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Effect of feeding systems on live-weight, reproductive performance, milk yield and composition, and the growth of lambs in native Spanish Ojalada sheep

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Abstract

To produce lambs of the Ojalada breed, included within the Protected Geographical Indication "Lechazo de Castilla y Leon", three feeding systems were compared (40 ewes/treatment): a) IND + CH + C, ewes kept indoors and fed chopped straw plus concentrate, prepared on location and distributed mechanically (total mixed ration; TMR); b) IND + W+C, ewes kept indoors and fed whole straw in the form of large bales, plus concentrate (TMR); and c) GR + C, free-range grazing plus concentrate (control group). Live-weight, reproductive endpoints, milk production and composition (10 sheep from single lambing/treatment), and growth of lambs up to 35 days were assessed. Live-weight of ewes from the IND + CH + C group were similar to those in the GR + C group ($p > 0.05$). Treatments did not differ for fertility or prolificacy, except for fecundity in the IND + W + C group compared to values for the IND + CH + C and GR + C groups. The quantity of milk produced through 35 days did not differ (~1,300 mL d^{-1}), with peak production in all three groups in the third week of lactation (~1,500 mL d^{-1}). Milk chemical composition generally did not differ among treatments; only ewes in the IND + CH + C group presented greater protein content in the third week of lactation. Although treatments did not differ in live-weight at birth to 35 days, IND + CH + C lambs differed in average daily gains, reaching 9 kg of live-weight (minimum weight for slaughter) at ages younger than the other groups whether from simple or double lambing. We can conclude that this type of production, keeping sheep closed and fed a TMR, is possible.

Additional key words: barley straw; ewe; grazing; local breed.

Resumen

Efecto del sistema de alimentación sobre el peso vivo, los parámetros reproductivos, la producción y composición de la leche y el crecimiento de los corderos en ovejas de la raza autóctona española Ojalada

Para producir corderos de la raza Ojalada, incluida en la Indicación Geográfica Protegida "Lechazo de Castilla León", se compararon tres sistemas de alimentación (40 ovejas/tratamiento): a) IND + CH + C: ovejas cerradas, alimentadas con paja de cebada picada + concentrado, elaborado en la explotación y distribuido de forma mecanizada (TMR); b) IND + W + C: ovejas cerradas, alimentadas con paja de cebada entera+concentrado, en forma de pacones (TMR); c) GR + C: pasto + concentrado (grupo control). Se controló peso vivo, parámetros reproductivos, producción y composición de la leche (10 ovejas de parto simple/tratamiento), y crecimiento de los corderos hasta los 35 días. El peso vivo de las ovejas IND + CH + C fue similar al de GR + C ($p > 0,05$). No hubo diferencias entre tratamientos para fertilidad ni para prolificidad, la fecundidad en IND + W + C fue significativamente superior a los otros grupos. No hubo diferencias en la cantidad de leche a los 35 días (~1.300 mL d^{-1}), encontrándose el pico de la producción en la tercera semana (~1.500 mL d^{-1}). No se encontraron diferencias entre tratamientos en composición química, únicamente las ovejas IND + CH + C presentaron un mayor contenido en proteína en la tercera semana. Aunque no hubo diferencias entre tratamientos en el peso vivo del nacimiento a los 35 días, los corderos IND + CH + C presentaron mayor ganancia media diaria de peso, alcanzando los 9 kg (peso mínimo al sacrificio) a una edad inferior a la de los otros grupos, tanto si eran de parto simple como doble. Se observa así, como es posible este tipo de producción manteniendo a las ovejas cerradas y alimentadas con una ración TMR.

Palabras clave adicionales: paja de cebada; pastoreo; razas locales.

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Abbreviations used: CP (crude protein); DM (dry matter); GR + C (free-range grazing plus concentrate); IND + CH + C (ewes kept indoors and fed chopped straw plus concentrate, prepared on location and distributed mechanically); IND + W + C (ewes kept indoors and fed whole straw; in the form of large bales, plus concentrate); NFD (neutral-detergent fibre); PGI (Protected Geographical Indication); TMR (total mixed ration).

Introduction

The region of Castilla y León (Spain), which holds the PGI (Protected Geographical Indication) "Lechazo de Castilla y Leon", is the main producer of suckling lambs of this category in Spain. Lambs from the Churra, Ojalada, or Castellana breeds are raised without having been separated by sex and are fed exclusively on mothers' milk. In this regard, milk production and composition from lactating ewes can affect the growth of lambs (Appedu *et al*., 2004; Casals *et al*., 2006; Sanz Sampelayo *et al*., 2007).

The two primary cost factors in traditional systems of sheep husbandry include expenses for dietary supplements and for labour; both of these factors have an economic effect as well as influencing quality of life for sheep raisers and causing them major labour difficulties. The conjunction of both factors demands a management strategy based on the use of agrarian subproducts through total mixed ration (TMR) diets to achieve automation of feeding over a minimum-cost equation (López, 2007). Many papers have been published following this line of research, dealing with using TMR diets of only one type of feed that can be given to animals kept indoors (Ciria *et al*., 1997; Hernández *et al*., 1997; Oviedo *et al*., 1997; Sanz *et al*., 1997; Joy *et al*., 2006), evaluating productive endpoints with the goal of a reduced dependence on grazing and labour.

