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EFFECT OF SHEARING DURING THE MILKING PERIOD ON THE LACTATIONAL PERFORMANCES OF TWO BREEDS OF DAIRY EWES

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Abstract

Effect of shearing during the milking period on the lactational performances of two breeds of dairy ewes

The effect of shearing during lactation under mild winter conditions was investigated in a total of 48 dairy ewes of 2 breeds (Manchega, MN; Lacaune, LC). From them, 32 were multiparous (MN, n = 16, 69.5 ± 1.7 kg BW; LC, n = 16, 69.1 ± 1.9 kg BW) and 16 were primiparous (MN, n = 8, 59.4 ± 2.0 kg BW; LC, n = 8, 57.4 ± 2.4 kg BW). Ewes were allocated in 4 equilibrated groups by breed to which the experimental treatments were randomly applied in duplicate. Treatments were: C (control: unshorn) and SH (shorn) during lactation (February 16). Diets consisted of alfalfa hay ad-libitum and concentrate rationed individually in the milking parlor according to their requirements (MN, 0.45 kg/d; LC, 0.65 kg/d). Ewe groups were in straw-wood chips bedded pens and ambient temperatures in the shelter were mild before (12.6 ± 0.9ºC) and after (13.0 ± 0.3ºC) shearing. Fleece weight was greater in shorn MN than LC (1.04 ± 0.10 vs. 0.75 ± 0.09 kg/ewe; $P < 0.05$). As a result of shearing, rectal temperature decreased in the MN-SH ewes, when compared to the MN-C (38.51± 0.11 vs. 38.88 ± 0.12ºC, respectively; $P < 0.001$), but did no vary in the LC ewes (38.57 ± 0.08ºC). No differences were detected ($P > 0.05$) in the fill value of the alfalfa hay, expressed as sheep fill units (SFU), used between MN and LC breeds (0.98 ± 0.04 vs. 0.96 ± 0.01 SFU/kg DM; respectively). Productive response to shearing treatments varied according to breed, the results in LC being most marked than in MN. Feed intake increased in the LC-SH (5%; $P < 0.01$), when compared to LC-C, but did not vary in MN. Moreover, the LC-SH ewes yielded more milk (10%; $P < 0.05$) than LC-C ewes, but no differences were detected in MN ewes. There were no differences in milk composition between treatments in both breeds. The milk protein and lactose yields were also higher for LC-S than LC-C ewes (20% at $P < 0.01$; and, 17% at $P < 0.05$; respectively). No effects of shearing were detected on metabolic (glucose, NEFA) and hormonal (cortisol, insulin) plasma values, as well as on body weight and body condition score. In conclusion, shearing lactating ewes during winter, under moderate cold conditions, can be a suitable management option for improving feed intake, milk yield, protein yield and lactose yield of high yielding ewes, without deleterious effects neither on physiological indicators nor milk composition.

Keywords: dairy sheep, shearing, lactation, milk yield, milk composition.

Resumen

Efecto del esquileo durante el periodo de ordeño sobre la producción de leche de dos razas de ovejas

Se estudió el efecto del esquileo durante la lactación en condiciones de invierno templado en un total de 48 ovejas lecheras de 2 razas (Manchega, MN; Lacaune, LC). De ellas, 32 eran multíparas (MN, n = 16, 69.5 ± 1.7 kg PV; LC, n = 16, 69.1 ± 1.9 kg PV) y 16 primíparas (MN, n = 8, 59.4 ± 2.0 kg PV; LC, n = 8, 57.4 ± 2.4 kg PV). Las ovejas se distribuyeron en 4 grupos equilibrados por raza a los que se aplicaron los tratamientos experimentales al azar y por duplicado. Estos fueron: C (control: sin esquilar) y SH (esquiladas) durante la lactación (16 de febrero). Las dietas consistieron en heno alfalfa ad libitum y concentrado racionado individualmente en la sala del ordeño según necesidades (MN, 0.45 kg/d; LC, 0.65 kg/d). Los grupos de ovejas se alojaron en corrales con cama de paja y viruta de madera, siendo moderada la temperatura ambiente media del aprisco antes (12.6 ± 0.9ºC) y después (13.0 ± 0.3ºC) del esquileo. El peso del vellón fue mayor en MN que en LC (1.04 ± 0.10 vs. 0.75 ± 0.09 kg/oveja; $P < 0.05$). Como resultado del esquileo, la temperatura rectal disminuyó en las ovejas MN-SH, al compararla con las MN-C (38.51 ± 0.11 vs. 38.88 ± 0.12ºC, respectivamente; $P < 0.001$), pero no varió en las ovejas LC (38.57 ± 0.08ºC). No se detectaron diferencias ($P > 0.05$) en el valor lastre del heno de alfalfa, expresado en unidades lastre ovinas (ULo) entre MN y LC (0.98 ± 0.04 vs. 0.96 ± 0.01 ULo/kg DM; respectivamente). Las respuestas productivas al esquileo variaron según la raza, siendo los resultados más marcados en LC que en MN. Así, la ingestión aumentó en las LC-SH (5%, $P < 0.01$), en comparación con las LC-C, pero no varió en las MN. Además, las ovejas LC-SH produjeron más leche (10%, $P < 0.05$) que las LC-C, pero no se detectaron diferencias en las MN. Tampoco se observaron diferencias en la composición de la leche entre tratamientos en ambas razas. Las cantidades diarias de proteína y de lactosa de la leche también fueron más elevadas en las ovejas LC-SH respecto a las LC-C (20%, $P < 0.01$; 17%, $P < 0.05$; respectivamente). No se detectaron efectos del esquileo en los valores plasmáticos de metabolitos (glucosa, NEFA) y hormonas (cortisol, insulina), así como tampoco en el peso y la condición corporal. En conclusión, esquilar a las ovejas durante la lactación, en condiciones invernales de frío moderado, puede ser una estrategia de manejo adecuada para mejorar la producción de leche, de proteína y de lactosa en ovejas de alta producción, sin efectos perjudiciales en los indicadores fisiológicos ni en la composición de la leche.

Palabras clave: ovejas lecheras, esquileo, lactación, producción y composición de leche.

Résumé

L’effet de la tonte pendant la période de traite sur la production du lait chez deux races ovines

L'effet de la tonte durant la lactation dans des conditions hivernales a été étudiée avec un total de 48 brebis laitières de 2 races (Manchega, MN; Lacaune, LC). Parmi elles, 32 étaient des multipares (MN, n = 16, 69.5 ± 1.7 kg PV; LC, n = 16, 69.1 ± 1.9 kg PV) et 16 étaient primipares (MN, n = 8, 59.4 ± 2.0 kg PV; LC, n = 8, 57.4 ± 2.4 kg PV). Les brebis ont été réparties en 4 groupes équilibrés par race à laquelle les traitements ont été appliqués d’une manière aléatoire et dupliquée. Les traitements étaient: C (contrôle: unshorn) et SH (tondues) durant la lactation (16 Février). Les régimes alimentaires étaient composés de foin de luzerne ad libitum et de concentré rationné individuellement dans la salle de traite selon les besoins (MN, 0.45 kg/j; LC, 0.65 kg/j). Les groupes des brebis étaient dans des enclos avec litière de paille et sciure de bois et les températures ambiantes à la bergerie étaient de (12.6 ± 0.9ºC) avant et (13.0 ± 0.3°C) après la tonte. Le poids de la toison était supérieur chez la MN que LC (1.04 ± 0.10 vs. 0.75 ± 0.09 kg/brebis; $P < 0.05$). Les résultats obtenues dans cette étude sont : La température rectale a diminué chez les brebis MN-SH par rapport aux brebis MN-C (38.51 ± 0.11 vs. 38.88 ± 0.12°C, respectivement; $P < 0.001$), mais elle n'a pas varié dans les brebis LC (38.57 ± 0.08ºC). Aucune différence n'a été observée ($P > 0.05$) de la valeur d’encombrement du foin de luzerne, exprimé en unités encombrement mouton (UEm), entre MN et LC (0.98 ± 0.04 vs. 0.96 ± 0.01 UEm/kg DM; respectivement).Les réponses productives de la tonte varient selon la race, les résultats des brebis LC étaient plus marqués que chez les brebis MN. Néanmoins, l’ingestion a augmenté chez les LC-SH (5%, $P < 0.01$), par rapport aux LC-C, mais elle n’a pas varié en MN. En outre, les brebis LC-SH ont produit plus de lait (10%, $P < 0.05$) que les brebis LC-C, mais aucune différence n'a été observé chez les brebis MN. Il n'y avait pas de différences dans la composition du lait entre les traitements dans les deux races. Les rendements de protéine et de lactose du lait étaient également plus élevés pour les brebis LC- S que les LC-C (20%, $P < 0.01$; 17%, $P < 0.05$; respectivement). Aucuns effets de la tonte n’ont été détectées sur les valeurs métaboliques (glucose, NEFA) et hormonales (cortisol, insuline) du plasma, ainsi que sur le poids vif et la note d'état corporel. En conclusion, tondre les brebis durant la lactation dans des conditions hivernales peut être une option de gestion approprié pour améliorer la production de lait, de protéine et de lactose pour les brebis de haute production, sans avoir aucuns effets négatifs ni sur les indicateurs physiologiques ni sur la composition du lait.

Mots-clés: brebis laitières, tonte, lactation, production laitière, composition du lait.

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List of abbreviations

ADF: Acid detergent fiber
aDMI: Average dry matter intake
BCS: Body condition score
BW: Body weight
CF: Crude fiber
CP: Crude protein
CN: Casein
dDM: Digestibility of dry matter
DM: Dry matter
DMI: Dry matter intake
EE: Ether extract
FV: Fill value
iDMF: Individual fecal dry matter output per ewe and day
LC: Lacaune
MN: Manchega
NDF: Neutral detergent fiber
NEFA: Non esterified fatty acid
NIRS: Near Infrared Reflectance Spectroscopy
OM: Organic matter
PEG: Polyethylenglycol
SCC: Somatic cells count
SFU: Sheep fill units
SH: Shorn
tDMF: Total dry matter fecal
tDMI: Total dry matter intake
TP: True protein
TS: Total solids
US: Unshorn

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Introduction

1. Introduction

Shearing is usually considered to be a necessary practice for flock management in order to improve the sheep welfare and production (Swanson and McGlone, 2010). Shearing modifies the limits of the thermo-neutral zone of the animals, increasing the critical inferior temperature and inducing different adaptive responses to maintain the body homeostasis (Aleksiev, 2008). Shearing boosts the heat transfer between the animal and its environment, especially in cold weather, resulting in a greater metabolic rate to match the increased energy demand for heat production.

Commonly, shearing is done once a year, the traditional shearing season being spring or early summer. However, in some countries and with high yielding wool breeds, shearing may take place twice or thrice annually, so the effects of shearing at the end of summer or at the end of winter have been evaluated (Hetem et al., 2009). When shearing is conducted during the end of winter or early spring, shorn sheep are exposed to cold thermal stress as a consequence of losing their insulation. Different degrees of cold stress can be expected by breed according to their traits and adaptation to climate (i.e., temperate or cold conditions).A greater degree of cold stress would result in a greater metabolic rate, thus increasing the amount of feed necessary for the maintaining the body mass (Piccione et al., 2002). These authors reported an elevation of over 1ºC in the core body temperature of sheep after shearing, probably as over-reaction to the mild cold stress.

