-Cr, a combination of yeast with organic selenium and chromium. Data are means±SE. Different letters differ at *P*<0.05.

Contradictory results were observed by Haddad and Goussous (2005), who indicated that addition of 3.0 g d^{-1} yeast did not influence DMI in Awassi sheep that were fed a high-energy diet for 74 d of study. However, they indicated that BW, ADG, and feed:gain ratio were all improved by a 3.0 g d^{-1} yeast supplementation, with no further improvement with 6.0 g d^{-1} yeast. In the current study, Cr-Se and yeast-Se-Cr supplementation increased DMI in lambs (Table 1). This is partially due to the effect of yeast and chelated Se-Cr, which increased DM degradability, resulting in higher availability of nutrients to metabolize. Results similar to those observed in the present study were reported by Domínguez-Vara *et al.* (2009), who indicated that an increase in Cr supplementation (0, 0.25 or 0.35 mg d^{-1}) resulted in a linear increase in DMI when supplemented to growing Rambouillet lambs. They also observed that inclusion of organic Cr not only improved ADG but also reduced body fat and increased protein retention in muscle, while Se alone produced no effect on these variables. In a study with Pelibuey lambs, Plata *et al.* (2004) indicatedthat supplementation of 1.0 g kg^{-1} DM of yeast (Yea $Saac_{1026}$) improved DMI, ADG and feed efficiency by 6.0, 18.2 and 10.0%, respectively. The authors reported that *in vitro* DM digestibility showed a negative response to the addition of yeast suggesting that this was due to the dosage used. In another study, Ayala *et al.* (1994) indicated that supplementation with 25.0 mg g^{-1} yeast to diets increased the population of protozoa (mL×10^{-3}), NDF digestibility of safflower pulp, and N retained in the body. In contrast, N retention did not promote changes in the energy balance of lambs. Yeast ratio was 25.0 mg g^{-1} of substrate, whereas in the present study, the ratio was 1.0 mg g^{-1} substrate. Se acts on the formation of the enzyme glutathione peroxidase and cell membrane maintenance, and in conjunction with vitamin E, it acts as an antioxidant in the balance of free radicals, while Cr acts directly on the sensitivity of cells to insulin and glucose metabolism (NRC 2007). However, when they act together (Se-Cr mixed), insulin increases, while use of lipids and carbohydrates is improved and protein degradation rate is reduced. These facts allow the formation of metabolites, which are associated with energy utilization in the animal. It is also proposed that Cr influences the energy partition between adipose and lean tissue in growing Holstein-Friesian calves (Bunting *et al.* 1994). As shown in the present study and other studies mentioned above, how much Se-Cr mixed to include in the diets of hair sheep still remains unsolved. The recommendations of NRC (2007) suggest that 0.44 mg kg^{-1} BW Se are required by European breeds of lambs about 30.0 kg of BW and ADG for growth of approximately 250 g d^{-1}. In contrast, they did not suggest the inclusion of any level of Cr although Cr inclusion in the diet is indicated as essential for growing lambs.

3.2. Growth performance

In the present study, yeast, Se-Cr mixed or yeast-Se-Cr supplementation had no effect on ADG and feed efficiency of lambs fed 80.0% concentrate diet supplemented with 1.5 g d^{-1} yeast, relative to the control animals (Table 1). This is due to the amount of yeast consumed. Low levels of supplements were not enough to stimulate DMI. Therefore, the amount of nutrients available was not sufficient to generate metabolites to support an increase in animal growth. These results are in agreement with other studies that have reported no effect of yeast supplementation on either ADG or feed:gain ratio in lambs (Tripathi *et al.* 2008; Romero *et al.* 2009) or feedlot steers (Baumann *et al.* 2004). Others have observed contradicting results. Haddad and Goussous