Improving reproductive endpoints (fertility, prolificacy and fecundity) is the objective of any sheep-raising venture. Although an increase in prolificacy (expressed as the number of lambs per lambing) is important, the viability should also be taken into account, as determined by mothers' milk production. Milk production in the ewes increases in the first weeks, reaches a maximum around the third week of lactation (Bencini and Purvis, 1990; Reynolds and Brown, 1991; Bencini *et al*., 1992), then declines until drying up completely. The milk composition depends not only on genetic factors but also on other factors such as the quantity and composition of the foods that are ingested (Palmquist *et al*., 1993; Chilliard *et al*., 2000; Pulina *et al*., 2006). Therefore, the principal components of ewe milk vary throughout the lactation period, with maximum production coinciding with the minimum content of the principal chemical compounds (Velasco *et al*., 2001).

Many papers have evaluated the fibre size effect on chewing activity and ruminal endpoints (Zhao *et al*., 2011). Further, some researchers have pointed out that fibre size can affect some production endpoints (Keshavarz *et al*., 2010; Miller-Cushon and DeVries, 2011).

The Ojalada breed occurs primarily in the centre and southwestern zones of the region of Soria (North-Center Spain). It differs from other breeds because of its peculiar morphological characteristics (half-fine white fleece with centrifugal black pigmentation). This breed is little studied with respect to other autochthonous Spanish breeds.

The objective of this study was to analyse and characterize the effect of management and feeding systems on the live-weight and reproductive endpoints in the ewes, along with milk production and composition (in single-birth ewes) and the growth of lambs from the Ojalada breed.

Material and methods

Location and animal resources

The study was carried out at the *Campo Agropecuario de San Esteban de Gormaz* (*Diputación Provincial de Soria*), located 70 km from Soria, Spain (41° 34' N, 3° 12' W, 879 m a.s.l.). At these installations, work has been ongoing for 30 years on the characterization, conservation, and genetic improvement of the native Ojalada breed, and a system involving three live births every two years has been employed.

The study was carried out throughout a productive cycle (breeding at the end of the lactation period). To this end, 120 ewes of the Ojalada breed between the ages of 4 and 6 years, 61.8 ± 8.2 kg live-weight, body condition score 2.92 ± 0.05, and the same production of milk from the previous lactation were distributed randomly into three groups (40 ewes per group). No hormonal treatment was used for the induction and synchronization of periods of heat. During breeding season (winter), two males were added to each group, remaining with the ewes for 45 days (for a possibility of breeding in two heat periods). The endpoints described as follows were recorded throughout the entire productive cycle, until the end of the lactation period in the month of August.

Feeding and handling

With regard to feeding and handling systems, the animals were randomly allocated to three pens ($n = 40$ per treatment), as follows:

a) IND + CH + C: ewes were permanently kept indoors (1.5 m^2 per ewe with access to a 80-m^2 outdoor pen) during the experimental period. Animals were provided with a TMR based on chopped barley straw (short fibre: 5 mm) mixed with concentrate, distributed mechanically, and administered *ad libitum*.

b) IND + W + C: ewes were permanently kept indoors (1.5 m^2 per ewe with access to a 80-m^2 outdoor pen) during the experimental period. Animals were provided with a TMR based on whole barley straw (long fibre) from large bales of approximately 450 kg mixed with concentrate using an industrial mixer and administered *ad libitum*.

c) GR + C: control group. Traditional management in which animals were let out to graze during the day with supplements provided only at given times (last third of gestation, lactation, or when adverse climatic conditions kept them from going outdoors). The flock was managed under a year-round grazing system involving the use of Mediterranean grassland and forest-shrub pastures in summer, autumn, and winter (Casasús *et al*., 2007) and permanent valley pastures in spring and autumn (30 ewes ha^{-1}). The pasture was composed of 24% legumes (mainly *Trifolium repens*), 65% grass (the main species were *Festuca arundinacea*, *Festuca pratensis*, *Poa pratensis*, *Lolium perenne*, and *Dactylis glomerata*) and 11% other species (mainly *Rumex acetosa* and *Ranunculus bulbosus*). Ten representative herb samples (in 10 quadrants) were taken at monthly intervals. Herbage dry matter (DM) (202.4 ± 56.2 kg DM ha^{-1}) was determined at 60°C until constant weight, crude protein (CP) (212.5 ± 11.7 g CP kg^{-1} DM) was determined by the Dumas procedure, according to the AOAC (1999), and neutral-detergent fibre (NDF) (510.8 ± 23.3 g NDF kg^{-1} DM) was analysed by the method of Van Soest *et al*. (1991).

