CIHEAM
Options Méditerranéennes

# Grazing: an alternative for low-yield barley crops

**Olmos G., Keli A., Vega A. de, Delgado I., Guada J.A.**

*in*

**Ranilla M.J. (ed.), Carro M.D. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.).**
**Challenging strategies to promote the sheep and goat sector in the current global context**

**Zaragoza : CIHEAM / CSIC / Universidad de León / FAO**
**Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 99**

**2011**
pages 23-29

**Article available on line / Article disponible en ligne à l'adresse :**

---

http://om.ciheam.org/article.php?IDPDF=801531

---

**To cite this article / Pour citer cet article**

---

Olmos G., Keli A., Vega A. de, Delgado I., Guada J.A. **Grazing: an alternative for low-yield barley crops.** In : Ranilla M.J. (ed.), Carro M.D. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.). *Challenging strategies to promote the sheep and goat sector in the current global context.* Zaragoza : CIHEAM / CSIC / Universidad de León / FAO, 2011. p. 23-29 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 99)

---

CIHEAM

http://www.ciheam.org/
http://om.ciheam.org/

# Grazing: an alternative for low-yield barley crops

**G. Olmos*, A. Keli*, A. de Vega*, I. Delgado** and J.A. Guada***

*Departamento de Producción Animal y Ciencia de los Alimentos, Universidad de Zaragoza, Miguel Servet 177, 50013 Zaragoza (Spain)
**Centro de Investigación y Tecnología Agroalimentaria, Carretera de Montañana 930, 50059 Zaragoza (Spain)

**Abstract.** An experiment was performed to evaluate the nutritive value of vitreous-grain barley grazed by sheep (instantaneous stocking rate of 66 sheep/ha). Available biomass (2353 kg dry matter (DM)/ha, on average) was determined at the beginning of the experimental period, which lasted for three consecutive weeks, and barley heads, leaves and stems were separated for quantification. Important amounts of Wimmera ryegrass (*Lolium rigidum*) were also found. Diet selection, intake and digestibility were estimated using the *n*-alkanes technique. Rumen fermentation characteristics and *in situ* degradation parameters were obtained from rumen cannulated animals. Transit kinetics of barley heads, leaves and stems was also assessed. The proportion of barley heads in the diet consumed was high (0.53 on average) and varied along the grazing period (0.30 in the first, 0.64 in the second and 0.65 in the third week). Wimmera ryegrass was highly selected during the first week of the experimental period (0.7) and much lesser afterwards (0.35). Estimated total DM intake was low (428, 376 and 657 g/day for weeks 1, 2 and 3, respectively), and changed with the botanical composition of the paddock and biomass availability. Average DM digestibility of the diet consumed was also low (56%) and decreased as the grazing period advanced (67%, 55% and 47% for weeks 1, 2 and 3, respectively). Rumen pH was, on average, 6.6, whereas ammonia concentration reached a value of 93 mg/l. Proportions of acetic (0.65), propionic (0.15) and butyric (0.15) acids were representative of a rumen environment driven by fibre fermentation. Effective DM degradability of barley heads, leaves and stems was, on average, 81%, 66% and 55%, respectively.