Moreover, shearing out of the traditional season at start of the summer, implies in many cases to coincide with the end of pregnancy or lactation during winter or spring, which makes hard the prediction of the metabolic and physiological consequences of shearing on the performances of the ewe and the lambs. In any case, for evaluating the effects of shearing, it should be distinguished between open and pregnant ewes (i.e., hormone and requirements), among seasons (i.e., photoperiod) and between hot and cold environments (i.e., thermoregulation).

In the case of the Mediterranean countries, traditional sheep production systems involve shearing at the beginning of the summer to match with the onset of hot temperatures (Dyrmundsson, 1991).In Spain, sheep are usually shorn around mid of May, according to the traditional shearing time, before mating and grazing on cereal stubbles.

Dairy sheep is also a typical production in the Mediterranean countries, milk being mainly addressed to cheese production. Manchega (**MN**) and Lacaune (**LC**) breeds are important populations of Mediterranean dairy sheep, producing the appreciated Manchego and Roquefort cheese types, respectively. The MN breed is mainly exploited in the large plateaus of the central Spain (La Mancha), while LC breed is at nowadays an international breed which comes from the plateaus of the south of France (Rayon de Roquefort). Although many traits of both breeds are similar, such as suggested ancestors (Sánchez, 1994), as well as morphology and body weight, milk yield and composition are markedly different (Such et al., 1999; Rovai et al., 1999), the MN breed being known as mid-yielding and high-composition and the LC high-yielding and mid-composition dairy breeds. These differences are basically due to the objectives and efficiency of their respective genetic selection programs, mainly focused on milk yield in the LC, and on several dairy traits (milk yield-composition-morphology) in the MN.

Despite the expected effects of thermoregulation on lactating animals, little is known on the effects of shearing in lactating dairy ewes. So, our working hypothesis is that shearing the ewes at the end of winter, when they are open and under milking, should cause a reduction of the corporal temperature due to the removal of the fleece, which will increase the metabolic rate and feed intake of the ewes to maintain the body temperature in the thermo-neutral zone. This catabolic effect will help the animal to keep its temperature but also may increase milk yield and may modify milk composition (i.e., increasing milk fat or protein) by modifying the hormonal profiles and the partitioning of nutrients between the body and the udder.

Bibliographic review

2. Bibliographic review

2.1. Thermoregulation and effects of shearing

The process of energy exchange between an animal and the environment is greatly affected by its coat, which is known to play a remarkable role in the maintenance of thermal balance. Maintenance of the homoeothermic conditions in sheep is influenced by the characteristics of the wool fleece, which is conditioned to intrinsic (i.e., breed, age, sex) and extrinsic (i.e., time from shearing, temperature, relative humidity and wind) factors (Sleiman and Abi Saab, 1995).

Sheep's fleece should be considered as a thermoregulatory bio-structure, which its thermal insulation reduces the convective heat loss from the body and the radiative heat gain, under cold or hot environments, respectively. Studies in shorn and unshorn ewes, exposed to extreme environmental conditions, have shown the importance of the fleece for maintaining their homoeothermia (Whittow, 1971; Piccione et al., 2010).

Removal of the fleece in sheep grazing under the sun and during the hottest hours of the day, is considered a necessary practice by shepherds, not only for hygienic reasons, but also for enabling sheep to better withstand under the exposure to high temperatures. In contrast with this generalized statement, usually accepted without discussion, it has been recognized that wool coat helps to defend against external factors (i.e., sun radiation, dryness) and to create an individual good thermal environment enabling the sheep to maintain its normal physiological, functional and productive processes (Avondo et al., 2000). Moreover, in many countries, sheep is usually sheltered under extreme weather conditions, which should modify the consequences of shearing.

2.2. The effect of shearing on the voluntary feed intake

The insulation loss in a recently shorn sheep and the increase of heat expenditure stimulates its metabolic rate, which results in an increase of feed intake to cope with the increased energy demand for heat production. Under environmental temperatures much lower than the critical, heat loss rate may be critical for maintaining the thermoregulation and hence compromising the level of production (Aleksiev, 2007).

Metabolic adaptations to shearing treatments are usually accompanied by an increase in feed intake, as reported by Dabiri et al. (1995) in non-pregnant, non-lactating ewes. The increase of feed intake depends on different factors amongst which the degree and duration of the cold stress, the type of the diet and the quality of the forages fed, as well as age on the reproductive status of the ewes (Weston, 1988).

According to Avondo et al. (2000), pregnant Comisana dairy ewes under Sicilian summer conditions showed a tendency to decrease their pasture intake when supplemented with concentrate. However, shorn pregnant ewes increased 20% pasture intake (Table 1). The increase found in intake could be the result of increased energy requirements linked to shearing treatment.

Intakes of shorn pregnant sheep have shown 20-60% increases on pasture, 14-43% on silage barley, and 2-15% on hay diets under winter conditions (Vipond et al., 1987).

Nevertheless, Hawker et al. (1985) did not observe differences in intake when Romney hogget were shorn under mild spring climatic conditions (Table 1). According to Aleksiev (2008) shearing was expected to increase voluntary food intake as a result of elevated heat loss, but intake remained almost unchanged all over the observation period. Similarly, shearing did not change intake nor milk yield of Tsigai dairy ewes during lactation (Aleksiev, 2008; Figure 1), independently of the environmental temperature fluctuations.

Donnelly et al. (1974) found an increase in intake up to 5% in newly shorn Merino ewes under moderate ambient temperature conditions. Aleksiev and Iliev (2003) also reported 27.5% increase of feed intake in ewe’s shorn under cold conditions in winter. Black and Chestnutt (1990) reported increases of intake due to shearing during pregnancy which were lower with silage (0.11 kg DM/d) than hat resulting from feeding earlier-cut silage (0.27 kg DM/d).

According to Revell et al. (2000), shearing increased the voluntary feed intake of twin-bearing ewes by 47% (Table 1) but it did not affect feed intake of single-bearing Coopworth ewes. Similarly, Dabiri et al. (1996) reported that shearing pregnant Border Leicester × Romney ewes increased 14% feed intake (Table 1), but the response was not evident until some weeks after shearing.

Table 1. Effect of shearing on the feed intake (kg DM/d) of ewes according to their physiological stage.

Stage	Author	Breed	Season	Average temp., °C		Treatments		SEM	Effect	
				Min.	Max.	Unshorn	Shorn		%	*P* <
Lactating	Aleksiev (2008)	Tsigai	April	4.7	15.6	1.78	1.80	-	-	NS
Pregnant	Leibovich et al. (2011)	Assaf	Summer	28.1	32.2	2.62	2.84	0.04	8	0.05
Pregnant	Avondo et al. (2000)	Comisana	Summer (August)	-	31.7	1.10	1.32	0.04	20	0.01
Pregnant										
Single	Revell et al. (2000)	Coopworth	-	9.3	12.7	2.50	2.50	0.04	0	NS
Twin	“ “	“	-	“	“	1.70	2.50	0.04	47	0.001
Pregnant	Dabiri et al. (1996)	Border Leicester × Romney	Autumn (May) and spring (August)	-	-	1.53	1.74	0.06	14	0.05
Dry	Hawker et al. (1985)	Romney	Spring	6.1	16.7	1.10	1.10	0.05	0	NS

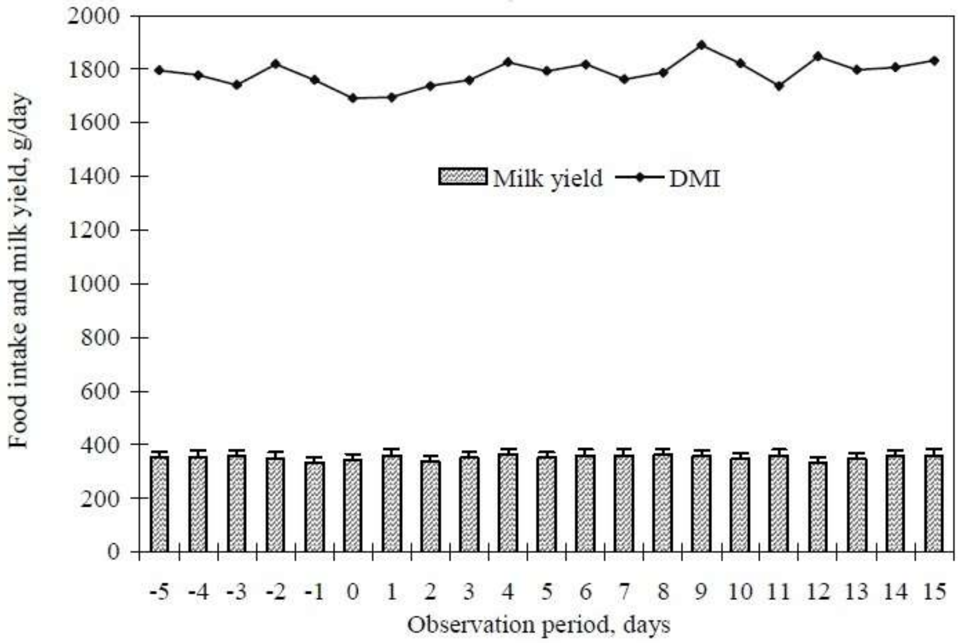


Figure 1. Dry matter intake and milk yield of Tsigai dairy ewes before and after shearing. (Aleksiev, 2008).

2.3. The effect of shearing on metabolic indicators

Additionally to the important role of the shelter microclimate on the welfare of animals, with the subsequent impact on their performances (Piccione and Caola, 2003), shearing also modified the physiological and haematochemical values of Valle del Belice dairy ewes and modified their response to heat stress (Piccione et al., 2008ab).

Symonds et al. (1989) found that shorn pregnant crossbreed ewes (Blue faced Leicester × Swaledale)under winter conditions had higher rates of mobilisation and oxidation of non-esterified fatty acids, and higher rates of glucose synthesis and oxidation, than unshorn ewes. Shorn ewes had higher plasma concentrations of thyroxine after shearing that will increase milk yield and milk fat content. In a later experiment in lactating ewes shorn 8 weeks before lambing, insulin concentrations were lower and growth hormone concentrations were higher than in control ewes (Symonds et al., 1990). These hormone changes could increase the glucose availability for lactation and increase the lipolysis of adipose tissue.

According to Mousa-Balabel and Salama (2010), shearing pregnant Egyptian Rahmani ewes improved the utilization of dietary protein and enhanced the mobilization of maternal fat reserves, thus justifying its necessity for the well-being of both ewes and lambs. However, shearing is also considered a stressing factor for sheep, capable of causing behavioral changes as a consequence of the altered comfort.

When ewes are subjected to cold stress, their glucose concentration in blood increases (Thompson, 1982). According to Cam and Kuran (2004), the increase in hormones and metabolites concentrations, in response to shearing treatment of Turkish Karayaka dairy ewes during pregnancy, may stimulate the mammary growth and hence increase subsequent milk yield, if it is not due to the greater mammary stimulation resulting from the demand of heavier lambs. As possible explanation for the increased milk production, Cam and Kuran (2004) suggested that mammary gland growth of shorn pregnant ewes may be improved by changes in the profiles of metabolites and hormones.