(2005) indicated that supplementation with 3.0 g d^{-1} yeast increased ADG (25.4%) and gain efficiency (16.0%) in fattening Awasi lambs fed an 80.0% concéntrate diet. Such responses were associated with an increase in

organic matter (OM) digestibility, N and NDF. Bases for discrepancies in growth performance responses due to Se-Cr or yeast-Se-Cr supplementation are difficult to establish. This is due, in part, to the fact that the response in animal growth depends on several factors, including the type and amount of yeast used, nutritive value of feeds, forage:concentrate ratio and CP content in the diet (Ding *et al.* 2008; Domínguez-Vara *et al.* 2009). Regarding to the amount of supplemented yeast, Estrada- Angulo *et al.* (2013) reported that supplementation with yeast-Cr enriched did not influence DMI of Pelibuey×Katahdin lambs, but yeast-Cr markedly increased ADG and final BW, net energy of diet, hot carcass weight and *longissimus dorsi* area of fattening lambs. ADG maximum response and feed efficiency were observed with yeast-Cr supplementation at a rate of 3.0 g $animal^{-1}$ d^{-1} (1.65×10^{10} g^{-1} CFU and 1.20 mg Cr). This response was different from that observed in the present study, but they used a dose of 3.0 g $animal^{-1}$ d^{-1}, whereas we used 1.5 g $animal^{-1}$ d^{-1} Besides the dosage, source and concentration of yeast are also important. Reséndiz-Hernández *et al.* (2012) indicated that the addition of 0.90 mg kg^{-1} of yeast (1.0×10^{10} CFU g^{-1} *S. cereviseae*), 0.9 mg kg^{-1} yeast-Se and 1.4 mg kg^{-1} of yeast-Cr and the combination of yeast-Se-Cr had no impact on DMI; however, it was observed that the addition of Cr-Se or yeast-Se-Cr increased ADG, back fat content, and apparent and total digestibility by 23.0, 12.0, 6.0 and 6.0%, respectively, without affecting other productive variables of creole lambs fed finishing diets. The same author also observed that supplementation with yeast-Se-Cr improved DM digestibility and acid detergent fiber (ADF) in the rumen. Importantly, yeast-Se-Cr supplementation did not influence NDF and CP digestion, or other rumen fermentation variables. The effect of yeast supplementation also depends on forage:concentrate ratio and quality of ingredients in the diet. Issakowicz *et al.* (2013) found that supplementation with 5.0 g $animal^{-1}$ d^{-1} yeast increased DMI, ADG, final BW, and cold carcass weight in confined Texel sheep. These animals were fed 80%:20% forage:concentrate diets. In contrast, the response was different when they used 60%:40% forage:concentrate diets. It was also observed that yeast supplementation did not modify carcass yield, rate of compaction, fat coverage score or conformation score.

3.3. Back fat content and carcass yield

In the present study, supplementation with yeast, Se-Cr, or yeast-Se-Cr did not affect back fat content, chop area or carcass yield of lambs that were fed 80%:20% forage:concéntrate diets (Table 2). This is due to low impact of the supplementation on final BW, since chop area, back fat content and carcass yield depend on final BW of the animals. In the present study, final BW was similar (P=0.30) in all treatment groups. Back fat coverage was not affected by yeast supplementation because the lambs were slaughtered at very young ages. At that age, back fat was uniformly distributed in the body without excessive levels of accumulation. Carcass yield not only correlates with animal BW but also with the level of body fat. The low response in animal back fat is possibly related to lamb age at slaughter. Bueno *et al.* (2000) indicated that fat deposition in the carcass has a high linear positive correlation with the animal's age (degree of maturity); these factors may explain the results of carcass yield since lambs were slaughtered at similar ages and did not exhibit excessive levels of fat deposited in the carcass.However, it was reported that Cr supplementation reduces the level of back fat and meat fat (Yan *et al.* 2010) with no detrimental effects on animal performance and carcass yield (Barajas *et al.* 2008), similar to that observed in the present experiment. Consistent with the present study, Kitchalong *et al.* (1995) indicated that supplementation with 0.25 mg kg^{-1} of Cr tri-picolinate did not affect heart, liver, kidney or pelvic fat weight of feedlot lambs. Like our study, Rodríguez *et al.* (2011) found that supplementation with 0.30 mg kg^{-1} Se and 0.40 mg kg^{-1} Cr did not affect DMI, ADG, feed efficiency or carcass yield in Suffolk×Dorper lambs during the fattening period. Romero *et al.* (2009) indicated that yeast-Cr supplementation (0.18 mg kg^{-1} DM of Cr) had no effect on *longissimus dorsi* or internal and external fat deposition measurements in feedlot steers. Domínguez-Vara *et al.* (2009) reported that an increase in Cr supplementation (0, 0.25, or 0.35 mg d^{-1}) or 0.3 mg d^{-1} Se in the yeast-Se-Cr combination resulted in a linear increase in hot carcass weight, *longissimus dorsi* area, and carcass protein levels, and decreased carcass fat in finishing Rambouillet lambs. These authors also suggested that Se should be formulated in function of BW and ADG, as recommended by the NRC (2007). By contrast, because Cr requirements for growing lambs are not accurate, NRC (2007) has no recommendation for the Cr level that should be included in the diets for lambs. One of the objectives of this study was to investigate the effects of supplementation with yeast, Se-Cr mixed or their association with yeast on the performance of growing lambs. As indicated above, the two concepts have important impacts on DMI, but there was no effect on final BW, back