Because one of the objectives of the experiment was to use a type of raw material that would not increase feeding costs, the principal component of the feed used in the test was barley straw in its natural state (918 g DM kg^{-1}, 38 g CP kg^{-1} DM, and 772 g NDF kg^{-1} DM), chopped for the IND + CH + C group and whole for the IND + W + C group. As a complement to the straw, concentrate was added throughout the experimental period (last third of gestation, lactation), the same kind for both groups and mixed so that the animals could not separate it. The composition of this concentrate (Table 1), along with the proportion of straw, varied according to the productive stage, as follows: a) maintenance and first two thirds of gestation, 80% barley straw and 20% concentrate; and b) last third of gestation and during lactation, 40% barley straw and 60% concentrate. The proportion of straw used at each production stage, was used by the distributor of large bales (GEPISA, Soria).

Only the average consumption of food was controlled in groups permanently kept indoors. Thus, in the IND + CH + C group, once supplied, this food was weighed, and in the IND + W + C group, the weight of the large bales was known.

The care and use of these animals followed the European guidelines (European Union Directive No. 86/609/CEE, 1986).

Data collection

Live-weight and reproductive endpoints of ewes

Once a month and early in the morning, the ewes from each group were weighed individually using a manual scale with an accuracy of 0.5 kg. The number of lambings per ewes presented to rams (fertility), the number of lambs born per number of lambings (prolificacy), and the number of lambs born per ewe presented to rams (fecundity) were recorded.

Milk yield and composition

During the 5 weeks of lactation, a weekly evaluation was carried out of both the quantity and the chemical composition (fat, protein, lactose, and non-fat solids) of the milk. The milk samplings were done in 10 single-birth ewes from each group chosen at random. To accomplish this, the lambs were separated from their mothers first in the morning. The ewes were injected with 5 IU of oxytocin and milked mechanically, followed by a second more complete milking by hand. Four hours after the first injection of oxytocin, the operation was repeated with the same dose of oxytocin, and the amount of milk obtained from this second milking was measured. The value obtained in this manner, when multiplied by six, indicates the productive capacity of the ewes over a period of 24 hours (Doney *et al*., 1981b).

The milk obtained in the second milking was mixed well before sampling, and two samples of 50 mL each were taken per animal. These were kept at 4°C until a later analysis of their chemical composition, by means of infrared rays, could be carried out (Milkoscan 104a/b Fos Electric).

Table 1. Ingredients, chemical composition, and nutritional value of the concentrate based on productive phase (all the data on fed basis)

	Maintenance and first two thirds of gestation	Last third of gestation and lactation
Ingredients (g kg^{-1})		
Barley	485	460
Sunflower flour 30%	300	300
DDGS[a] corn	1.0	—
DDGS[a] sorghum	—	150
Cane molasses	40	40
Salt	5	5
Dicalcium phosphate	10	4
Calcium carbonate	—	11
Calcium soap	—	20
Sodium bicarbonate	5	5
Magnesium oxide	2	2
Mineral-vitamin mix[b]	3	3
Chemical composition (g k^{-1})		
Dry matter	894.1	898.1
Organic matter	956.8	958.7
Crude protein	184.7	190.5
Neutral-detergent fibre	269.3	247.7
Nutritional value		
Energy (UFL[c] kg^{-1})	0.87	0.84
Protein (g PDIN[c] kg^{-1})	123.3	121.5
Protein (g PDIE[c] kg^{-1})	99.2	97.1

[a] DDGS: dried distillers grains with solubles. [b] Mineral-vitamin mix provided (per kg of premix): Zn, 5,000 mg; Mn, 5,000 mg; Fe, 1,750 mg; Co, 100 mg; I, 70 mg; Se, 25 mg; vitamin A, 600,000 IU; vitamin D3, 120,000 IU; vitamin E, 2,000 mg. [c] UFL, 7.11 MJ net energy for lactation; PDIN, protein digestible at the level of intestine when nitrogen is limiting; PDIE, protein digestible at the level of intestine when energy is limiting: estimated from INRA (2007).

Growth of lambs

The lambs born in the month of May were raised without being separated by sex (50% male and 50% female in each group, approximately), with feeding based exclusively on mothers' milk until 35 days of age. These lambs were weighed individually within the first 24 hours of birth and weekly thereafter (coinciding with the data collection for milk production), using a scale with an accuracy of 2 g and a maximum register of 30 kg.

Lamb average daily gains (ADGs) were calculated by the difference between final and initial weights divided by the total number of days. One period was calculated: from birth to 35 days (maximum age of slaughter for Lechazo lambs).

Statistical analyses

Differences between treatments concerning reproductive endpoints (fertility, prolificacy, and fecundity) were tested using χ^2 analysis. Data from ewes were analysed using the generalized linear model procedure of SAS according to the model:

$$y_{ij} = \mu + \alpha_i + \varepsilon_{ij} \qquad [1]$$

where y_{ij} = dependent variable, μ = overall mean, α_i = treatment effect, and ε_{ij} = residual error.

Data from lamb live-weights were analysed using the generalized linear model procedure of SAS according to the model:

$$y_{ij} = \mu + \alpha_i + l_j + (\alpha l)_{ij} + \varepsilon_{ijk} \qquad [2]$$

where $y_{ij,}$, μ, α_i, and ε_{ij} are as in [1], and l_j = lambing effect.