On the other hand, Carcangiu et al. (2008) reported that shearing caused acute stress in dairy Sarda ewes, as shown by the rise of cortisol concentration in blood. Plasma levels of glucose also rose in shorn ewes, the rise being directly proportional to the level of cortisol, and attributed to the hyperglycemic effect of this hormone through the sympathetic-adrenergic axis stimulation and the increase of the gluconeogenesis in the liver.

2.4. The effect of shearing on milk production

Milk synthesis strongly depends on genetic, nutritional and environmental factors, as stated by many authors. Sphor et al. (2011) reported that milk production of Australian Polwarth ewes shorn after parturition was 29% higher than that of unshorn ewes (Figure 2).

However, when the ewes were shorn during pregnancy and under pastoral conditions, Banchero et al. (2010) did not observe lactation curves with a peak, as usually found in unshorn ewes milked with the help of oxytocin. The authors concluded that the maximum milk yield occurred from the first day of lactation, and that it was related to the breed and the nutritional status of the ewe.

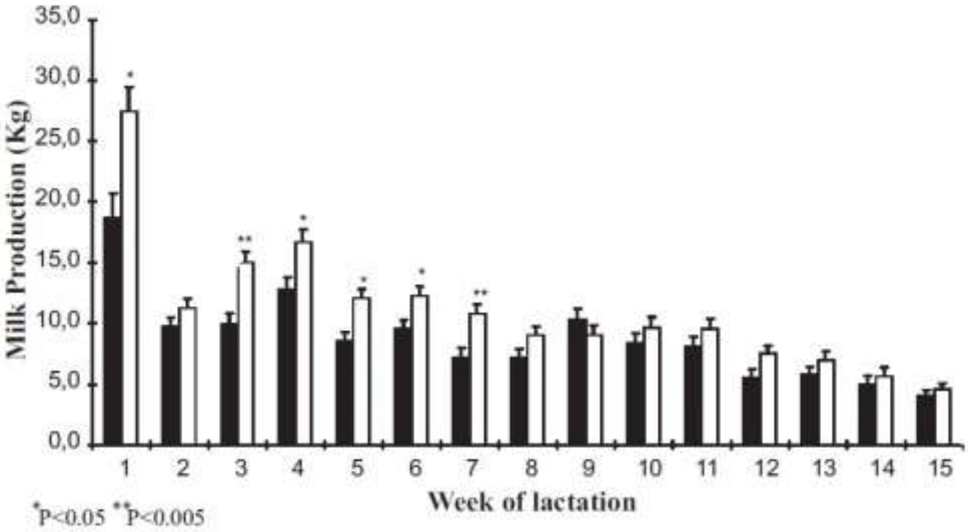


Figure 2. Milk production (kg/week) of Polwarth ewes shorn (white) or unshorn (black) during pregnancy(Sphor et el., 2011).

With regard to dairy ewes, Cam and Kuran (2004) found that shearing pregnant Turkish Karayaka ewes increased measured milk yield (Figure 3) and estimated 75 d lactation yield based on the test-days results. Moreover, Leibovich et al. (2011) tested the combination of shearing and cooling in hot conditions in pregnant Assaf ewes at the end of the dry period. The effect of shearing and cooling increased 8% intake during lactation (Table 1), as well as 7.4 and 9.7% milk and ECM yield, respectively, when compared with the control ewes. The rise in ECM reflected a 14% increase in milk fat and 2% in milk protein contents when compared to the control ewes (Table 2).

Nevertheless, Gudev et al. (2000) found a decrease of milk yield after winter shearing in high yielding Danube Merino ewes during the suckling period, but not in the low yielding ewes. These results suggest a homeostatic regulation which was influenced by many factors, the most important being the energy intake, the level of production, the partitioning of nutrients between the tissues and organs, and the environmental conditions.

In another study under controlled environment, McBride and Christopherson (1984) noticed that exposure of shorn lactating Suffolk ewes to low ambient temperatures caused an increase in heat production by up to 55%, compared to the ewes kept under

Table 2. Milk production and milk composition of sheep according to shearing treatment.

Stage	Author	Breed	Season	Mean T°C		Lactation item	Treatments		SEM	Effect	
				Min.	Max.		Unshorn	Shorn		%	*P* <
Pregnant	Sphor et al. (2011)	Polwarth	Winter (July)	-	-	Milk yield, kg/d	1.24	1.60	0.09	29.0	0.01
						Fat, %	7.8	7.6	0.3	-	NS
						Protein, %	4.4	4.3	0.1	-2.3	0.05
						Lactose, %	5.3	5.2	0.1	-	NS
						Total solids, %	18.3	17.9	0.3	-	NS
Pregnant	Leibovich et al. (2011)	Assaf	Summer	28.1	32.2	Milk yield, kg/d	2.70	2.90	0.07	7.4	0.05
						ECM, kg/d	3.51	3.85	0.03	9.7	0.05
						Fat, %	4.9	5.6	0.1	14.0	0.05
						Protein, %	4.9	5.0	0.1	2.0	0.05
						Lactose, %	5.0	5.0	0.1	-	NS
						Total solids, %	15.6	15.9	0.2	2.0	0.05
Lactating	Aleksiev (2008)	Tsigai	April	4.7	15.6	Milk yield, kg/d	0.35	0.35	-	-	NS
Lactating	Knight et al. (1993)	Dorset	February	-	-	Milk yield, kg/d	1.38	1.37	0.07	-	NS
						Fat, %	6.7	7.7	0.1	14.9	0.001
						Protein, %	5.1	5.6	0.1	9.8	0.001
						Lactose, %	4.8	4.8	0.1	-	NS
						Total solids, %	17.4	18.8	0.2	8.0	0.001
Lactating	McBride et al. (1984)	Suffolk	-	0.0	21.0	Milk yield, kg/d	1.56	1.54	0.07	-	NS
						Fat, %	7.2	9.1	0.4	26.4	0.01
						Protein, %	5.1	5.1	0.2	-	NS
						Lactose, %	5.7	5.7	0.1	-	NS

thermoneutral conditions, although this did not substantially affect milk production(Table 2).

Black and Chestnutt (1990) also reported that there were no effects of shearing in ewes carrying twins at various stages of pregnancy, on milk yield and composition measured at d 15 and 30 after shearing treatment.

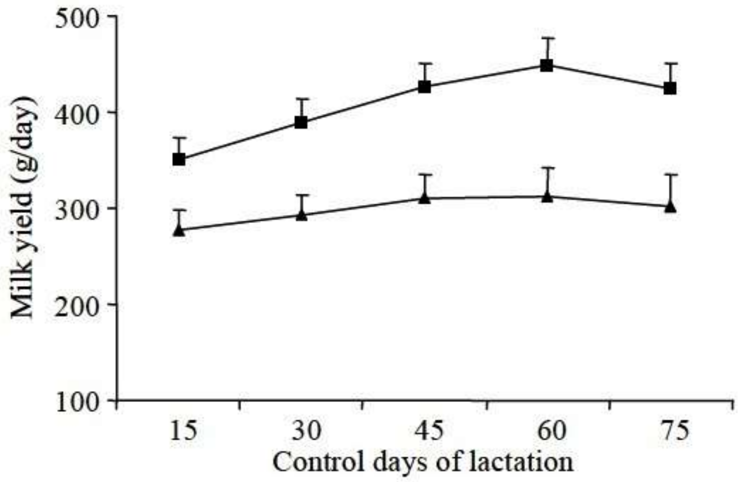


Figure 3. Milk yield of the unshorn (▲) and shorn (■) pregnant Turkish Karayaka ewes (Cam and Kuran, 2004).

2.5. The effect of shearing on milk composition

The expected main effects of shearing ewes before or during lactation are to increase the concentration of fat and protein in the milk. Changes in feed intake could also account for increased concentrations of protein and fat in the milk of shorn ewes.

Knight et al. (1993) reported 8-24% increase of total solids of shorn Dorset ewes, the increases in the concentration of milk protein being more consistent than in fat. Effects of shearing on lactose content in milk were not significant. The increase in the concentrations of protein and fat in the milk of the shorn ewes may be caused by a change in feed intake. Nevertheless, the high coefficients of variation observed for milk traits, even when using pre-shearing values as covariates, meant that changes in milk yield and composition were not significant with the number of ewes used in these experiments.

In another study under controlled environment, McBride and Christopherson (1984) noticed that exposure of shorn lactating Suffolk ewes to low ambient temperatures caused an increase in the milk fat content by up to 26.4%, compared to that of ewes kept under thermoneutral conditions (Table 2).

Sphor et al. (2011) reported no difference in total milk solids content between control and shorn pregnant Polwarth ewes, however, when milk solids were analysed separately, milk protein content of the unshorn ewes was higher than in the shorn ewes (Table 2).

Despite the consistent increase in the fat, protein, and total solids contents reported in milk after shearing, there were no consistent increases in yields of these milk constituents. The increased concentrations of fat and protein in the milk of shorn ewes should provide a better quality of milk for processing and may increase the unitary yield of cheese per litre of milk.

2.6. The effect of shearing on rectal temperature

Rectal temperature measurements carried out after shearing showed that this practice causes an alteration in thermal homeostasis. In fact, rectal temperature is an indicator of thermal balance and may be used to assess the adversity of the thermal environment which can influence the ewes. Variations in rectal temperature are a sensitive indicator of physiological response to heat stress in ewes because rectal temperature is nearly constant under normal conditions (Silanikove, 2000). Shearing causes an elevation of the metabolic rate, which could induce thermal stress by leading to oxidative stress under hot conditions.

According to Piccione et al. (2002), shearing dry ewes in spring (May) caused an increase in rectal temperature of over 1°C in 3 breeds of Mediterranean sheep (Comisana, Barbaresca Siciliana, and Pinzirita). Since the animals were kept indoors (without direct exposure to solar radiation) at an ambient temperature of 16-28°C, the rise in body temperature cannot be related to heat stress. Considering that the thermoneutral environment for shorn sheep is approximately 28°C (Graham et al., 1959), and sheep were maintained at temperatures ranging from 16 to 28°C, it is reasonable to assume that shorn sheep were actually under cold stress. Therefore, the elevation of core body temperature could have been the result of an overshoot of thermoregulatory responses directed at heat conservation. On the other hand, there is a hyperthermic response to stress, producing the rise of rectal temperature, as already shown in animals (Bouwknecht et al., 2007).

Nevertheless, this hyperthermia can be neutralized by ambient temperature. Shearing pregnant Assaf ewes in a cooling ambient decreased rectal temperature by 0.2°Cduring lactation, compared with the control (non-cooled and non-sheared) ewes (Leibovich et al., 2011).

According to Aleksiev (2007), rectal temperature decreased significantly, and remained lower than that recorded in the unshorn sheep throughout the pre-shearing period (2 months), after winter shearing in fine wool sheep. A fall in rectal temperature was observed in the sheep shorn in spring but at a smaller extent than those shorn in winter (Figure 4).