**Keywords.** Barley – Vitreous grain – Grazing – Sheep.

***Pâturage: une alternative pour la cultures d'orge à faible rendement***

***Résumé.*** *Un essai a été mené pour évaluer la valeur nutritive de l'orge en stade de grain vitreux pâturé par les ovins (taux de charge animale instantanée de 66 brebis/ha). La biomasse disponible (2353 kilogrammes de matière sèche (MS)/ha, en moyenne) a été déterminée au début de la période expérimentale, qui a duré trois semaines consécutives, et les épis, les feuilles et les tiges de l'orge ont été séparés pour leur quantification. Des quantités importantes d'ivraie raide (*Lolium rigidum*) ont été également rencontrées. Le choix alimentaire, les quantités ingérées et la digestibilité du régime ont été estimés en utilisant la technique des n-alcanes. Les caractéristiques de fermentation ruminale et les paramètres de dégradation* in situ *ont été obtenues en utilisant des animaux canulés dans le rumen. La cinétique de passage des épis, des feuilles et des tiges d'orge a été également évaluée. La proportion des épis d'orge dans le régime consommé était élevée (0,53 en moyenne) et variait le long de la période de pâturage (0,30, 0,64 et 0,65 pendant la première, la deuxième et la troisième semaine respectivement). L'ivraie raide a été fortement choisie pendant la première semaine de la période expérimentale (0,7) et beaucoup moins après (0,35). Les quantités ingérées estimées de MS étaient faibles (428, 376 et 657 g/j pendant la 1ère, 2ème et 3ème semaine, respectivement), et changeaient avec la composition botanique et la disponibilité de la biomasse. La digestibilité moyenne de MS du régime consommé était également faible (56%) et diminuait avec la progression de la période du pâturage (67%, 55% et 47% durant la 1ère, 2ème et 3ème semaine, respectivement). Le pH ruminal était, en moyenne, de 6,6, tandis que la concentration en ammoniaque atteignait une valeur 93 de mg/l. Les proportions d'acide acétique (0,65), propionique (0,15) et butyrique (0,15) étaient représentatives d'un milieu ruminal propice d'une fermentation cellulolytique. La dégradabilité effective de la MS des épis, des feuilles et des tiges d'orge était, en moyenne, 81%, 66% et 55%, respectivement.*

***Mots-clés.*** *Orge – Grain vitreux – Pâturage – Ovins.*

## I – Introduction

The cultivation of winter cereals for grain and by-products is one of the most important farming practices in the Mediterranean basin, barley being the crop to which more surface is allocated to in Spain (3.5 $10^6$ ha in 2007, mainly without irrigation; *http://www.ine.es/*). However, production costs are high and dry matter (DM) production varies dramatically depending on rainfall and frequent plagues. The consequence is often a negative profit margin, and hence the direct consumption by ruminants as summer pasture has been suggested (Vallentine, 1990).

The nutritive evaluation of this resource for sheep has been carried out in terms of stocking rate (Valiente, 2004). However, there is still a lack of information about diet selection, intake, digestibility, transit kinetics and rumen fermentation characteristics. The aim of the present paper was then to collect data to assess the nutritive value of whole crop barley for grazing sheep.

## II – Materials and methods

The study was carried out in July-September 2002, on 1.33 ha of vitreous-grain barley divided in four homogeneous paddocks, two for the experiment and the other two as feed reservoir. An instantaneous stocking rate of 66 non-pregnant, non-lactating sheep/ha (average live weight of 60±8.0 kg) was used for each of the two experimental paddocks. After one week of adaptation to the diet in reservoir paddocks, animals were randomly allocated to the experimental paddocks and a grazing period of three weeks was allowed. Only six out of the 22 animals within each paddock were used for estimations of diet selection, intake and digestibility. Four out of these six animals were fitted with permanent ruminal cannula (5 cm ID) and were used for studies of rumen fermentation (pH and concentration of volatile fatty acids (VFA) and ammonia) and degradability of barley heads, leaves and stems. Transit kinetics of barley fractions was also assessed.

During the whole length of the experiment a once-daily dose of 1.5 g of paper pellets containing equal amounts of tetracosane ($C_{24}$), dotriacontane ($C_{32}$) and hexatriacontane ($C_{36}$) was given to each animal with a dosing gun in the morning (at 09:00 h, for 24-h clock). About 5% of the pellets were sampled and analysed for alkane concentration (Valiente *et al*., 2003). Average concentration (± SEM) of $C_{24}$, $C_{32}$ and $C_{36}$ in the dosed pellets was 60.2±4.07, 61.6±4.25 and 60.3±4.29 mg/pellet for the first week of the experimental period, 56.3±3.89, 62.6±4.27 and 62.1±4.76 mg/pellet for the second week, and 62.7±2.98, 60.2±2.94 and 58.3±3.07 mg/pellet for the third week. During the 3-week grazing period spot faecal samples were collected daily, directly from the rectum, at the same time as alkane dosing, freeze-dried and pooled, on a DM basis, to a single weekly sample per animal for analysis.