Table 2 Ingredients, chemical composition and nutritive value of diets fed to Pelibuey×Katahdin lambs during an experimental period of 56 d in confinement fat content or carcass yield.

Item	Contents
Ingredient (% on a DM basis)	
Corn stover	22.0
Alfalfa hay	15.0
Corn grain	25.0
Sorghum grain	20.0
Sugar cane molasses	11.5
Corn gluten	4.0
Buffers	1.5
Urea	0.5
Minerals Premix[1)]	0.5
Chemical Composition (%)	
Crude protein	13.6
Neutral detergent fiber	30.2
Digestible energy	2.92
Metabolizable energy	2.42

[1)]Trace mineral-vitamin premix contained (per kg): 5 000 mg Zn; 60 mg Co; 5 mg Cr; 2 000 mg Fe; 4 000 mg Mn; 30 mg Se; 100 mg I; 500 000 IU vitamin A; 300 000 IU vitamin D; 1 000 IU vitamin E.

The lack of response depends on several factors including the amount and type of yeast, levels of Se-Cr mixed, and the nutritional value of feeds and forage in the diet. Additionally, supplementing with Se and Cr, as used in the present study, must consider some interactions between these minerals, physiological state of the animal and forage: concentrate ratio of diets. Unique to the present study is the demonstration that addition of Se-Cr (1.5 g d_{-1} animal$_{-1}$ of both minerals) improved DMI and had no adverse effects on growing animals fed a 80%:20% forage: concentrate ratio. However, the question of what levels of yeast or Se-Cr mixed are optimal for inclusion in the diet of growing sheep remains unanswered. The search for the answer surely requires further studies of dose-responses separately, and then together, of both minerals. It is also necessary to study their interactions at various stages of growth in sheep completion. The current study and others literature showed that supplementation with yeast, Se-Cr mixed or combination is essential in lamb production. The potential effects of yeast in the stimulation of cellulolytic activity in fiber digestión (Zeoula *et al.* 2011), improvement of feed intake (Payandeh and Kafilzadeh 2007), average daily gain (Ding *et al.* 2008), and carcass characteristics (Abdelrahman and Hunaiti 2008) are important facts in raising lambs. These potential effects confirm the importance of this study for producers who choose to supplement with those products. This study also confirms that the relationship between yeast and Se-Cr should be studied more carefully before their future use in lamb diets. Another important feature of the study is the clarification that inclusion of a mixture of 1.5 mg d_{-1} Se and 1.5 mg d_{-1} Cr increased DMI in sheep. This dosage and higher amounts of the same minerals not only improve growth performance but also health of the animals.

4. Conclusion

In conclusion, supplementation with yeast, Se-Cr mixed or the combination of yeast-Se-Cr did not improve ADG, final BW, back fat content and carcass yield of growing Pelibuey×Katahdin lambs. Supplementation with a mixture of Se-Cr and the combination of yeast-Se-Cr increased DMI, and levels of 1.5 g d_{-1} Se in combination with 1.5 g d_{-1} Cr produced an ADG of approximately 250 g animal$_{-1}$ d_{-1} with no negative effects on growth or health of the animals.