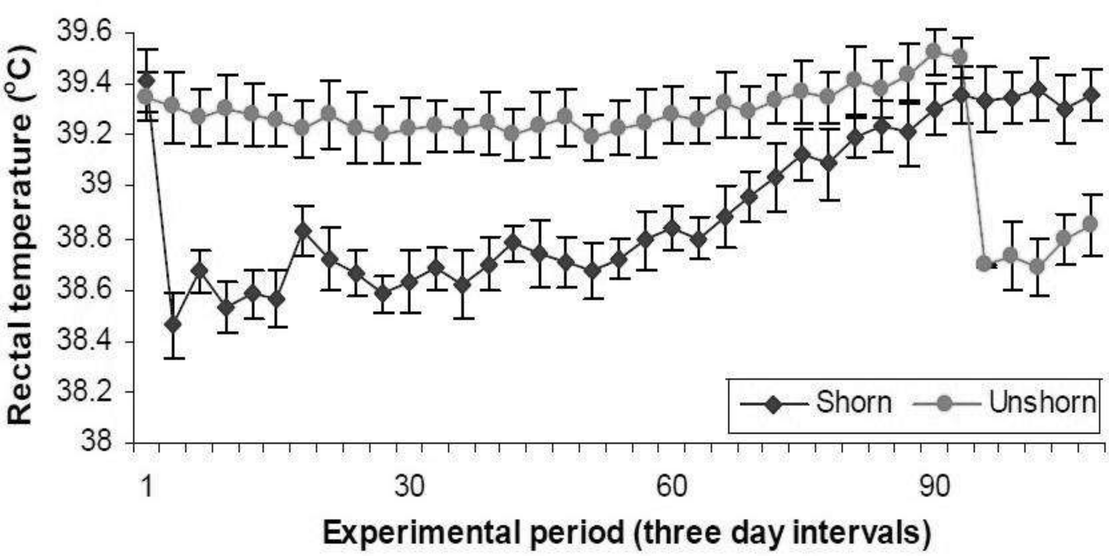


Figure 4. Rectal temperature in fine wool sheep shorn at different seasons (Aleksiev, 2007).

Body temperature is widely used as a physiological indicator for studying the adaptation to the environment. The considerable fall in rectal temperature recorded after winter shearing by Aleksiev (2007), which persisted thereafter, indicated a possible shift of thermoregulatory set point as a result of shearing. It returned to the pre shearing level in May as a result of elevation of the ambient temperature and of full restored external insulation. Shearing at the end of May was also accompanied by remarkable decrease in rectal temperature, showing that the ambient temperatures at this time of the year are still out of the zone of thermoneutrality. A decrease in respiratory rate was also observed after winter shearing in order to minimize heat loss, which contributes to maintaining the internal temperature. Similar signs of adaptation to the environment, independently of the shearing season, proved that sheep's heat balance, after fleece removal, was dependent on environmental temperatures.

According to Al-Ramamneh et al. (2011), rectal temperature decreased after shearing in German Blackhead ewes to values identical to those found in the shorn control group. This is in accordance with previous findings (Aleksiev, 2007; Beatty et al., 2008), in which the presence of fleece was associated with increased core body temperatures compared with those of shorn sheep. However, in contrast to these results, Piccione et al. (2002) have found that shearing increased rectal temperature.

2.7. The effect of shearing on other variables

Shearing at the beginning of April produced a marked decline of water intake (24.5%, on average) in lactating Tsigai dairy ewes kept in indoor conditions, as reported by Aleksiev (2008), without effects on intake or milk yield (Figure 5).

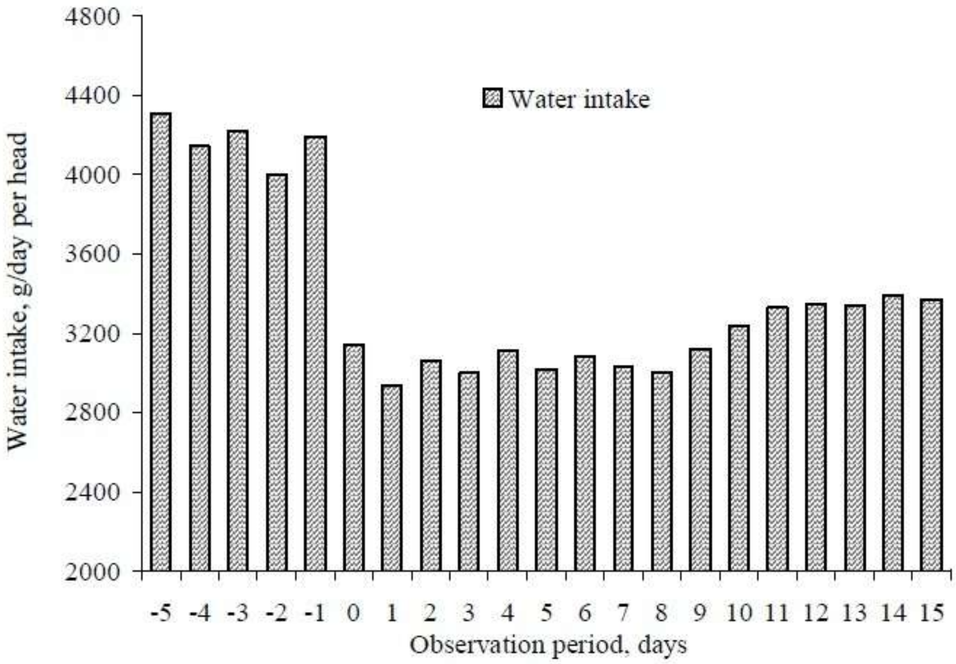


Figure 5. Daily water intake (g/d) before and after shearing (Aleksiev, 2008).

Finally, Al-Ramamneh et al. (2011) found similar results in German Blackhead sheep, reporting that shearing decreased water intake and respiratory rate, linked to panting and respiratory water loss by evaporative cooling, which has been reported to amount to 65% of the total heat loss in shorn sheep. Thus, the greater water intake in unshorn ewes was most likely due to increased evaporative cooling.

Objectives

3. Objectives

The main objective of this thesis of Master of Science in Animal Nutrition was to study the nutritional and productive responses of dairy ewes to shearing during lactation under winter conditions. The specific aims were to measure the effects of shearing on:

- Feed intake
- Milk yield
- Milk composition:
    - Total solids
    - Fat
    - Protein: total and true protein, and casein
    - Lactose
- Physiological indicators:
    - Blood metabolites: Glucose and Non esterified fatty acid (NEFA)
    - Hormones: Insulin and cortisol

The experimental design included 2 treatment groups of ewes: unshorn (US: 1 year wool) and shorn (SH) with two dairy ewes Manchega and Lacaune known by their similar body weight and different milk yield and composition.

Materials and Methods

4. Materials and Methods

A total of 60 ewes of MN and LC dairy breeds, located at the experimental farm of the SGCE (Servei de Granges i Camps Experimentals) of the Universitat Autònoma de Barcelona in Bellaterra (Barcelona, Spain), were used in 2contemporary experiments done in lactating and dry ewes.

In Exp. 1, 48 dairy ewes at mid lactation were used to study the nutritional and productive responses to shearing during lactation under mild-winter conditions in Bellaterra. In Exp. 2, 12 dry ewes were used to calculate the effects of shearing on the fill value (FV) of the forage used in the experiment.

4.1. Experiment 1

4.1.1. Animals, nutrition and management

From the 48 dairy ewes used, 32 were multiparous (MN, n = 16, 3.3 ± 0.5 yr, 69.5 ± 1.7 kg BW; LC, n = 16, 3.1 ± 0.4 yr, 69.1 ± 1.9 kg BW) and 16 were primiparous (MN, n = 8, 1.0 ± 0.0 yr, 59.4 ± 2.0 kg BW; LC, n = 8, 1.0 ± 0.0 yr, 57.4 ± 2.4 kg BW).All ewes wore a set of plastic ear tags (4.5 g, 38 × 33 mm) and ceramic rumen mini-boluses (20.1 g, 56.4 × 11.2 mm) containing passive half-duplex transponders (32 × 3.8 mm) for visual and electronic identification for automatic milk recording, respectively (Rumitag, Esplugues de Llobregat, Barcelona, Spain).

An adaptation period to the experimental conditions (group and diet) was applied during 4 weeks (15 January to 16 February 2015) for all animals. The diet consisted of alfalfa hay ad libitum and concentrate offered individually in the milking parlor in two portions at the a.m. and p.m. milking (MN, 450 g/d; LC, 650 g/d; as fed)according to with their requirements (INRA, 2010)using the INRAtion v. 4.06 software (Educagriéditions, Dijon, France).

The ingredients of the concentrate are shown in Table 3, and the chemical composition of the experimental diet is shown in Table 4. All ewes had free access to water and mineral blocks.

Table3. Ingredient composition of the concentrate used (as fed).

Ingredient	**%**
Corn	4.0
Barley	10.0
Oats	10.0
Gluten feed	10.0
Rapeseed Meal "00"	5.0
Soybean hulls	50.0
Soybean oil	5.0
Phosphatebicalcium 18%	2.5
Cane molasses	2.0
Vitamin premix[1]	1.0
Salt	0.5
Total	100.0

[1]VitafacOvino 0.3% (DSM Nutritional Products Europe, Switzerland): Ca, 15.28%; Mg, 5.05%; S, 3.33%; Vitamin A, 3,333,333 IU/kg; Vitamin D3, 333,333 IU/kg; Vitamin E, 5,666 mg/kg; Vitamin B1, 666 mg/kg; Vitamin B2, 333 mg/kg, FeCO3, 11,666 mg/kg; MnO, 13,333 mg/kg; 3Co(OH)2.H2O, 66 mg/kg; ZnO, 13,333 mg/kg; Ca(IO3)2, 166 mg/kg; Na2SeO3, 100 mg/kg (as fed).

Table4. Chemical composition of the experimental diets according to the experimental period (%DM basis).

Item, %	Before shearing			After Shearing		
	Alfalfa hay	Concentrate	Corn	Alfalfa hay	Concentrate	Corn
DM	88.5	90.6	87.8	89.0	91.1	87.8
OM	10.7	7.5	1.2	11.2	7.6	1.2
CP	16.8	15.1	8.0	17.8	15.3	7.8
Fat	1.9	8.1	3.9	1.7	8.1	4.0
CF	30.4	21.2	1.7	30.4	20.5	1.7
NDF	46.3	39.4	7.9	46.2	38.9	7.8
ADF	33.4	25.1	1.4	34.4	24.7	1.3

Machine milking was conducted twice daily (07:00 and 17:00 h) in a double-12 stall parallel milking parlor (Amarre Azul I, DeLavalEquipos, Alcobendas, Madrid, Spain) with a central high milk pipeline, 12 DeLaval SG-TF100 milking clusters, and 12 MM25SG milk flow and recording units (both from DeLaval, Tumba, Sweden).

Milking was performed at a vacuum of 40 kPa, 120 pulses/min, and 50% pulsation ratio. The milking routine included cluster attachment (without udder preparation), machine milking, and automatic cluster detachment (milk flow rate < 0.1 L/min or milking time > 3 min). Teat dipping with an iodine solution (P3-ioshield, Ecolab Hispano-Portuguesa, Barcelona, Spain) was done at the end of each milking.

4.1.2. Experimental design

The experimental design consisted of 2 × 2 factorial (breed × treatment) to which the ewe groups were randomly allocated (Table 3). Treatments were: unshorn (US) and shorn (SH) during milking. The US group was not shorn from the previous year and the SH group was sheared at mid of February (16 February).