Available biomass at the beginning of the grazing period (kg DM/ha) was determined, the day prior to the introduction of the sheep in the experimental paddocks, by throwing four 0.5 $m^2$ squares per paddock and cutting the contents inside at ground level. Apart from barley, important amounts of Wimmera ryegrass (*Lolium rigidum*) were observed. After drying at 60ºC to constant weight, the material was separated by hand to calculate the contribution to the total biomass of barley heads, leaves and stems, and of Wimmera ryegrass. Grinding through a 1 mm screen was then carried out, storing the ground material in plastic bottles for further analysis. Specimens of prickly saltwort (*Salsola kali*) were also found in the paddocks, hence samples were collected for n-alkane analysis.

The live weight of the animals was registered at the beginning and the end of the experiment, and weekly during the grazing trial.

The first day of each week of the grazing trial samples of rumen liquor were obtained at 8:00, 10:00, 12:00, 14:00, 16:00, 20:00 and 8:00 h. The pH was immediately registered and aliquots were taken for VFA and ammonia analysis. The VFA concentration was determined following the

methods proposed by Jouany (1982), whereas ammonia concentration was analyzed according to the procedures described by Chaney and Marbach (1962).

*In situ* degradability of barley heads, leaves and stems was studied by incubation in polyester bags for 0, 2, 4, 8, 12, 24, 36, 48, 72 y 96 h (Mehrez and Ørskov, 1977).

Also in weeks 1 and 3 transit kinetics of barley heads (labelled with Eu-acetate) and stems (labelled with Yb-acetate) was assessed. Transit kinetics of barley leaves (labelled with Eu-acetate) was studied in the second week of the grazing period. After the infusion of the labelled materials spot faecal samples, taken directly from the rectum, were collected at 2, 4, 8, 12, 24, 36,48, 72, 96 and 120 hours and ground through a 1 mm screen for marker analysis (de Vega and Poppi, 1997).

Estimates of diet selection, intake (using the n-alkane pair $C_{31}/C_{32}$) and digestibility (with $C_{32}$ as marker) were obtained as described by Mayes *et al*. (1986). A previous discriminant analysis was performed (using the PROC DISCRIM procedure of the 8.2 SAS statistical package) to assess the n-alkanes which best discriminated among barley heads, leaves or stems, Wimmera ryegrass and prickly saltwort. Faecal recoveries relative to $C_{32}$ or $C_{36}$, the dosed alkanes with higher faecal concentration/dose ratio, were calculated as suggested by Dove *et al*. (1999).

Degradation and transit parameters were obtained by fitting the data (polyester bags residues or faecal concentrations of Cr, Eu and Yb) to the models developed by Ørskov and McDonald (1979) and Grovum and Williams (1973), respectively.

The chemical composition of the different samples [DM in spot faecal samples and polyester bags residues, and DM, organic matter (OM), CP and ether extract (EE) in barley fractions and *Lolium rigidum*] was carried out according to the procedures given by the AOAC (2005), whereas NDF, acid detergent fibre (ADF) and acid detergent lignin in barley fractions and ryegrass were determined following the procedures suggested by Van Soest *et al*. (1991). Analysis of variance was performed using the PROC MIXED procedure of the SAS for repeated measures, and following the recommendations given by Littell *et al*. (1998). The model included effects for week, grazing plot, animal within plot, interaction between week and plot, and residual error.

## III – Results and discussion

Available biomass at the beginning of the trial was 2583 and 2123 kg DM/ha (paddocks 1 and 2), whereas the residual biomass was 1181 and 1018 kg DM/ha. Hence biomass availability did not theoretically limit voluntary intake. Proportions of *Lolium rigidum* at the beginning of the trial were 19.7 and 27.8% of the DM in paddocks 1 and 2, respectively, and its chemical composition together with that of barley fractions is shown in Table 1. Chemical composition of *Salsola kali* was not included due to its very low contribution to the diet of the animals. Barley heads had the highest OM and CP contents. The CP content of barley fractions was abnormally high, probably due to the bad meteorological conditions along the crop cycle. The expected low DM production was probably matched with immaturity, and hence a higher N content and a lower NDF concentration. As expected, barley stems showed the highest NDF and ADF contents, whereas barley leaves presented the highest EE contents. Wimmera ryegrass was highly lignified.

