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Concentrate plus ground barley straw pellets can replace conventional feeding systems for light fattening lambs

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ABSTRACT

Forty male Merino lambs (6–8 weeks old and 14.1 ± 0.20 kg body weight, BW) were used to compare the traditional feeding system for this animal, based on concentrate and long form barley supplied separately, with total mixed ration (TMR) pellets including different proportions of ground barley straw, for their effects on feed intake, animal performance and carcass and meat characteristics. Lambs were divided into four experimental groups ($n = 10$), each randomly assigned to one dietary treatment: Control (conventional system: long form barley straw and concentrate feed in separated feeding troughs), F05 (TMR pellet including 50 g barley straw/kg), F15 (TMR pellet including 150 g barley straw/kg) and F25 (TMR pellet including 250 g barley straw/kg). Lambs were fed the corresponding diet *ad libitum*. On days 22–26, feces and urine were collected from four animals per group. When animals reached 27 kg BW, they were slaughtered. Barley straw, total dry matter (DM), crude protein (CP), neutral detergent (NDF) and acid detergent (ADF) fiber and metabolizable energy intake linearly increased ($P < 0.001$) with the level of barley straw in the TMR. Dry matter digestibility decreased as barley straw in the diet increased, but NDF and ADF digestibility and N-balance were not affected ($P > 0.10$). F25 lambs had the greatest and F05 the smallest ($P = 0.002$) values of average daily gain, but the feed to gain ratio was not significantly affected by the dietary treatments ($P = 0.172$). Abomasum-intestine content weight linearly increased with barley straw in the TMR ($P = 0.041$). Neither carcass (carcass weight, chilling losses, dressing percentage, conformation, measurements, fat thickness or jointing into commercial cuts) nor meat characteristics (pH, fat and meat color, cooking losses and texture) were affected by the level of barley straw in the TMR ($P > 0.10$). Therefore, it is possible to fatten light lambs on a TMR pellet including ground barley straw by increasing average daily gain and reducing the fattening period, without any negative impact on carcass and meat characteristics.

1. Introduction

In the Mediterranean countries, sheep meat production is derived from young animals (up to 30 kg live weight, less than 5 months old), lighter and paler than that from the northern European regions (Sañudo et al., 1998, 2007). To promote high growth rates during this phase, the conventional feeding system is based in the supply of concentrated rations *ad libitum* supplemented with straw (usually from barley, coarsely chopped or in long form), which is an inexpensive source of fiber intended to mitigate the metabolic disorders, such as acidosis, associated to high consumption of concentrates (Bodas et al., 2010; Rodríguez et al., 2008; Sañudo et al., 1998). Even though barley straw is supplied *ad libitum*, its consumption is usually below 10% of total dry matter intake (Bodas et al., 2010; López-Campos et al., 2011), and it requires a high storage capacity and increases

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labor costs, because this source of fiber must be supplied to the animals manually (Pérez-Torres et al., 2011).

The use of rations devoid of barley straw has been already proposed, but the system has been demonstrated to be neither economically nor ecologically competitive, whereas the problems associated to the high concentrate intake still persist (Cooper et al., 1996; Rodríguez et al., 2007). The design of a feeding system based on the use of a concentrate pellet which includes a proportion of ground straw (total mixed ration – TMR-pellet) can be regarded as an interesting alternative to maintain this ingredient in the ration while avoiding the storage and distribution problems associated with its manipulation, because it would allow automatic delivery of the feed while reducing labor and storage costs, and hence farm profit would be increased. Thus, the use of TMR automatically delivered to the troughs for small ruminants has become the usual practice in dairy sheep and goats due to its reduced labor and storage costs (Pérez-Torres et al., 2011; Tufarelli et al., 2011). However, these animals can consume thicker pellets than young lambs (thus allowing a larger forage grinding size) and forage contents is greater than the ratio required to maintain an optimal growth rate and lamb performance (Bodas et al., 2010; López-Campos et al., 2011; Sañudo et al., 1998).