Ewes were allocated in 8 balanced groups of 6 animals according to breed, age (4 multiparous and 2 primiparous in each group), body weight (BW), body condition score (BCS) and milk yield from the previous lactation, to which the experimental treatments were applied. Experimental groups are summarized in Table 5.

Table 5. Experimental groups of dairy ewes according to treatment1 and breed.

Group	Breed	Treatment[1]	Ewes, n
1, 2	Manchega	US	12
3, 4		SH	12
5, 6	Lacaune	US	12
7, 8		SH	12

[1] US, unshorn or control ewes; SH, shorn ewes during lactation.

4.1.3. Sampling, procedures and analyses

4.1.3.1. Voluntary feed intake measurement in groups

Voluntary dry matter intake (DMI) was determined from group data (6 ewes). An adaptation period to the experimental conditions (group and diet) was applied during 4 weeks before shearing (January 15to February 16 of 2015) and the measurement period was performed 3 weeks after shearing (February 16 to March 5 of 2015).

Alfalfa hay offered ad libitum per group was weighed daily to determine total DMI (tDMI) which was used to calculate the individual average of dry matter intake (aDMI) by dividing the total group intake by the number of ewes (n = 6)in each group, according to the expression:

$$aDMI = tDMI/n$$

4.1.3.2. Individual feed intake measurement by using Poly-ethyleneglycol

Poly-ethyleneglycol 6000 (PEG) was used as indigestible external marker for the estimation of individual DM intake (iDMI), according to Landau et al. (2002) and Hassoun et al. (2007), with the adaptations proposed for dairy ewes by Caja et al. (2009).

After 2 week of adaptation to the diet, each ewe received 50.0 ± 0.2 g/d of PEG 6000 (Panreac, MolletdelVallés, Barcelona, Spain) for five weeks (2 week before and 3 week after shearing). The PEG was offered as a powder (by milling ~1 mm diameter), in 2 daily doses of approximately 25 g, mixed with the concentrate offered in the milking parlor (07:00 and 17:00 h).

Feces were sampled directly from rectum twice a day (08:00 and 18:00 h) from each ewe during 6 d (2 d before and 4 d after shearing). Feces were frozen for posterior analysis.

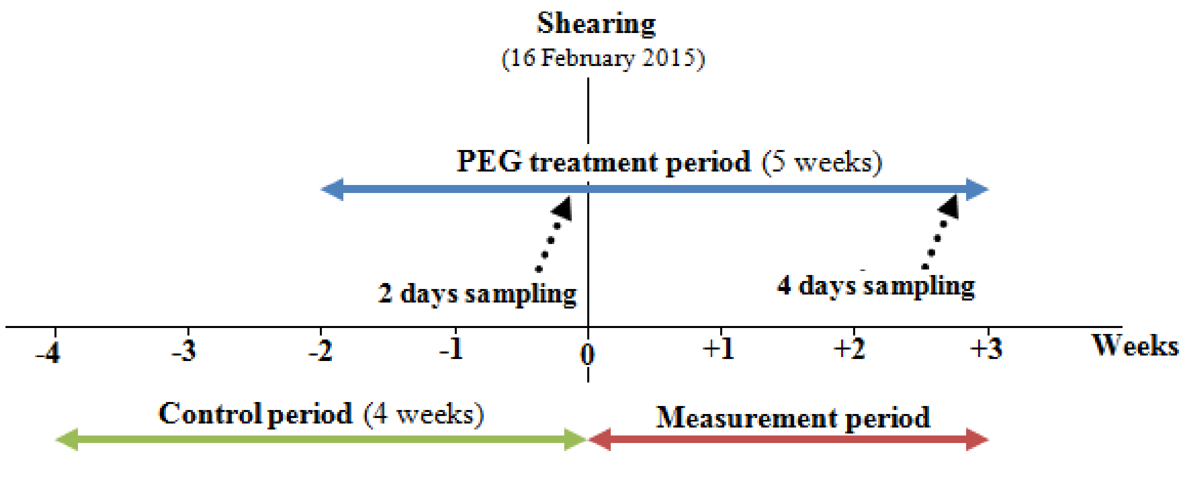


Figure 6. Experimental periods.

The fecal samples were used for producing 2 composites per ewe for each experimental periods. Composites were dried (forced-air oven, 60°C for 48 h), ground through a 1 mm sieve and stored at room temperature until PEG analysis.

4.1.3.3. Feces analysis

For PEG analysis, samples were conditioned at 40°C for 1 h and scanned in duplicate in a near infrared spectrophotometer (Foss NIRSystems 5000, Foss, Hillerod, Denmark) using a 1 to 12% PEG 6000 calibration according to Caja el al. (2009) to determine fecal concentration of PEG.

Individual fecal DM output per ewe and day (iDMF) was calculated from fecal concentration of PEG ([Fecal PEG]) through the equations:

$$\text{PEG intake (g)} = \text{PEG fecal (g)}$$

$$\text{PEG fecal (g)} = \text{iDMF (g)} \times [\text{Fecal PEG}]i$$

$$\text{iDMF (g)} = \text{PEG intake (g)} / [\text{Fecal PEG}]i$$

Intake partitioning between ewe fed in the same group was calculated assuming that DM digestibility (dDM) of the diet for each group was, on average, the same that for the individual animals:

$$dDM = (DMI - DMF) / DMI$$

$$dDM = 1 - DMF / DMI$$

$$dDM = 1 - \Sigma\, iDMF / tDMI$$

$$dDM = 1 - iDMF / iDMI$$

$$iDMI = iDMF / (1 - dDM)$$

Given that, dDM was assumed as constant for all the animals in the same group, tDMI partitioning can be directly calculated from the tDMF partitioning without knowing the value of dDM, being:

$$iDMI = tDMI \times (iDMF / \Sigma iDMF)$$

4.1.3.4. Feed analyses

Dry matter (DM) was determined by gravimetry, desiccating the sample in an air-forced stove at 103ºC for 24 h. Organic matter (OM) content was measured gravimetrically by putting samples in a muffle furnace at 550ºC for 4 h (AOAC, 1990).

Total N was determined by the Dumas method (AOAC) using a Leco analyzer (Leco Corporation, St. Joseph, Michigan, USA), and crude protein (CP) was calculated as N × 6.25.

Crude fiber (CF) was analyzed according to AOAC (1990), and neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined adding amylase and sodium sulphite solutions according to Van Soest et al. (1991), on ash-free basis, using an Ankom200 Fiber Analyzer incubator (Ankom Technology, Macedon, New York, USA).

Ether extract (EE) was analyzed by the Soxhlet method (AOAC) using aSoxtec2055 Fat Extraction System (Foss Analytical, DK-3400 Hillerod, Denmark).

4.1.3.5. Milk yield

Milk yield of individual ewes was recorded daily during the whole experiment period by using the MM25SG milk flow and recording units of the milking parlour. Data were daily uploaded by using the AlPro software (DeLaval, Tumba, Sweden) and then they were weekly reviewed and saved in a previously designed Excel (Microsoft) spread sheet.

4.1.3.6. Milk composition

Representative milk samples (100 mL) of the day were taken before shearing (d −3) and after shearing (d+3, +5, +7 and+15) for the compositional analysis. Milk samples were composited with 60 mL from the morning and 40 mL from the afternoon milkings, according to the milking interval, and preserved with an antimicrobial tablet (Bronopol, Broad Spectrum Micro-tabs II, D&F Control Systems, San Ramon, California, USA) and stored at 4°C until analysis.

Unhomogenized milk samples were analyzed using a near infrared spectrometer (Foss Electric, Nordersted, Germany) for the content of total solids (TS), fat, crude protein (CP) (N×6.38), true protein (TP) and casein (CN) according with Albanell et al. (1999). Calibrations were performed using data obtained by conventional methods including Gerber method for fat, Kjedahl for nitrogen and oven-drying at 103ºC for total milk solids content.

Duplicated samples (100 mL/ewe) were also analyzed in the Dairy Herd Improvement Laboratory of Catalonia (Allic, Cabrils, Barcelona, Spain) using an automatic cell counter (Fossomatic 5000, Foss Electric, Hillerod, Denmark) to determine somatic cells count (SCC).

4.1.3.8. Body weight and condition

Body weight (BW) and body condition score (BCS) of all ewes were evaluated at d –15, 0 and +15. Weighing was performed using a digital scale (Tru-test A6500, Auckland, New Zealand)interfaced with an electronic identification reading system consisting of a stationary transceiver (F-210, Rumitag, Espluges de Llobregat, Barcelona, Spain). The BCS of the ewes were also estimated at the same time according to Russell et al. (1969).

Additionally, the degree of wool extension in the fleece was evaluated subjectively in all ewes by a 3 points scale (accuracy, 0.5 points), being: 1 = open, 2 = medium, and 3 = extended.

4.1.3.9. Blood measures

Blood samples were taken at d–7, +3, +7 and +15 from the jugular vein into 10 mL BD vacutainer tubes with sodium heparin 170 IU (BD, Belliver Industrial Estate, Plymouth, UK) before the morning feeding. Plasma was obtained by centrifugation of whole blood for 15 min at 2,000 ×g and stored at –20°C for glucose, NEFA, insulin, cortisol and IGF-1 analyses.

The insulin was measured by ELISA type sandwich using the commercial kit (Mercodia Ovine Insulin ELISA, Mercodia, Switzerland).The glucose was determined by hexokinase method (OSR 6121, Reagent System Olympus, Beckman Coulter, Ireland).

The equipment used to make these determinations is the Olympus AU400 analyzer (Olympus Europa, Hamburg, Germany). The cortisol was measured by ELISA type competitive using the commercial kit (Salivary Cortisol ELISA, DRG Instruments, Marburg, Germany). The reader used for ELISA analysis was EMS Reader MF V.2.9-0. The NEFA were determined by the colorimetric enzymatic test ACS-ACOD method using a commercial kit (Wako Chemicals, Neuss, Germany). The IGF-1 was measured by ELISA technique using the commercial kit (MyBioSource, insulin-like growth factor (IGF1) ELISA Kit, San Diego, California, USA), the results of the IGF-1 analysis were below the detection range (0.75 to 60 ng/ml) and were eliminated.

4.1.3.10. Rectal and environmental temperatures

Rectal temperature was recorded at d–1, +1, +3, +7 and +15 using a digital clinical thermometer (Model ICO Technology "mini color", Barcelona, Spain; range, 32 to 43.9°C; accuracy, ± 0.1°C).

Data of environmental temperature and humidity were recorded every 10 min throughout the experiment by using an automatic data logger (Opus 10, Lufft, Fellbach, Germany).

4.2. Experiment 2

4.2.1. Measurement of the fill value (FV) of the forage used in the experiment

A total of 12 dry ewes (Manchega, n = 6, 74.1 ± 3.8 kg BW; Lacaune, n = 6, 71.1 ± 5.5 kg BW) were used. All ewes wore plastic ear tags and ceramic rumen mini-boluses for visual and electronic identification, respectively, as previously indicated for the lactating ewes.

The experimental period lasted 6 weeks (25 January to 5 March 2015) in which the voluntary DMI of the same alfalfa hay used in the lactating ewes was evaluated. Body weight and BCS score of all ewes were evaluated at the beginning and the end of the experimental period, as previously indicated.

