Short Communication

The drying rate and chemical composition of field and artificially dried lucerne hay

C.J.C. Muller[1#], C.W. Cruywagen[2], F.J. du Toit[2,3] and J.A. Botha[1]
[1] Institute for Animal Production: Elsenburg, Private Bag X1, Elsenburg 7607, South Africa
[2] Department of Animal Sciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa

Abstract

The drying rate and chemical composition of lucerne hay that was field dried (sun cured) or artificially dried in a forced air bulk drier (FABD) were compared during summer (which is the dry season in the Western Cape Province). On six hay cutting occasions, plant material was left in the field for 24 hours after which some material was transferred to a FABD while the rest was left in the field for sun curing. The drying rate of lucerne hay in the FABD was significantly higher than in the field. The chemical composition of sun cured and lucerne hay dried in the FABD did not differ significantly. The study showed that, under good hay making conditions, sun cured lucerne hay is just as good as artificially dried lucerne hay, although the drying rate in the FABD was higher than field drying.

Keywords: Sun drying, field drying, forced air bulk drier, artificial drying, Mediterranean climate
[#] Corresponding author. E-mail: carelm@elsenburg.com
[3] Present address: Nova Feeds, P.O. Box 700, Malmesbury 7299, South Africa

Dairy farmers in the Western Cape often experience problems in producing high quality lucerne hay under field conditions during summer, even though this is the dry season in this region with its Mediterranean climate. Problems include occasional rain showers and the occurrence of heavy dew or fog at night because of the close proximity to the coast. This causes a slow drying process in the field (Muller, 2001 – unpublished data). Slow drying results in dry matter (DM) and quality losses because of respiration, rain damage and shatter/loss of dried leaves (Akkharath *et al*., 1996). Sun bleaching also reduces the carotene content of lucerne hay (Vough, 2002). Drying and handling losses of 4% were experienced in the yield for every day that cut material remained in the field (Radajewski *et al*., 1990). In cases where rain occurred during the drying process, losses could exceed 40% of total DM yield (Wilkinson, 1981). To reduce the drying time in the field, lucerne hay is usually turned over once or twice by raking to improve air circulation. This process, however, causes a loss of leaves. More leaves are lost as the material becomes drier.

Artificial drying of lucerne in forced air bulk driers (FABD) has been used in Northern Hemisphere countries; because weather conditions necessitate an extended drying process in the field. Hart *et al.* (1932) reported on the effect of artificial drying on the availability of nutrients in alfalfa hay. Sokhansanj & Patil (1996) and Wu (2004) showed that the different components of alfalfa hay have different dehydration characteristics. Removing harvested material from the field accelerates the regrowth of lucerne while the number of operational days in the field is also reduced (Radajewski *et al*., 1990). With artificial drying, only one day of dry weather is needed instead of the four to five consecutive dry days needed for field drying. Artificial drying of lucerne should reduce leaf loss; thus, improving hay quality because of a higher crude protein (CP) and lower crude fibre (CF) content (Tietz, 2005). This would reduce feeding cost while shattered leaves could be collected from the floor of the drier and used as an ingredient in animal rations.

The advantages of artificial drying are usually advocated for areas with a high risk of field drying (Arinze *et al*., 1993). A perception also exists locally that artificial drying would increase the quality (chemical composition and nutritive value) of lucerne hay, regardless of weather conditions. At present no information is available in South Africa on the drying rate and chemical composition of lucerne hay dried in a FABD in comparison to field drying. This study was undertaken to evaluate the possible practical advantages of artificial drying of lucerne hay and to obtain drying rate trends for Western Cape weather conditions.

The study was conducted at the Elsenburg Research Farm of the Western Cape Department of Agriculture. Elsenburg is situated approximately 50 km east of Cape Town in the winter rainfall region of South Africa. A north facing lucerne field, consisting of 4 x 0.5 ha blocks, was used in the study. On six occasions during summer, lucerne was harvested with a mower-conditioner when in the mid-flowering stage, (*ca.* 50% of plants in bloom). At each harvesting occasion, two blocks (representing treatments) were chosen randomly. Lucerne was cut on the same day before nine o'clock in the morning in all blocks and left in the field for 24 h to dry. The material was then turned over with a four-wheel finger rake. For Treatment 1, cut lucerne was left in the field to dry naturally, while for Treatment 2, the cut material was transferred to the FABD where it was artificially dried. In both instances a moisture content of 15 – 18% was deemed desirable for baling (Iwan *et al*., 1993).