The particle size or dietary physical effective fiber is an important influential factor for chewing activity, intestinal fiber and starch digestibility and ruminal pH (Zhao et al., 2011). Hence, the proportion of ground straw to be included in the pellet could be higher than the amount of long form straw that the animals consume in the conventional system, but must be kept within a limit, in order to maintain the superior performances in fattening lambs fed on diets based on concentrates (Bodas et al., 2007, 2010). Likewise, it is known that the level and way of supply of fiber in the diet have a clear effect on carcass and meat characteristics (Al-Saiady et al., 2010; Bas and Morand-Fehr, 2000; Bodas et al., 2007, Normand et al., 2001) that must not be overlooked. Therefore, it will be necessary to determine the optimum level of straw that has to be included in the pellet.

To the best of our knowledge, there are no published studies comparing the conventional feeding system for light fattening lambs with an alternative one based on concentrate pellets including a ground forage source that can be fully automatically delivered to the animals. We hypothesize that the use of *ad libitum* concentrate plus ground barley straw pellets (TMR), which would ease feed management and distribution, is a suitable alternative to the conventional feeding system for light fattening lambs. Therefore, the objective of this study was to compare the latter (based on concentrate and long form barley supplied separately) with pelleted TMRs including different proportions of ground barley straw for their effects on feed intake, animal performance and carcass and meat characteristics.

2. Materials and methods

2.1. Animals and diets

Forty male Merino lambs (6–8 weeks old and mean BW 14.1 ± 0.20 kg at the beginning of the experiment) were used in this study. Lambs remained with their dams, with free access to commercial starter concentrate and alfalfa hay, and were treated to prevent white muscle disease (Vitasel, Lab. Ovejero, Spain), vaccinated against enterotoxemia (Miloxan, Merial Lab., Spain) and given an anthelmintic treatment (Ivomec, Merial Lab., Spain) before the commencement of the trial. After weaning, lambs were randomized on the basis of BW, each lamb being randomly allocated to one of four experimental treatments ($n = 10$), according to the feeding system: Control (conventional system: long form barley straw and concentrate pellet in separated feeding troughs), F05 (TMR pellet including 50 g barley straw/kg), F15 (TMR pellet including 150 g barley straw/kg) and F25 (TMR pellet including 250 g barley straw/kg). Barley straw to be included in the pellets was ground to pass a 2 mm screen, mixed with the rest of ingredients and steam pelleted (85 °C, 4 bar) to 4 mm × 10 mm (diameter × length) pellets. Lambs were housed in individual pens (one lamb per pen, with individual feeding and watering troughs), where they remained during the entire experimental period.

After five days of adaptation to the diets, each lamb was individually fed the corresponding experimental diet *ad libitum*; fresh drinking water was provided. The ingredients and chemical composition of the feeds are shown in Table 1. The amount of feed offered was adjusted daily on the basis of the previous day's intake, allowing refusals of *ca.* 200 g/kg feed offered. Samples of the feeds offered and orts were collected daily and pooled in weekly composites for each animal analyzed for DM content.

All handling practices followed the recommendations of the Directive 2010/63/EU of the European Parliament and of the Council on the protection of animals used for scientific purposes, and all of the animals used were able to see and hear each other.

2.2. Feces and urine collection

On day 19 of the experimental period, four lambs per treatment were confined to individual metabolism cages fitted with specific devices to collect feces and urine separately. The number of animals used was the minimum we considered necessary according to both statistical and welfare criteria. After two days of adaptation to the cages, feces and urine were collected for 5 days. The feces of each animal were collected daily,

Table 1
Ingredients and chemical composition of the experimental feeds and the barley straw.

	Control	F05	F15	F25	Barley straw
Ingredients (g/kg)					
Barley	530	490	433	388	
Corn	230	210	150	80	
Soybean meal 44	210	220	237	252	
Barley straw	–	50	150	250	
Mineral vitamin mix	30	30	30	30	
Chemical composition (g/kgDM)					
NDF	166	196	259	323	626
ADF	58	59	94	138	413
CP	182	181	181	181	47
Ash	63	60	73	83	104
Metabolizable energy (kcal/kg DM)[a]	2744	2662	2495	2328	1200

[a] Calculated from feed composition tables (FEDNA, 2010).