By definition, 1 kg DM of the reference forage in the INRA system (INRA, 1988) has a filling value (FV) of 1 FU (Fill Unit). The reference forage is a standard hay from a natural pasture cut at a grazing stage of first growth (average composition: 15% CP and 25% CF), having an organic matter digestibility in sheep dMO = 0.77, and a net energy value for lactation of NE_L= 0.95 UFL/kg DM (1.62 Mcal NE/kg DM).Voluntary intake of the reference forage measured on Texel whether of 90 kg BW individually penned indoors is 2.19 kg DM (75 g DM/kg $BW^{0.75}$).

Based on the data above mentioned, the FV of any forage for sheep may be calculated as:

$$\text{FV sheep} = 75/\text{g DM per kg BW}^{0.75}$$

The INRA system proposed a single expression for ingestibility by defining the "*Unités Encombrement mouton*" (UEm) or sheep fill units (FUs). Each forage has a single FV and each type of animal has a single value for the intake capacity (IC). For a given feed and type of animal, when the feed is given alone and adlibitum (105 to 115% allowance), the two values are related as followed (Dulphy et Demarquilly, 1994):

$$\text{DMI} = \text{IC (intake capacity of the animal in FU)/FV (forage filling value in FU)}$$

This expression was used to calculate the FV of the amount of forage (F) ingested under ad libitum conditions and to calculate the substitution (S) effect of the amount of concentrate (C) administered (and fully consumed)on the intake capacity of the ewes estimated according to INRA (2010), being:

$$\text{IC} = \text{F} \times \text{FV forage} + \text{C} \times \text{FV concentrate}$$

$$\text{S} = \text{FV concentrate/FV forage}$$

$$\text{IC} = \text{F} \times \text{FV forage} + \text{C} \times \text{S} \times \text{FV forage}$$

$$\text{IC (FU/d)} = 0.024 \times \text{BW (kg)} + 0.9 \times \text{ECM (L/d)}$$

$$\text{S} = 3.35 - 2.3 \times \text{FV forage}$$

4.1.3.11. Statistical analyses

Data were analyzed by the PROC MIXED for repeated measurements of SAS (v. 9.1.3, SAS Institute Inc., Cary, NC, USA). The statistical mixed model contained the fixed effects of the treatment (unshorn vs. shorn), the random effect of the animal, and the standard error.

In the analysis of performances (i.e., feed intake, milk yield and milk composition), physiological indicators (i.e., rectal temperature), metabolic (glucose, NEFA) and hormonal (cortisol, insulin) plasma values, the measurements taken before shearing were used as covariates. Significance was declared at $P < 0.001$, $P < 0.01$ and $P < 0.05$ and tendency at $P < 0.10$.

The model was:

$$Y_{ijkl} = \mu + S_i + T_j + S \times T_{ij} + A_k + \varepsilon_{ijkl}$$

Being,

Y_{ijkl} = dependent variable,

μ = overall mean,

S_i = shearing treatment fixed effect (i = SH and C),

T_j = time fixed effect (j = –7, –3, –1, +1, +3, +5, +7 and +15),

$S \times T_{ij}$ = interaction between shearing treatment and time

A_k = individual animal's random effect (k = 1 to 48),

ε_{ijkl} = residual error effect.

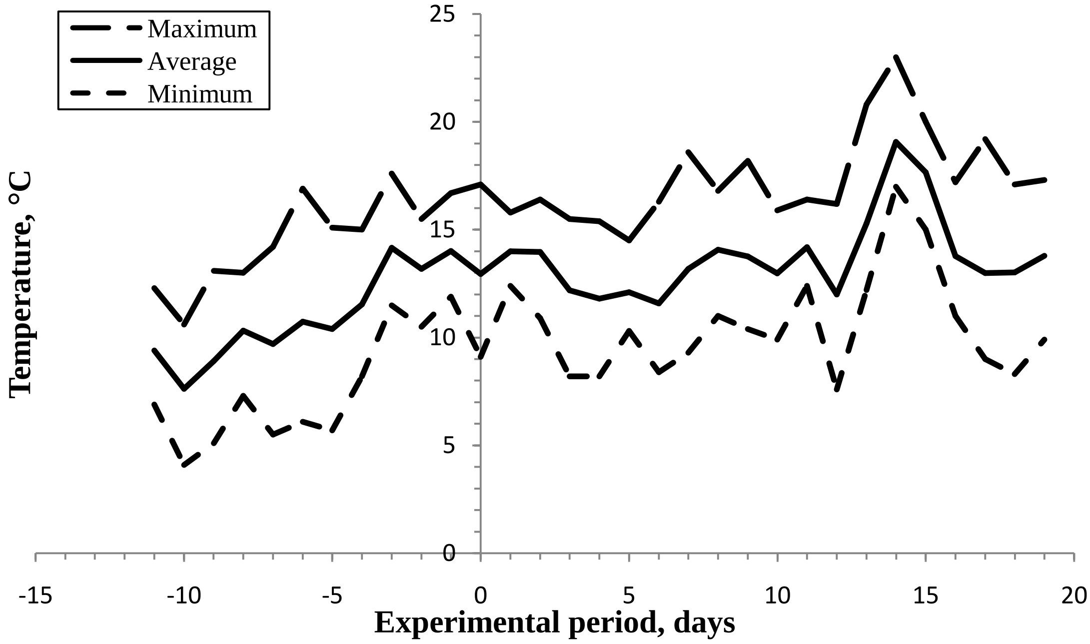
Results and Discussion

5. Results and Discussion

5.1. Experimental conditions

Changes ambient temperatures recorded inside and outside the sheep barn during the whole experimental period are shown in Figures 7a and 7b.

a) Indoor temperatures:



b) Outdoor temperatures:

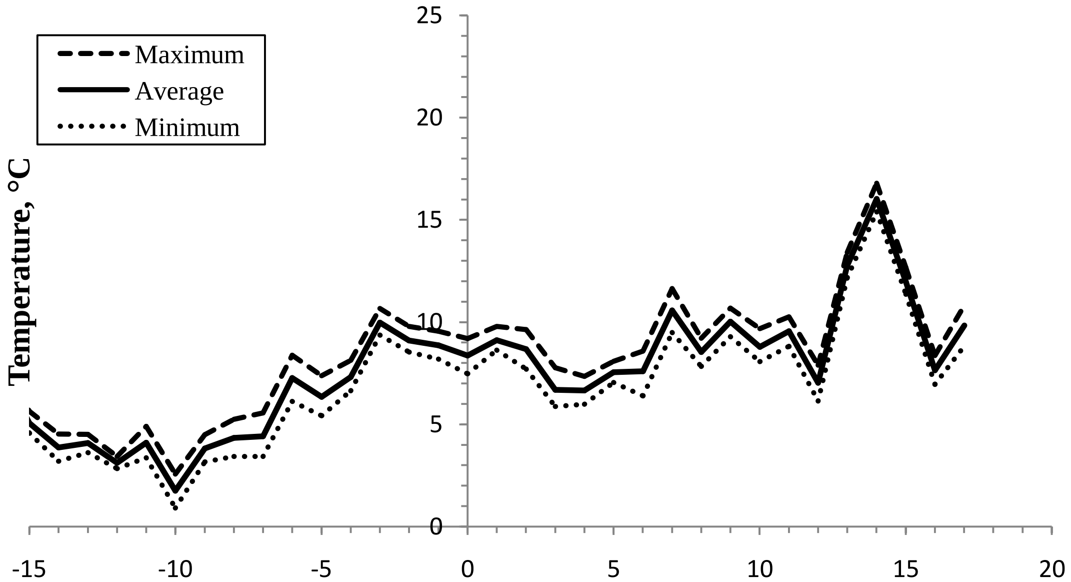


Figure 7. Ambient temperatures before and after shearing.

Outdoor temperatures were quite stable in the days immediately before and after shearing, although it increased and piked around d 14 after shering. On average, the environmental temperatures in the shelter (with open windows in the west wall next to the ewe's pens) during the period before (12.6 ± 0.9ºC) and after (13.0 ± 0.3ºC) shearing, were mild and related to the mild winter temperatures observed outside the barn during the same period (Figure 7b).

The extreme mean temperatures, to which the ewes were submitted after shearing inside the barn, ranged between the minimum (on average, 8.8 ± 0.5ºC) and maximum (on average, 15.8 ± 0.4ºC). Both extremes were below the critical lower temperatures of the thermoneutral zone as reported by Graham et al. (1959) for shorn sheep fed at different levels. Heat production of the sheep was minimal at 39-40°C for the lowest feeding level, at 33°C for the medium feeding level, and 24-27°C for the highest feeding level (Graham et al., 1959). Consequently, it is reasonable to assume that our shorn ewes were under cold stress at the recorded temperatures.

Clipped fleece weight was greater in shorn MN than LC (1.04 ± 0.10 vs. 0.75 ± 0.09 kg/ewe; $P < 0.05$; Figure 8). Moreover, fleece was also more extended in MN than LC ewes, as indicated by the subjective wool index of the ewes before applying the shearing treatments (Figure 9). So, we expected to produce a greater cold stress in the MN ewes, when compared to the LC ewes that were less covered and protected by the fleece.

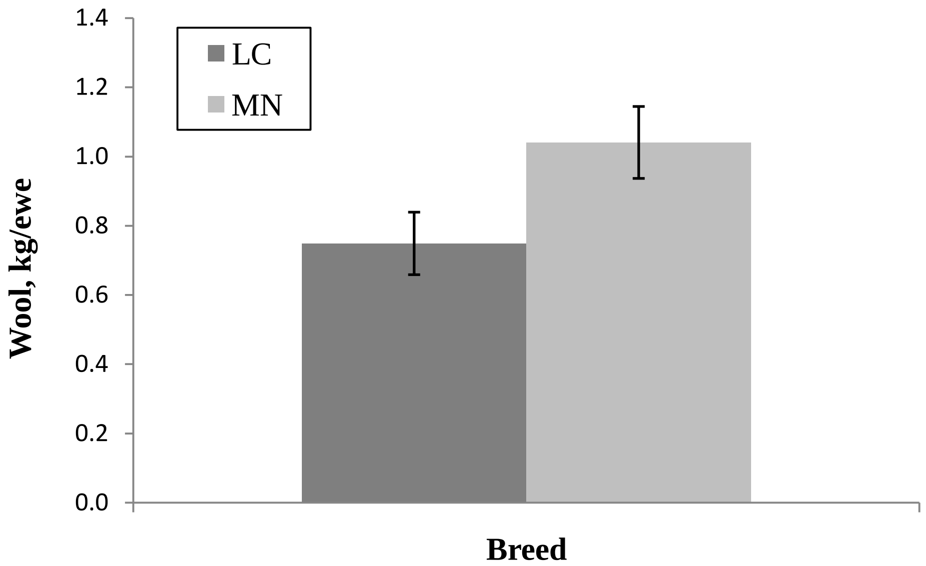


Figure 8. Wool production (mean ± SEM) in the experimental ewes.