5. Materials and methods

5.1. Area of study

The study was conducted at Experimental Station 13 property of the Chapingo Autonomous University, located in the municipality of Huitzilac, Morelos, México, located at 19°01´20´´N and 99°16´10´´W. Altitude is 2 260 m, and climate is temperate sub-humid. Average annual temperatura is 12.8°C with annual rainfall of 1358 mm, distributed mainly from June to September, 2012 (García 2004).

5.2. Animals and diets

Thirty-two Pelibuey×Katahdin lambs, 4.5 mon old (initial BW=(30.55±1.67) kg; *n*=8), were stratified by BW and randomly assigned to one of four treatments: 1) control group (0.0 g kg^{-1} yeast); 2) yeast (1.50 g kg^{-1} DMI d^{-1}); 3) Se-Cr mixed (1.5 mg kg^{-1} DMI d^{-1} of each mineral); and 4) yeast-Se-Cr mixture. Diets were designed according to the recommendations of the NRC (2007) for growing animals (Table 2). Lambs were fed at two different times during the day: 07:00 a.m. and 17:00 p.m. and trained to feed from individual feeders. These feeders were containers (about 10.0 kg) in which we supplied the feed. Lambs were housed in experimental pens. All animals were vaccinated against common diseases, de-wormed and injected with of vitamins (A, D and E) before beginning the experiment. At the beginning of day, each animal was fed according to lamb number and treatment. Offered feed was previously weighed and recorded. At the end of the day, we collected and recorded the orts and calculated the difference between feed offered and orts; the result was taken as the amount of dry matter consumed by animal. Body weight changes were recorded weekly; these values, together with DMI, were used to estimate feed efficiency. Health of the animals was monitored during the experimental phase and injury or illness was not observed. At the end of the experiment, carcass fat thickness was measured and chop area was estimated with ultrasound equipment (Silva *et al.* 2005). The animals were sacrificed the day after the experiment ended and hot carcass weight was recorded to estimate carcass yield.
Feed and orts of each lamb were sampled every week. Both samples were used to determine nutrient intake and quality of feed consumed during the experimental period. After collection, samples were stored at –20°C and subsequently dried at 55–65°C in a forced-air oven for 48 h to determine dry matter. Later, samples were ground in a Willey Mill (A. H. Thomas, Philadelphia, PA). Percent of DM was determined after drying in an oven at 100°C for 24 h. Samples were later ashed in a muffle furnace at 500°C to determine OM and ash. NDF and ADF were determined using the method of Goering and van Soest (1970). Additionally, samples were analyzed for CP using the Kjeldahl method (AOAC 1996).

5.3. Statistical analysis

Data analyses were conducted using the procedures of SAS (2002). DMI was determined daily for each lamb throughout the experiment. Initial BW and the increase in weekly BW were used to estimate ADG. DMI and ADG were analyzed using PROC MIXED in a completely randomized design for repeated measurements. The model includes treatment, week and treatment×week interaction, with lamb within treatment used as the repeated form. The final model is as indicated, after removing the covariables and the doublé or triple interactions that were not significant (*P*>0.05). The full statistical model was:

$$Y_{ijk}=\mu+TRAT_i+TIME_j+(TRAT\times TIME)_{ij}+E_{ijk}$$

Where, Y_{ijk} is an observation of the response variable; μ is the general mean; *TRAT* is the fixed effect of *i*th treatment (*i*=1, 2, 3 and 4); *TIME* is the fixed effect of the *j*th week of the experimental period (*j*=1, 2, 3, …, 8); *TRAT×TIME* is the fixed effect of the interaction treatment×week; E_{ijk} is the random error. Feed CP, NDF, ADF and DM were analyzed with the same model; whereas chop area, back fat and carcass yield were analyzed using a one-way ANOVA. A compound symmetry covariance structure was used for ADG, changes in BW and feed efficiency. DMI required the use of autoregressive order 1 covariance, whereas CP, NDF, ADF and DM required compound symmetry covariance. In all cases covariances were used with the lowest information Akaike criteria (Littell *et al.* 1998).

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