Data from milk yield and composition were analysed using the MIXED procedure of SAS. Only single birth data were used for milk production and composition analysis. A previous analysis of variance was performed to ensure no significant differences among treatments ($p < 0.05$) at the beginning of the trial. The final model was as follows:

$$y_{ij} = \mu + \alpha_i + d_j + \beta_k + (\alpha\beta)_{ik} + \varepsilon_{ijk} \quad [3]$$

where $y_{ij,}$, μ, α_i, and ε_{ij} are as in [1], and d_j = animal effect j, β_k = week effect.

Relationships among variables were determined using the Pearson correlation procedure in the SAS package.

Results

Live-weight and reproductive endpoints of ewes

The average consumption of food in the IND + CH + C group was 1.43 and 2.41 kg ewe^{-1} d^{-1} in the phases of maintenance and lactation, respectively; for the IND + W + C group, values were 1.49 and 2.16 kg ewe^{-1} d^{-1} in the phases of maintenance and lactation, respectively. The consumption in the phase of lactation of ewes from the IND + W + C group was lower than that of the IND + CH + C group.

Table 2 lists the live-weight of ewes in the three treatments, taking into account their physiological condition. No significant differences were found among the three groups, either in their initial live-weight or in changes in their weights during the period in which they were fed with the maintenance ration. Nevertheless, significant differences were detected in the final stage of gestation and during lactation, with the ewes from the IND+W+C group presenting lower weights during all of this period. In the first half of this stage, which coincides with the stage prior to lambing, the ewes in the GR+C group presented with greater weights ($p \le 0.05$); however, ewes from the IND + CH + C group registered heavier weights ($p \le 0.05$) in the second half (end of lactation).

Table 3 presents results for the reproductive endpoints, based on the type of treatment; as can be observed, groups did not differ ($p > 0.05$) for fertility (0.73, 0.93, and 0.68 births per ewe in the IND + CH + C, IND + W + C, and GR + C groups, respectively). Neither were there differences in prolificacy (1.42, 1.46, and 1.54 lambs per ewe per lambing), although fecundity for the IND + W + C group (1.36) was significantly superior ($p \le 0.05$) to the IND + CH + C and GR + C groups (1.04 and 1.05, respectively).

Milk yield and composition

Table 4 shows the milk production results (mL) in single-birth ewes, depending on the type of treatment

Table 2. Live-weight in ewes (kg) depending on treatment and physiological status

	Treatment (n = 40 per treatment)[a]			Sign.
	IND + CH + C	**IND + W + C**	**GR + C**	
Maintenance and first two thirds of gestation				
October	62.87 ± 8.98	61.80 ± 6.70	60.90 ± 8.36	ns
November	64.42 ± 8.12	60.52 ± 7.32	60.45 ± 7.71	ns
December (service)	63.89 ± 7.47	60.15 ± 7.32	60.80 ± 7.58	ns
January	62.44 ± 8.14	58.95 ± 7.79	59.70 ± 6.97	ns
February	60.39 ± 9.26	57.50 ± 7.96	59.32 ± 7.02	ns
March	59.18 ± 9.29	55.79 ± 7.90	62.10 ± 6.59	ns
Δ live-weight	–3.15 ± 3.71	–5.47 ± 3.68	+1.20 ± 3.42	
Last third of gestation and lactation				
April	57.92^{ab} ± 10.89	51.26^{b} ± 7.05	62.22^{a} ± 7.76	**
May (lambing)	63.86 ± 9.67	59.26 ± 9.54	66.94 ± 10.12	ns
June	60.76^{a} ± 9.27	50.76^{b} ± 7.37	59.06^{a} ± 8.06	*
July	64.76^{a} ± 8.95	51.29^{b} ± 7.52	58.19^{ab} ± 7.35	**
Δ live-weight	+4.88 ± 5.01	–5.11 ± 4.59	–4.37 ± 3.74	

[a] Treatments: IND + CH + C, chopped barley straw + concentrate; IND + W + C, whole barley straw + concentrate (large bales); GR + C, grazing + concentrate. ns: Not significant ($p > 0.05$); *significant difference ($p \le 0.05$); ** significant difference ($p \le 0.01$). Different letters in the same string indicate significant differences among treatments at $p \le 0.05$.

Table 3. Reproductive performance depending on treatment

	Treatment (n = 40 per treatment)[a]			SEM	Sign.
	IND + CH + C	IND + W + C	GR + C		
Fertility	0.73	0.93	0.68	0.01	ns
Prolificacy	1.42	1.46	1.54	0.12	ns
Fecundity	1.04[b]	1.36[a]	1.05[b]	0.06	*

[a] Treatments: see Table 2. SEM: standard error of least square mean. ns: not significant ($p > 0.05$); *significant difference ($p \leq 0.05$). Different letters in the same string indicate significant differences among treatments for $p \leq 0.05$.

followed throughout the lactation period (35 days). Average production was an estimated 1,300 mL d^{-1} approximately, and no differences were found based on feeding, with the peak lactation occurring in the third week for all three groups (peak = ~1,500 mL d^{-1}; Fig. 1).

Table 4 and Figure 2 show results for the content of fat, protein, lactose, and non-fat solids (%) up to 35 days of lactation. No significant differences were found in any of the chemical components in terms of the type of handling and feeding employed during lactation, with one exception: ewes in the IND + CH + C group presented a greater protein content in the third week of lactation.