Odd-chain alkanes appeared in higher concentrations than even-chain alkanes. Ryegrass showed the highest concentrations in $C_{29}$ (130 mg/kg DM) and $C_{31}$ (234 mg/kg DM), whereas leaves were richer in $C_{33}$ (208 mg/kg DM) than the other barley fractions or *Lolium rigidum*.

Average concentrations (recovery-corrected) of n-alkanes in spot faecal samples were higher for odd-chain paraffins, especially $C_{29}$, $C_{31}$ and $C_{33}$, reflecting the concentration of the diet.

Estimates of diet composition were carried out using the discriminant n-alkanes $C_{29}$, $C_{30}$, $C_{31}$, $C_{33}$ and $C_{35}$. The results of diet composition, intake and digestibility estimates (on DM basis) are given

in Table 2. According to the table, animals only consumed *Lolium rigidum* and barley heads, and this matched the visual observations performed in the field. Although the animals actually consumed all the prickly saltwort specimens, the contribution of these latter to the DM intake (DMI) was so low that they were not considered in the diet composition estimates. Intake of barley heads was lower during the first week (0.30 *vs* 0.64 and 0.65 for weeks 1, 2 and 3, respectively). The higher selection of ryegrass during the first week was unexpected due to its lower CP and higher fibre content, both characteristics associated to a low palatability (Arnold, 1981). In addition, the availability of *L. rigidum* in the paddocks was low, and this has been associated to low selection (Champion *et al*., 2004). However, the density of ryegrass plants was higher during the first week, and this fact may have helped to acquire heavier bites during feed consumption (Newman *et al*., 2003).

**Table 1. Chemical composition (g/kg dry matter) of vitreous-grain barley heads (BH), leaves (BL) and stems (BS), and of Wimmera ryegrass (*L. rigidum*)**

| | BH | BL | BS | *L. rigidum* |
|---|---|---|---|---|
| Organic matter | 964 | 889 | 917 | 943 |
| Crude protein | 156 | 92 | 81 | 71 |
| Neutral detergent fibre | 328 | 489 | 652 | 530 |
| Acid detergent fibre | 135 | 284 | 333 | 371 |
| Acid detergent lignin | 7 | 32 | 35 | 42 |
| Ether extract | 14 | 52 | 11 | 12 |

**Table 2. Effect of grazing week (W) and experimental paddock (P) on proportions of barley heads (BH) and *Lolium rigidum* (Lr) in the diet, and dry matter intake (DMI; g/day or g/kg $PV^{0,75}$) and digestibility (DMD; %), in sheep grazing vitreous-grain barley. Estimates obtained using the n-alkane methodology**

| | W1 | | W2 | | W3 | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P1 | P2 | P1 | P2 | P | W | P x W |
| BH | $0.39_a{}^1$ | $0.21_b{}^1$ | $0.62^2$ | $0.67^2$ | $0.56_a{}^2$ | $0.74_b{}^2$ | 0.6989 | <0.0001 | 0.0029 |
| Lr | $0.61_a{}^1$ | $0.80_b{}^1$ | $0.38^2$ | $0.33^2$ | $0.44_a{}^2$ | $0.26_b{}^2$ | 0.7200 | <0.0001 | 0.0029 |
| DMI | | | | | | | | | |
| kg $day^{-1}$ | 494 | 362 | 514 | 238 | 877 | 437 | 0.0084 | 0.0409 | 0.3747 |
| g/kg $PV^{0.75}$ | 26.7 | 19.0 | 31.5 | 15.9 | 51.1 | 25.8 | 0.0082 | 0.0504 | 0.3702 |
| DMD | 67.1 | 67.4 | 49.4 | 59.6 | 41.5 | 52.5 | 0.0088 | <0.0001 | 0.1212 |

*P*: Probability of the differences.

[a, b] Different subscripts indicate significant differences between paddocks for a determined week at P=0.05.