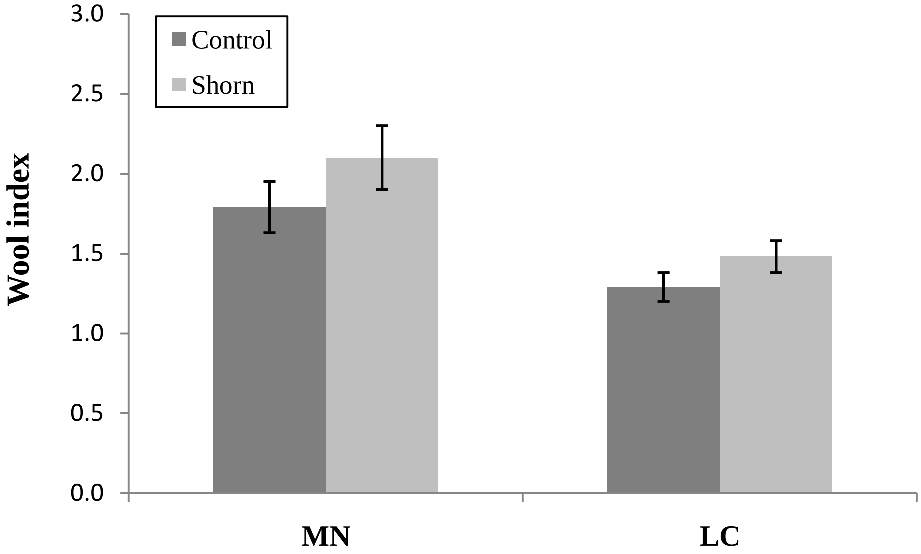


Figure 9. Fleece extension as estimated by the wool index (1, open; 2, medium; 3, extended) in the experimental groups before shearing (MN, Manchega; LC, Lacaune).

According to the expected differences in cold stress induced by the removal of the fleece, we observed a different response to shearing in the recorded rectal temperatures after shearing according to breed ($P < 0.001$). So, in the case of the MN-SH ewes, rectal temperature decreased 0.27°C when compared to MN-C ewes (38.51 ± 0.06 vs. 38.88 ± 0.06°C; $P < 0.001$), whereas LC ewes did not shown appreciable difference in rectal temperature between shearing treatments (38.56 ± 0.08 vs. 38.58 ± 0.08°C; $P = 0.885$).

Our results in MN breed are consistent, but smaller with regard to the observed rectal temperature drop, with those earlier reported by Aleksiev (2007) that observed a significant decrease in the rectal temperature of shorn wool ewes during the two months following shearing during winter. Moreover, Leibovich et al. (2011) also reported that shearing pregnant Assaf ewes with cooling ambient during lactation, decreased their rectal temperature by 0.2°C, similar to our results, when compared with the control ewes. However, in contrast to these results, Piccione et al. (2002) reported that shearing increase the rectal temperature of the shorn sheep which can be a result of stress induced hyperthermia.

5.2. Voluntary feed intake

On average, total dry matter intake (Table 7 and Figure 10) was significantly affected by the shearing treatment in the LC ewes despite the evaluation methodology used (group vs. individual). Intake values were similar The LC-SH ewes increased 5% (P < 0.01) their voluntary feed intake when compared to LC-C ewes. These results agreed with those of Ruiz et al. (2008), who found an increase in dry matter intake in lactating Latxa dairy ewes shorn during winter. The increase in intake found under our experimental conditions could be the result of an increased energy requirements linked to cold stress resulting from shearing.

Some authors noticed that an increase in feed intake may not be evident until a few weeks after shearing (Dabiri et al., 1996). With this regard, Hawker et al. (1985) did not observe differences in intake caused by the absence of fleece in a trial performed in spring under mild climatic conditions.

On the contrary, in our study, no difference was observed in the feed intake of MN ewes as a result of the experimental treatments (P > 0.05; Table 7).

Moreover, according with their milk yield, there were differences in intake between MN and LC ewes. On average, LC ewes had 13% greater voluntary feed intake than MN ewes before and after the shearing treatment (2.78 ± 0.03 vs. 2.47 ± 0.03 kg/d, respectively; P < 0.001).

Estimated substitution rate of the concentrate was, on average, high (1.12 ± 0.29) which agreed with the low fill value of the alfalfa hay used, as later discussed.

5.3. Physiological indicators

Results of blood metabolites and hormones of the dairy ewes measured during the experimental period, according to breed and shearing treatment, are shown in Table 7. Despite de lack of general differences observed in the physiological indicators (glucose, NEFA, insulin and cortisol) in the LC ewes during the experiment (P > 0.05), a 3% increase (P < 0.05) in the glucose concentration of the MN-SH ewes when compared to MN-C ewes. This increase agrees with the decrease in rectal temperature of the MN-SH ewes and with the expected increase in the concentration of blood glucose reported in ewes subjected to cold stress (Thompson, 1982). No differences between treatments (*P* > 0.05) were detected in the case of the LC ewes which did not show change of rectal temperature.

Table 6. Effect of shearing on the lactational performances of dairy ewes.

Breed	Item	Treatment		SEM	Effect	
		Control	Shorn		%	*P* <
LC[1]	DMI, kg/d					
	Group	2.67	2.80	0.03	5	0.005
	Individual[3]	2.71	2.83	0.11	-	0.449
	Milk yield, kg/d	1.32	1.45	0.04	10	0.025
	ECM[4], kg/d	1.32	1.44	0.08	-	0.246
	Fat yield, g/d	93.8	101.4	7.21	-	0.412
	Protein yield, g/d	70.1	83.8	3.02	20	0.004
	Lactose yield, g/d	57.7	67.7	2.54	17	0.012
	Fat, %	6.89	6.65	0.22	-	0.401
	Protein, %	5.80	5.74	0.06	-	0.495
	Lactose, %	4.52	4.58	0.04	-	0.338
	SCC[5], Log	5.44	5.15	0.11	-	0.086
MN[2]	DMI, kg/d					
	Group	2.42	2.46	0.02	-	0.387
	Individual	2.44	2.47	0.08	-	0.799
	Milk yield, kg/d	0.76	0.71	0.03	-	0.261
	ECM, kg/d	0.96	0.88	0.04	-	0.142
	Fat yield, g/d	69.6	67.9	3.82	-	0.745
	Protein yield, g/d	50.9	48.8	2.69	-	0.579
	Lactose yield, g/d	34.8	32.0	1.78	-	0.289
	Fat, %	8.98	9.14	0.18	-	0.514
	Protein, %	6.50	6.59	0.10	-	0.545
	Lactose, %	4.56	4.39	0.05	–4	0.032
	SCC, Log	5.11	5.33	0.09	-	0.105

[1:]Lacaune; [2:]Manchega; [3:]Estimated by using polyethylene glycol; [4]Energy corrected milk; [5]Somatic cell count.

According to Carcangiu et al. (2008), cortisol concentration in blood showed that shearing procedures in Sarda ewes caused severe acute stress. Plasma levels of glucose rose in shorn ewes (Carcangiu et al., 2008), the rise being directly proportional to the level of cortisol and attributed to the hyperglycemic effect of this hormone which stimulates the sympathetic-adrenergic axis and increases the glucose production in the liver (gluconeogenesis).

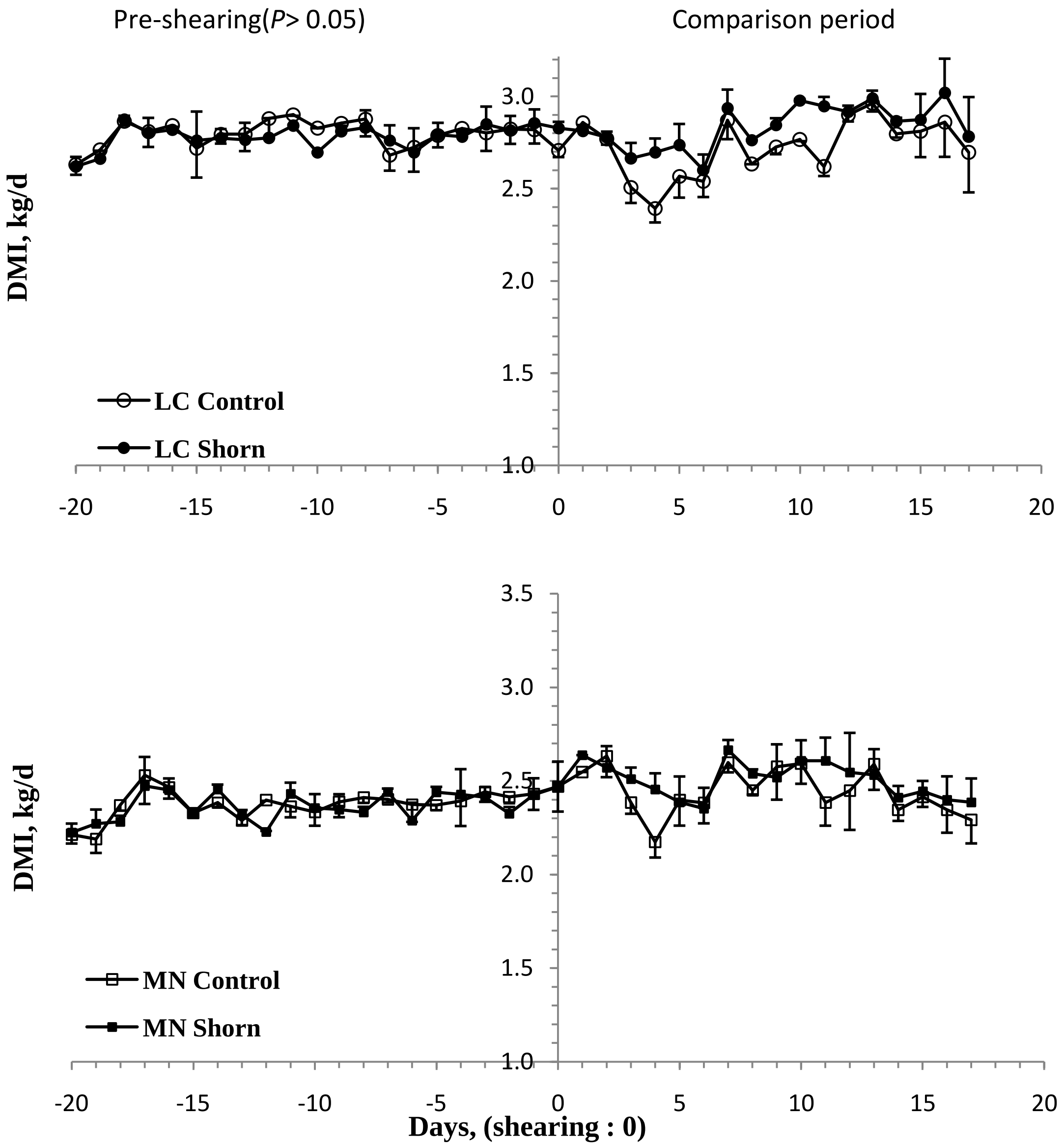


Figure 10. Voluntary feed intake before and after shearing treatments in MN and LC breed.

Table7. Effect of shearing on blood metabolites and hormones.