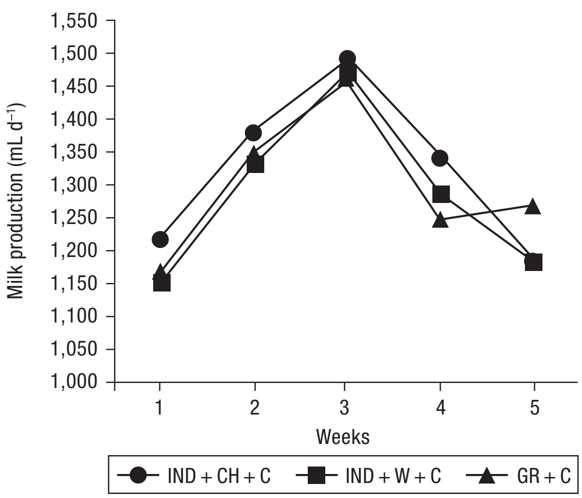

Figure 1. Milk production (mL d^{-1}) depending on week of lactation (1-5) and treatment (see Table 2), in single-birth ewes.

For all of the chemical components analysed, a variation was observed throughout the lactation period in accordance with the amount of milk produced (Fig. 2); the minimum chemical content in all cases occurred around the third week of lactation, the moment when the greatest production of milk was obtained in the three treatments for the animals studied.

Growth of lambs

As Table 5 shows, although no differences were found between treatments for the same type of lambing in the live-weight at birth, ADG birth to 35 days was significantly higher ($p \leq 0.05$) in the lambs of the IND + CH + C group, as was live-weight to 35 days. Lambs from the IND + CH + C group reached the minimum slaughtered weight within the commercial category of Lechazo (9 kg) sooner than the lambs from the other two treatment groups. In all cases, the maximum slaughtered weight within the commercial category Lechazo (12 kg) was reached at ages exceeding 35 days.

Table 4. Milk estimated yield (mL d^{-1}) and chemical composition (%) depending on week of lactation (W) and treatment (T), in single-birth ewes

	Treatment (n = 40 per treatment)[a]			SEM	Sign.	
	IND + CH + C	IND + W + C	GR + C		W	T
Milk yield	1,322.4	1,283.8	1,298.3	104.2	ns	ns
Fat	5.44	5.34	5.56	0.23	ns	ns
Protein	4.01	3.92	4.16	0.17	ns	ns
Lactose	4.99	4.85	5.09	0.13	ns	ns
Non-fat solids	8.54	8.57	8.81	0.24	ns	ns

[a] Treatments: see Table 2. SEM: standard error of least square mean. ns: not significant ($p > 0.05$).