[1, 2] Different superscripts indicate significant differences between weeks for a determined paddock at P=0.05.

The highest DMI values were observed for the third week (428, 376 and 657 g/sheep/day for weeks 1, 2 and 3, respectively; P=0.0409). Differences between paddocks (P<0.05) were also observed and probably due to biomass availability. On average, sheep lost 0.5 kg/day during the three weeks of the grazing trial, which is consistent with the low intakes recorded; it must be taken into account that OM intake and digestibility were not measured hence the proportion of maintenance requirements covered by the pasture could not be estimated. Assuming biomass availability did not limit intake, the question of why sheep decided to ingest so low amounts and loose so much weight remains open. It can be argued that the n-alkane method is not valid for this resource, and that it will give no reliable estimates of diet composition and intake. However

Valiente *et al*. (2003) validated the method indoors with sheep given different proportions of barley grain and straw, and there are no reasons to suspect a different outcome in grazing conditions. A deficiency in dietary protein was also unlikely, as barley heads and ryegrass had sufficient nitrogen to meet the maintenance requirements of sheep (AFRC, 1992). A combination of environmental factors (average daily temperature of 29.8 ºC) and pasture distribution (patch-like) may have had an influence. It is likely that if animals had felt hungry they would have consumed barley leaves and stems. As this was not the case, they conclusion is that a loss of 0.5 kg/day did not cause a great discomfort to the animals, and that they preferred to ingest a diet of moderate quality rather than filling their rumen with a high-fibre low-digestibility material.

Higher DM digestibility values were found in the first week (67.2%, 54.5% and 47.0%, for weeks 1, 2 and 3, respectively; P<0.0001), probably due to the higher selection of ryegrass, with differences also between paddocks (52.7% *vs* 59.8%; P=0.0088). It must be taken into account that barley heads include not only grain but also fibrous components, hence their digestibility is expected to be much lower.

Values of rumen pH, concentration of ammonia and volatile fatty acids (VFA), and molar proportions of acetic, propionic and butyric acids are shown in Table 3. The pH was constant through the experiment, with no differences (P=0.0907) between weeks and always higher than 6.0. This would indicate that, despite the high proportions of barley heads consumed, especially during weeks 2 and 3, there was no risk of acidosis.

**Table 3. Effect of grazing week (W) and experimental paddock (P) on rumen pH, concentrations of ammonia ($NH_3$; mg/l) and volatile fatty acids (VFA; mmol/l), and molar proportions of acetic, propionic and butyric acids in sheep grazing vitreous-grain barley**

| | W1 | | W2 | | W3 | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|
| | P1 | P2 | P1 | P2 | P1 | P2 | P | W | P x W |
| pH | 6.73 | 7.04 | 6.60 | 6.07 | 6.25 | 6.72 | 0.699 | 0.091 | 0.105 |
| $NH_3$ | 68 | 84 | 148 | 147 | 60 | 48 | 0.922 | <0.0001 | 0.226 |
| VFA | 119 | 74 | 80 | 68 | 91 | 60 | 0.009 | 0.070 | 0.255 |
| Acetic | 0.62 | 0.63 | 0.67 | 0.67 | 0.69 | 0.64 | 0.502 | 0.066 | 0.280 |
| Propionic | $0.13^{1}$ | $0.15^{1}$ | $0.16_{a}{}^{2}$ | $0.18_{b}{}^{2}$ | $0.16^{2}$ | $0.15^{1}$ | 0.068 | 0.001 | 0.026 |
| Butyric | 0.18 | 0.17 | 0.14 | 0.12 | 0.11 | 0.16 | 0.702 | 0.143 | 0.288 |

*P*: Probability of the differences.

[a, b] Different subscripts indicate significant differences between paddocks for a determined week at P=0.05.

[1, 2] Different superscripts indicate significant differences between weeks for a determined paddock at P=0.05.

Ammonia concentration was higher (P<0.0001) in the second and lower in the third week (74, 147 and 54, mg/l for weeks 1, 2 and 3, respectively). The value of 50 mg/l was always met, guaranteeing an appropriate microbial protein synthesis (Satter and Slyter, 1974).