Four samples of lucerne were collected just after cutting (0 h) and, thereafter, four samples were collected from the lucerne in the field and in the FABD at regular intervals, i.e. at 4, 8, 22, 26, 28, 32, 48, 52, 56, 58, 72, 76 and 80 h after cutting. Sampling was continued until the harvested material was considered cured and ready for baling. One half of the collected samples was dried at 50 °C to be analysed for chemical composition, while the other half of the sample was dried at 100 °C to determine the moisture content and the drying rate of the material. To determine the time of baling, lucerne hay was dried in a microwave oven (set on high) until a constant weight was reached.

The FABD consisted of a brick shed (8.3 x 4.2 m) with a maximum packing height of 2 m providing a drying compartment of *ca.* 70 m^3. Airflow was created by a 600 mm diameter centrifugal fan driven by a 5.5 kW motor supplying airflow of 4 m^3/s. A 48 kW element heater was used to increase the air temperature by 10 °C. Hot air was blown through a chute with a closed end and rectangular openings along the top and sides to let the air out. Wooden slats were installed inside the FABD at the same height from the floor alongside the chute. Lucerne hay, in loose bulk form, was transferred from the field onto the chute and slats. Each trailer load of lucerne was packed up to a maximum height of 2 m. Successive loads were packed in front of the previous load to prevent excessive trampling and compacting material that would reduce airflow. An even height was maintained to avoid material forming a wedge that would cause material to be dried unevenly. Once the FABD was filled up to capacity, it was closed up at the open end to allow a build-up of air pressure.

At each of the six drying occasions, two lucerne hay samples of freshly cut, artificially dried and naturally dried lucerne hay were collected and analysed for CP content according to the methods of the AOAC (1984). The *in vitro* organic matter digestibility was determined according to the method of Engels & Van der Merwe (1967). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents were determined by the method of Goering & Van Soest (1970) and Robertson & Van Soest (1981), respectively.

The chemical composition of freshly cut, artificially dried and naturally dried lucerne hay was compared by a one-way analysis of variance using the Statgraphics statistical package (1985). Each of the six harvesting occasions was regarded as a replication. Data concerning the DM content of the harvested material were analyzed using the LSMLMW program of Harvey (1990) to obtain a trend curve for a visual representation of the drying rate of lucerne hay in the field and in the FABD. The following model was fitted to the data:

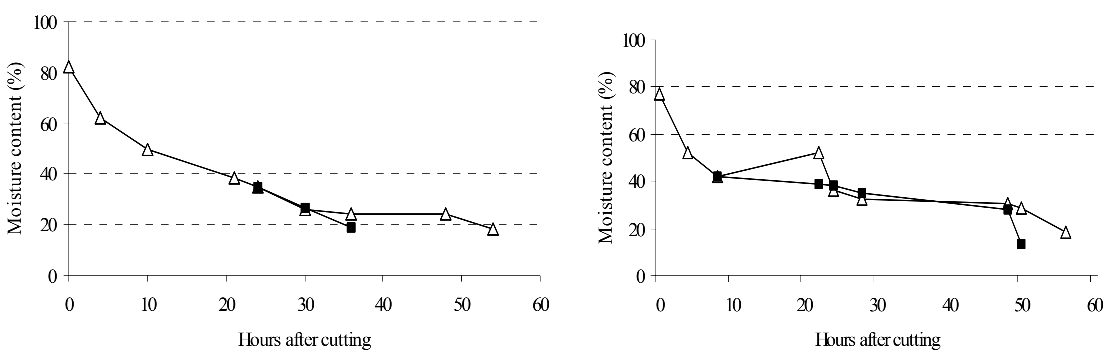
$$Y_{ijk} = \mu + rep_i + desig_j + r_i d_j + b_L(t-T) + b_Q\,(t-T) + e_{ijk}$$

where Y_{ijk} = the k^{th} moisture content of a sample at a specific time; μ = overall mean moisture content; rep_i = the effect of the i^{th} date; $desig_j$ = the effect of the j^{th} treatment (j = natural or artificial drying); $r_i d_j$ = interaction of rep_i and $desig_j$; t = the time lapse from cutting lucerne; T = the average time lapse from cutting; b_L = a linear regression coefficient depicting the linear change associated with time since cutting and b_Q = a quadratic regression coefficient depicting the quadratic change associated with time since cutting.

Studies that depend on natural climatic conditions are difficult to execute because of the unpredictability of the weather. For this study, cool and moist conditions during summer were required to demonstrate the value of a FABD. However, weather conditions were ideal for field drying on all the drying occasions. Warm weather was experienced with an average maximum and minimum temperature of 27.4 °C and 12.0 °C, respectively. Radiation was high with the number of sunshine hours per day ranging from six to 10.4. High wind speeds also occurred on most days. Rain occurred on one day only when a total rainfall of 0.20 mm over a 24 h period was recorded. The evaporation rate was high while the relative humidity levels on harvesting days were lower than the monthly average humidity levels, i.e. 61% *vs*. 77%, indicating drier than normal days. The favourable weather resulted in shorter field drying periods (three to four days) than what would normally be expected. These conditions therefore only allowed comparison between hay made under good natural conditions and artificial oven drying conditions.