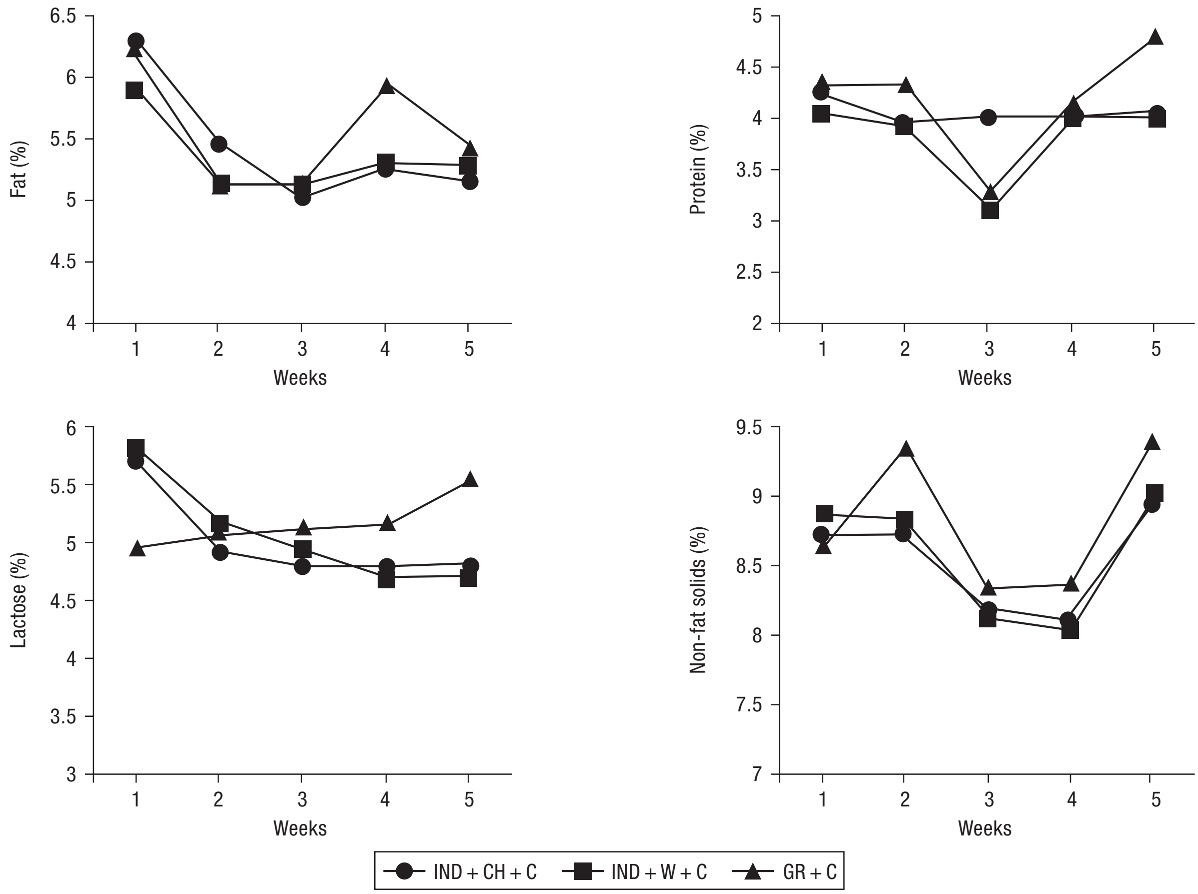

Figure 2. Milk chemical composition (%) depending on the week of lactation (1-5) and treatment (see Table 2), in single-birth ewes.

As could be expected, the lambs from single lambings presented a birth weight significantly greater ($p \leq 0.05$) in the three groups than those from double births (Fig. 3); this difference disappeared in successive controls until the fourth week of life, when again important differences ($p \leq 0.05$) emerged that remained during the fifth week.

Discussion

With respect to the weight of the ewes during the experimental period, the data reflect that this is a lighter type of breed, in which the free-range ewes (GR + C) were observed to demonstrate the expected outcomes, with weight gain from the moment of breeding until

Table 5. Age at slaughter (days), average daily gains (ADG in g) and live-weight (kg) in lambs depending on treatment[a] (T) and type of lambing (L)

	Single lambing					Double lambing				
	IND + CH + C (n = 16)	IND + W + C (n = 20)	GR + C (n = 12)	SEM	Sign.	IND + CH + C (n = 26)	IND + W + C (n = 34)	GR + C (n = 30)	SEM	Sign.
Birth weight	4.6	4.1	4.7	0.9	ns	4.0	3.6	3.9	0.8	ns
Weight at 35 days	12.2[a]	10.2[b]	10.9[b]	0.7	*	10.7[a]	9.2[b]	9.3[b]	0.6	*
ADG birth to 35 days	217.1[a]	174.3[b]	177.1[b]	17.5	*	191.4[a]	160.1[b]	154.3[b]	12.7	*
Age at 9 kg live-weight	21.3[b]	25.3[ab]	28.2[a]	1.2	*	25.1[b]	31.1[a]	32.4[a]	1.6	*
Age at 12 kg live-weight	40.9[b]	43.1[b]	55.3[a]	5.6	*	42.2[b]	48.3[ab]	53.1[a]	4.5	*

[a] Treatments: see Table 2. ns: not significant ($p > 0.05$); *significant difference ($p \leq 0.05$). Different letters in the same string indicate significant differences among treatments for $p \leq 0.05$.

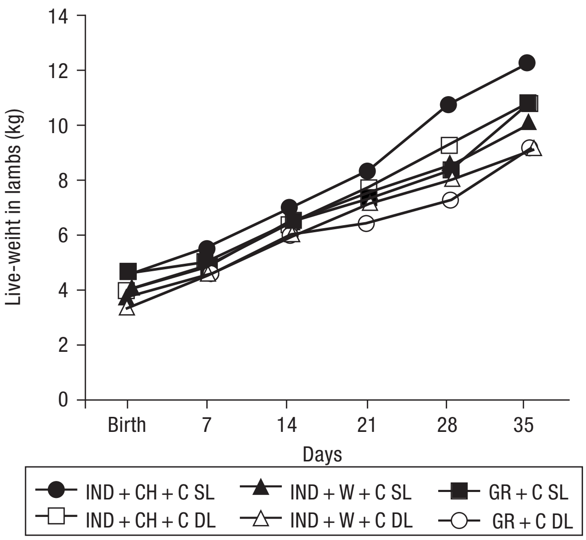

Figure 3. Live-weight in lambs depending on age (days), treatment (see Table 2), and type of lambing (SL: single lambing; DL: double lambing).

lambing and weight loss during lactation. Different researchers, such as Álvarez-Rodríguez *et al*. (2007), have observed this situation in ewes of the Churra Tensina breed, using a similar pasture with a mean botanical composition of 67% grass and 19% legume.

The ewes from the IND + CH + C and IND + W + C groups demonstrated weight loss from the moment of breeding, perhaps brought on by their adapting to being kept indoors. In the IND + CH + C group, it is especially noteworthy that their weight gain coincided with the end of lactation, a fact that has been observed in ewes from the Churra Tensina breed kept indoors during the suckling period and given TMR (Joy *et al*., 2007). Also of note is the fact that, after losing weight in the postpartum period, the ewes fed with large bales of straw (IND + W + C) did not recover, perhaps because reducing the particle size in low quality forages requires that the intake of DM, and therefore of nutrients, increase significantly (González *et al*., 2009; Keshavarz *et al*., 2010).