There was no effect of the grazing week on either total concentration of VFA (P=0.0698) or molar proportions of acetic (P=0.0658) and butyric (P=0.1433) acids. In the case of propionic acid, a significant interaction appeared between grazing week and experimental paddock (P=0.0256). The paddock effect was significant only for the total concentration of VFA (97 *vs* 68 mmol/l; P=0.0089). Fermentation parameters were representative of a rumen environment driven by fibre degradation.

Degradation parameters and rate of passage of barley heads, leaves and stems through the rumen are given in Table 4. Potential degradability of DM was higher (P<0.0001) for heads (84.4%) and lower for stems (65.3%). There were no differences between grazing weeks (P=0.3881).

Fractional rate of DM degradation varied with grazing week (P<0.0001), the extent of variation depending on the botanical fraction considered. As a result, the interaction week x fraction was highly significant (P<0.0001). Fractional degradation rate of leaves and stems was not affected (P>0.05) by week, whereas degradation of heads was faster in the first one (P<0.05).

**Table 4. Effect of grazing week (W) and botanical fraction (F) on rumen degradation parameters (a+b: potential degradability, %; c: fractional rate of degradation, % $h^{-1}$; DMED: dry matter effective degradability, %) and outflow rate ($k_1$, % $h^{-1}$) of barley heads (BH), leaves (BL) and stems (BS) in sheep grazing vitreous-grain barley**

| | W1 | | | W2 | | | W3 | | | *P* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BH | BL | BS | BH | BL | BS | BH | BL | BS | W | F | W x F |
| a+b | 84.8 | 79.0 | 65.7 | 84.9 | 78.7 | 65.5 | 83.6 | 77.1 | 64.9 | 0.3881 | <0.0001 | 0.9883 |
| c | $28.7_{b}^{2}$ | $5.3_{a}$ | $4.3_{a}$ | $10.4_{b}^{1}$ | $4.9_{a}$ | $4.4_{a}$ | $10.0_{b}^{1}$ | $5.8_{a}$ | $4.5_{a}$ | <0.0001 | <0.0001 | <0.0001 |
| $k_1$† | 0.89 | – | 0.86 | – | – | – | 1.23 | – | 1.44 | 0.0498 | 0.6426 | 0.5638 |
| DMED | 83.0 | – | 57.0 | – | – | – | 78.5 | – | 52.2 | 0.0080 | <0.0001 | 0.9125 |

*P*: Probability of the differences.

[a, b] Different subscripts indicate significant differences between paddocks for a determined week at P=0.05.

[1, 2] Different superscripts indicate significant differences between weeks for a determined paddock at P=0.05.

† The $k_1$ values for leaves, and hence the DMED, have not been included as they were obtained only in the second week.

Fractional outflow rate of heads and stems through the rumen ($k_1$) was affected only by the grazing week (P=0.0498), with higher values in the third than in the first one (0,0133 *vs* 0,0087 $h^{-1}$). As a result, the effective degradability of the DM (DMED) was higher (P=0.0080) in the first (70.01%) than in the third (65.36%) week. Regarding the differences between botanical fractions, the heads showed (P<0.0001) higher DMED (80,78%) than the stems (54.60%). Rumen outflow rate of leaves was obtained only in the second grazing week (0.0091 $h^{-1}$), and the DMED was 65.70%. Low outflow rates were consistent with low intakes and high DMED values.

## IV – Conclusions

Sheep grazing vitreous-grain barley in conditions where the biomass availability is not limiting tend to consume a diet of constant composition, with *ca* 65% heads. If the presence of other preferred species such as *Lolium rigidum* is high, this proportion can be considerably lower. It also seems that if the acquisition of food is not easy, sheep grazing in summer in semiarid environments might prefer to loose weight rather than to ingest a very low quality diet. How much weight the animals are keen to loose before ingesting more fibre is a matter of high interest. Even for low intake values, rumen pH and ammonia concentration are adequate and representative of a correct fibre fermentation. Low intakes are also compatible with the low values of rumen outflow rate and the high values of rumen degradation of barley fractions found in the present work.