Breed	Item	Shearing		SEM	Effect	
		Before	After		%	*P* <
LC	Insulin, µg/L	0.43	0.44	0.08	-	0.893
	Cortisol, ng/ml	6.54	5.41	0.74	-	0.293
	NEFA[1], mmol/L	0.125	0.095	0.014	-	0.119
	Glucose, mg/dL	65.7	66.2	1.11	-	0.765
MN	Insulin, µg/L	0.34	0.40	0.05	-	0.388
	Cortisol, ng/ml	5.64	3.81	1.13	-	0.268
	NEFA[1], mmol/L	0.115	0.100	0.008	-	0.172
	Glucose, mg/dL	63.2	65.2	0.66	3	0.050

[1:] Non esterified fatty acid.

5.4. Milk yield

Results of milk yield of the dairy ewes measured during the experimental period, according to breed and shearing treatment, are shown in Table 6. On average, LC ewes produced more milk during the experimental period than MN ewes (1.39 ± 0.07 vs. 0.74 ± 0.07 kg/d, respectively; $P < 0.001$). The differences between MN and LC agreed previously reported data by Rovai et al. (2008) and Castillo et al. (2008).

Despite de lack of differences observed in milk yield of the MN ewes by the experimental treatments ($P > 0.05$), a response to shearing during lactation was observed in the LC ewes, the LC-SH ewes increasing milk yield 10% ($P < 0.05$), when compared to LC-C ewes. In the case of the MN ewes, the MN-C ewes were numerically ($P < 0.15$) more productive than the MN-SH as a result of the increase of milk yield immediately after shearing (Figure 11).

Our results agreed, in the case of LC ewes, with those of Cam and Kuran (2004) and Sphor et al. (2011), which reported an increase in milk yield of the ewes shorn in winter, when compared to unshorn ewes (Table 2). On the other hand, Aleksiev (2008), Ruiz et al. (2008) and McBride et al. (1984) did not found an increase in milk yield of shorn ewes, when compared to unshorn ewes, agreeing our results in the case of the MN ewes. The controversial results with some of the references may be consequence of the methodology used, some of them obtained in meat ewes in which milk yield was estimated by milking after injecting oxytocin, whereas in the present study milk was measured directly by milking.

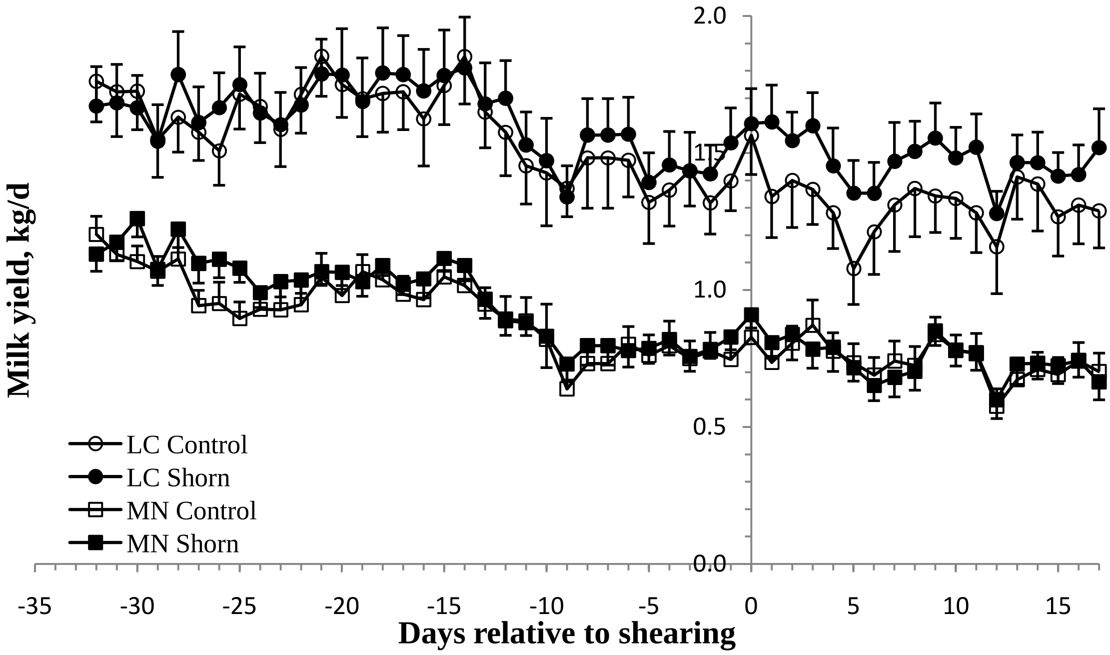


Figure 11. Milk yield (kg/d) before and after shearing treatment.

On the other hand, when comparing the results in the LC and MN, it should be taken into account that the MN ewes are lower milk yielders and adapted to extreme climate conditions than LC ewes.

5.5. Milk composition

There were no differences in milk composition between shearing treatments in both breeds throughout the experimental period (Table 6). Nevertheless, milk protein and lactose yields were also higher for shorn than control LC ewes breed (20% at $P < 0.01$; and, 17% at $P < 0.05$; respectively), but MN ewes did not shown any differences between shearing treatments ($P > 0.05$). No negative effects of the shearing treatment were observed for milk composition in both breeds. These results are not consistent with earlier findings reported by McBride et al. (1984), Knight et al. (1993) and

Leibovich et al. (2011) who found that shearing treatment improve the milk fat content 26.4, 14.9 and 14.0%, respectively (Table 2).

As expected, milk composition differences (MN vs. LC, respectively) were detected by breed (P < 0.001) for milk fat (8.92 ± 0.22 vs. 6.94 ± 0.22%; P < 0.001) and milk protein (6.86 ± 0.15 vs. 5.81 ± 0.15%; P < 0.001). On the other hand, lactose content did not vary by breed, being 4.49 ± 0.07%, on average. These results agreed with those of Castillo et al. (2008) who also found differences in milk composition between both breeds, except for lactose.

5.6. Experiment 2

5.6.1. Fill value (FV) of the forage used in the experiment

Evolution of the average dry matter intake (aDMI) values of experimental forage of Manchega and Lacaune dry ewes recorded daily during the experimental periods are shown in Figure 12.

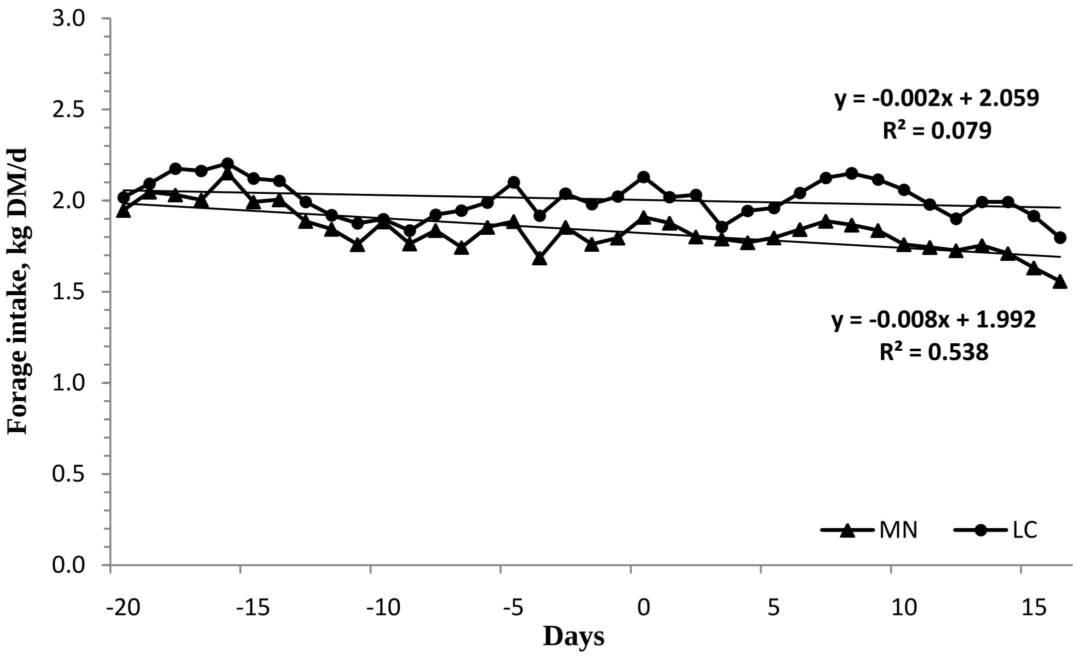


Figure 12. Forage intake of dry ewes fed in groups according to breed during the experimental period (Manchega, ▲; Lacaune, ●).

Intake curves of the dry ewes fed in group showed a slow decrease during the experimental period (2 and 8 g DM/d en LC and MN, respectively) consequence of the moderate increase of body weight and body condition scores (Table 8). A small difference between breeds was detected (MN vs. LC: 1.84 ± 0.06 vs. 2.01 ± 0.00 kg DM/d; $P < 0.05$). Ambient temperatures were mild (12.7 ± 0.5ºC) and similar to those of the dairy ewes during the experimental period.

Table 8. Fill value of experimental forage in dry Manchega and Lacaune ewes fed in groups during the control period.

Item		Breed	
		Manchega	Lacaune
Ambient temperature, °C		12.7 ± 0.53	
Ewes, n		6	6
BW, kg	Before	67.9 ± 4.5	74.8 ± 2.39
	After	69.4 ± 4.4	75.8 ± 3.63
BCS[1]	Before	3.13 ± 0.27	3.00 ± 0.19
	After	3.38 ± 0.20	3.25 ± 0.12
Intake, kg DM/d	Before	1.88	2.01
	After	1.79	2.01
	Mean	1.84 ± 0.06	2.01 ± 0.00
Intake, g DM/kg $BW^{0.75}$	Before	79.5	79.0
	After	74.4	78.2
	Mean	77.0 ± 3.6	78.6 ± 0.6
Fill value, SFU[2]/kg DM			
	Before	0.95	0.95
	After	1.01	0.96
	Mean	0.98 ± 0.04	0.96 ± 0.01

[1]Body condition score (1 to 5); [2]Sheep fill units.

On average, daily aDMI was 9% greater ($P > 0.05$) in LC than MN ewes, the difference between breeds beings smaller (2%) when the data were expressed by metabolic weight. The obtained SFU value for the alfalfa hay used was low, indicating a high ingestibility close to the INRA's forage of reference, and the difference not being significant between MN and LC breeds (0.98 ± 0.04 vs. 0.96 ± 0.01 UEm/kg DM; respectively; $P >$ 0.05; Table 8) and between experimental periods.

Conclusion

6. Conclusion

In conclusion, the results of the present study show that shearing high yielding dairy ewes, like LC sheep, during the milking period increases feed intake and lactational performances (milk yield, protein and lactose yield) in the shorn ewes. In the case of MN ewes, no differences were detected neither in feed intake nor lactational performances after shearing.

There were differences in intake, milk yield and milk composition between breeds, the LC ewes eating and yielding more milk than the MN ewes, but the MN ewes showing richer milk. There were no differences in milk composition by effect of shearing treatments during the milking period. So, despite the shorn lactating LC ewes producing more milk, their milk composition was not degraded.

On the other hand, no differences in physiological indicators were found between shearing treatments in both sheep breeds.

Therefore, shearing dairy ewes at milking period under moderate cold conditions, can be a suitable management option for improving feed intake, milk yield, protein yield and lactose yield of high yielding ewes, without deleterious effects on physiological indicators and without impairing milk quality.

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