In spite of all this, it is important to point out that this variation in the weight of the ewes caused no differences in the endpoints of fertility and prolificacy among the various treatments and, what appears most important, the greatest fecundity statistic was obtained in the ewes fed with large straw bales (IND + W + C). In terms of prolificacy, the results presented can be considered similar to those found for other Spanish breeds (MAPA, 2003), an aspect that is particularly important because it has to do with an endpoint of great economic interest that could even constitute an objective for selection in programmes of genetic improvement. In the Churra breed, Díez *et al*. (1993) found a prolificacy of 1.54%, a value similar to what was identified in the current work.

No differences were found among the three treatments in terms of milk production up to 35 days of lactation, with peak production occurring around three weeks of age. Other researchers have already reported these findings (Sánchez *et al*., 2000; Velasco *et al*., 2001) for other Spanish breeds and also with foreign breeds (Ampueda and Combellas, 2000).

When Sanz Sampelayo *et al.* (1998) studied lactating goats and fed them a diet in which the forage fraction was provided in long-fiber or in pelleted form, the milk production and the concentration fat in the milk was unaffected. In the opinion of Morand-Fehr *et al*. (2000), the effect of the physico-chemical nature of the diet is greater among animals with highest than medium level of productive capability (Sanz Sampelayo *et al.,* 2007). Maulfair *et al*. (2010) found no differences in yield and composition of the milk in cows when comparing different particle sizes in the ration. Marin *et al.* (2010) concluded than the effect of dietary on ruminant milk fat differs between species probably due to digestive and metabolic interspecific differences.

Calvo *et al*. (2006), in their work with ewes from the same breed used in the current work, kept indoors and fed a diet of alfalfa hay and concentrate, found the greatest milk production during the seven weeks of lactation, with the maximum production occurring in the first week (1,980 mL d^{-1}), diminishing in a linear manner to 1,250 mL d^{-1} at seven weeks. This distribution in milk production has been described by Ampueda and Combellas (2000) in young ewes of the West African breed. Doney *et al*. (1981a) also described this phenomenon, noting that when the lambs demanded a greater amount of milk, as occurs in the first stages of lactation, the response from the ewe is to increase the quantity of milk produced. Nevertheless, a point is reached at which the milk requirements of the lambs become progressively less satisfied as ingestion becomes a limiting factor.

In a study carried out with the Talaverana breed, fed with vetch-oats and concentrate, Velasco *et al*. (2001) found a maximum production of 1,223 mL d^{-1} at three weeks of lactation, less than the milk production found in this study for the three treatments (1,492.7, 1,470.2, and 1,560.9 mL d^{-1}, for the IND + CH + C, IND + W + C, and GR+C groups, respectively). Later, the production in the Talaverana ewes followed a downward tendency, presenting values of 974 and 850 mL d^{-1} at four and six weeks of lactation, respectively. Both of these values are considerably inferior to those found in the current study. Joy *et al*. (2007), comparing free-range feeding to indoor feeding with concentrate supplements in the Churra Tensina breed, found higher values in free-range ewes at two and four weeks of lactation (1,616 and 1,322 mL d^{-1}, respectively) than in the GR + C group (1,348.5 and 1,247.6 mL d^{-1} at two and four weeks, respectively). On the other hand, the Churra Tensina ewes kept indoors produced less milk at both two and four weeks of lactation (1,383 and 955 mL d^{-1}, respectively) than the IND + CH + C and IND + W + C groups (1,318.4 and 1,389.3 mL d^{-1} at two weeks, respectively, and 1346.4 and 1,286.2 mL d^{-1} at four weeks, respectively). At six weeks of lactation, the ewes from the free-range Churra Tensina breed presented less milk production than those from the GR + C group (1,073 mL d^{-1} as opposed to 1,212.3), while the ewes kept indoors showed similar values (1205 as compared to 1,201.3 and 1,296.5 mL d^{-1}, in the IND + CH + C and IND+W+C groups, respectively).

Although the type of feeding did not influence the principal chemical components of the milk, it was clear that levels of some contents were directly inverse to the quantity of milk produced. Therefore, a lesser content in fat, lactose, protein, and non-fat solids was obtained at around three to four weeks of lactation in the three treatments, the same time points at which production was greatest. This pattern has previously been described by various researchers, such as Velasco *et al*. (2001) for the Talaverana breed; in the third week of lactation, they found minimum values of 7.00% and 17.68% for fat and non-fat solids, respectively (both of these values are higher than those found in the current study: 5.03%, 5.10%, and 5.13% for fat in the IND + CH + C, IND + W + C, and GR + C groups, respectively, and 8.17%, 8.12%, and 8.33% for non-fat solids in the IND + CH + C, IND + W + C, and GR + C groups, respectively). Their 3.84% finding for protein is a value in keeping with what was found in the current study (4.01%, 3.07%, and 3.26% in the IND + CH + C, IND + W + C, and GR + C groups, respectively).