## References


**AFRC, 1992.** Nutritive requirements of ruminant animals: protein. In: *Nutrition Abstracts and Reviews (Series B)*, 62, p. 787-835.

**Arnold G.W., 1981.** Grazing behavior. In: F.H.W. Morley (ed.), *Grazing Animals*. Amsterdam: Elsevier Scientific Publishing Co. p. 79-104.

**Association of Official Analytical Chemists (AOAC), 2005.** *Official Methods of Analysis*, 18th ed. Washington: AOAC.

**Champion R.A., Orr R.J., Penning P.D. and Rutter S.M., 2004.** The effect of the spatial scale of heterogeneity of two herbage species on the grazing behaviour of lactating sheep. In: *Applied Animal Behaviour Science*, 88, p. 61-76.

**Chaney A.L. and Marbach E.P., 1962.** Modified reagents for determination of urea and ammonia. In: *Clinical Chemistry*, 8, p. 130.

**De Vega A. and Poppi D.P., 1997.** Extent of digestión and rumen condition as factors affecting passage of liquid and digesta particles in sheep. In: *Journal of Agricultural Science*, 128, p. 207-215.

**Dove H., Wood J.T., Simpson R.J., Leury B.J., Gatford K.L., Siever-Kelly C. and Ciavarella T.A., 1999.** Spray-topping annual grass pasture with glyphosate to delay loss of deeding value during summer III. Quantitative basis of the alkane-based procedures for estimating diet selection and herbage intake by grazing sheep. In: *Australian Journal of Agricultural Research*, 50, p. 475-485.

**Grovum W.L. and Williams V.J., 1973.** Rate of passage of digesta in sheep. 4. Passage of marker through the alimentary tract and the biological relevance of rate constants derived from the changes in concentration of marker in feces. In: *British Journal of Nutrition*, 30, p. 313-329.

**Jouany J.P., 1982.** Volatile fatty acid and alcohol determination in digestive contents, silages juices, bacterial cultures and anaerobic fermentor contents. In: *Science des Aliments*, 2, p. 131-144.

**Littell R.C., Henry P.R. and Ammerman C.B., 1998.** Statistical analysis of repeated measures data using SAS procedures. In: *Journal of Animal Science*, 76, p. 1216-1231.

**Mayes R.W., Lamb C.S. and Colgrove P.M., 1986.** The use of dosed and herbage n-alkanes as markers for the determination of herbage intake. In: *Journal of Agricultural Science*, 107, p. 161-170.

**Mehrez A.Z. and Ørskov E.R., 1977.** A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. In: *Journal of Agricultural Science*, 88, p. 645-650.

**Newman C.Y., Sollenberger E.L. and Chambliss G.C., 2003.** Canopy characteristics of continuously stocked limpograss swards grazed to different heights. In: *Agronomy Journal*, 95, p. 1246-1252.

**Ørskov E.R. and McDonald I., 1979.** Estimation of protein degradability in the rumen from incubation measurement weighted according to rate of passage. In: *Journal of Agricultural Science*, 91, p. 483-486.

**Satter L.D. and Slyter L.L., 1974.** Effect of ammonia concentration on rumen microbial protein production in vitro. In: *British Journal of Nutrition*, 32, p. 199-208.

**Valiente O.L., 2004.** *Valoración de la cebada en pie y de su rastrojera como dietas de verano para el ganado ovino en pastoreo.* Tesis doctoral. Universidad de Zaragoza, 296 p.

**Valiente O.L., Delgado P., de Vega A. and Guada J.A., 2003.** Validation of the n-alkane technique to estimate intake, digestibility, and diet composition in sheep consuming mixed grain:roughage diets. In: *Australian Journal of Agricultural Research*, 54, p. 693-702.

**Vallentine J.F., 1990.** *Grazing Management.* ISBN: 0127100008. San Diego: Academic Press, INC Publishers, 533 p.

**Van Soest P.J., Robertson J.B. and Lewis B.A., 1991.** Methods of dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. In: *Journal of Dairy Science*, 74, p. 3583-3597.