Other researchers such as Joy *et al*. (2007), when comparing free-range grazing with supplementation in the Churra Tensina breed, found no differences either between the two treatments in the same week of lactation, discovering values similar to the current findings for fat and protein, but greater for lactose (5.4%, 5.6%, and 5.4% for the second, fourth, and sixth weeks of lactation, respectively). López *et al*. (1998), at the beginning of lactation in the Merina breed, on free range, found higher values for fat and protein (6-8% and 6%, respectively) and similar values for lactose (5%) compared to the current work.

With respect to the milk-producing ability of the breeds, Pamela (2007) obtained higher average values for fat and protein in the Guirra breed (8.74% and 6.67%, respectively) and the Manchega breed (9.11% and 6.55%, respectively), while their contents in lactose were similar to the current findings (4.6% for the Guirra breed and 4.5% for Manchega). The average values published by Ugarte and Legarra (2003) for Latxa ewes are along the lines of those found in this study in terms of fat content (5.67%) and slightly higher for protein (5.23%). Castro *et al*. (2009), dealing with ewes from the Lacaune breed, reported average results that were clearly higher for fat content (9.3-9.7%) and protein (7.1-7.5%) compared to current results.

The lambs from the three groups showed a significantly higher live-weight at birth in the case of single lambings compared to double lambings, a difference that later disappeared as the milk production in the ewes was sufficient for satisfying the demand of two lambs, until the lambs were weighed in the fourth week of life (22-28 days). At this point, it was again observed that, in the case of those ewes that had to feed two lambs, there was not enough milk produced to allow the two lambs to grow at the same rate as those coming from a single lambing. Other authors have also found weight differences in lamb weights at birth, depending on the type of lambing (Mavrogenis, 1996; Rastogi, 2001; Boujenane, 2002).

The birth weight recorded for the lambs from the Ojalada breed was greater than what has been found in some Spanish breeds, such as the Churra Tensina, by Álvarez-Rodríguez *et al*. (2007), who recorded weights of 3.7-3.9 kg, or Joy *et al*. (2007), working with lambs from single lambings in the same breed (3.6 kg). In the Gallega breed, Sánchez *et al*. (2000) reported weights of 2.8 to 3.0 kg at birth. Also, in some foreign breeds like the Churra Galega Bragançana, Jiménez *et al*. (2005) registered weights that were greater in lambs from single births, but in both of these breeds, they were also lower than those recorded in the current study (3.9 and 3.2 kg, for single and double births, respectively). Furthermore, lower birth weights were observed by Ampueda and Combellas (2000) in the West African breed (2.5-3.8 kg), and also by Rosa *et al*. (2007) in the Merino Branco breed (3.82 kg), with values similar to those found in the Romney Marsh breed (4.25 kg).

Although different researchers such as Appedu *et al.* (2004) and Titi *et al.* (2008) found higher growths in the lambs whose mother had more content in fat in milk, other researchers such as Casals *et al*. (2006), reported that despite the higher fat content in milk of the ewes (1-4 week of lactation), there were no effects on lamb growth. In our case, in spite of the fact that no significant differences were found in milk production among the three groups, marked differences were identified in the lambs' weight. Those lambs whose mothers were fed a diet of chopped straw plus concentrate (IND + CH + C) presented a live-weight that was significantly greater ($p \leq 0.05$) at 35 days than the lambs from the other two groups. Although this finding is difficult to explain, it may arise from the fact that, even though no statistically significant differences were found among the three groups with respect to their production of milk, a tendency indeed emerged indicating a greater production in ewes from the IND + CH + C group until 35 days of lactation. Further, the content of protein in the milk of sheep of the IND + CH + C group was higher than that of the other groups in the third week of lactation, as was the weight of the lambs at birth, although the differences were not significant.

Results along the same lines as those for the current breed have been found by Gutiérrez (2006) in the Churra breed; this breed is also included in the PGI "Lechazo de Castilla y Leon", having yielded weights at birth of 3.92 kg with significant differences based on the type of lambing (4.40 kg in single-birth lambs as opposed to 3.64 kg in double births). This breed reached butchering weight (10 kg) at an age of around 23 days.

As final conclusions, retaining the ewes indoors and administering TMR to them, either chopped or whole barley straw supplemented with concentrate, is a viable alternative from a technical point of view to traditional grazing and addresses labour problems related to work hours. The ewes fed on chopped straw and concentrate presented live-weight and reproductive endpoints (fertility, prolificacy, and fecundity) similar to those fed by grazing. Feeding based on large bales (whole straw plus concentrate), although associated with an inferior live-weight of the ewes, resulted in a better index of fecundity (lambs born per ewe) than ewes fed using the other two methods. Other factors, however, also must be considered, such as the male effect, as there were two different males in each of the groups.

Although there were no significant differences in the production or composition of the milk from the ewes in the three groups, notable differences were discovered regarding the weight of the lambs. Those lambs whose mothers were fed a diet of chopped straw plus concentrate reached the minimum slaughtered weight required by the PGI "Lechazo de Castilla y Leon" (9 kg live-weight) a week earlier than those whose mothers were fed whole straw plus concentrate, or those who grazed free range. These differences in weight, however, cannot be attributed only to the food system effect.

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