The rate of moisture loss of the harvested lucerne hay in the field and in the FABD on two occasions is presented in Figure 1. Plant material started losing moisture immediately after it was cut. From Figure 1(a) it appears that the drying rate was high for the first 30 h after cutting. Thereafter, the moisture content of the material remained constant for a period of 18 h. This period occurred from 16:00 until 10:00 the following morning. The moisture content of the material in the field started to decrease again from 48 h after harvesting.

During the drying occasion presented in Figure 1(b), a moisture content of 19% for field dried lucerne hay was reached 56 h after cutting while the moisture content of lucerne hay dried in the FABD was 13% at 50 h after cutting. The increase in moisture content (from 42 to 52%) of the cut material in the field that occurred between eight and 23 hours after cutting was due to a small amount of rain (0.2 mm) that fell during that time.



(a) (b)

Figure 1 The drying rate of lucerne hay in the field (Δ) and in the bulk drier (■) on two occasions.

On another drying occasion, the material in the FABD reached a moisture content of 19% at 46 h after cutting while the material in the field reached a moisture content of 19% at 52 h after cutting. The final moisture content of the material in the FABD was 16% at 58 h after cutting. The moisture content of the cut material in the field stayed fairly constant (changed from 64% to 62%) for a 14 h period between nine and 23 hours after cutting. This was because of higher than normal relative humidity levels during this drying occasion (78% *vs*. 68% for the total drying period). The total evaporation was also low (3%) in contrast to an average of 7% for the remaining three days it took for the cut material to dry in the field.

Field drying is accelerated by factors such as high daytime temperatures, low relative humidity levels and high winds. Under field drying conditions, plant material collects some moisture at night as dew forms because of lower air temperatures and higher relative humidity levels. This was observed by an increase in the moisture content of the plant material on the first morning after the initial harvest (Muller, 2001 - unpublished data).

The data on the moisture content of the lucerne hay dried in the field and in the FABD on the six drying occasions were regressed against time after harvesting. Average regression equations were calculated for field and FABD dried hay. There was a trend (P = 0.08) for the linear regression coefficients (depicting the linear rate of drying) to differ between cuttings (Figure 2), while the quadratic regression coefficients differed significantly

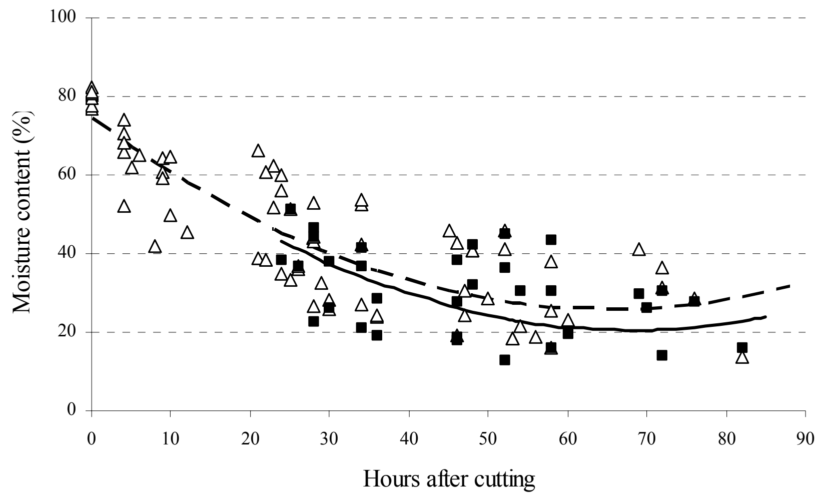


Figure 2 The moisture content (x hours after cutting) of lucerne dried naturally (Δ) (Y = 39.51 - 0.789 (x - 30.65) + 0.0114(x - 30.65)^2) and in the bulk drier (■) (Y = 36.76 - 0.870 (x - 30.65) + 0.0116(x – 30.65)^2).

(P = 0.02). This indicates that the weather conditions on each separate drying occasion had an effect on the rate at which the plant material lost moisture in the field during the natural drying process.

Data obtained during the artificial drying process showed that the values for the respective drying occasions representing the average moisture content of the material at 50.4 h after harvest differed significantly (P <0.001). The values representing the linear regression coefficients for the artificial drying curves also differed significantly (P = 0.02). This indicates that the rate at which the cut material dried in the FABD differed between the individual drying occasions.

The equations derived from the average values of the field and FABD dried lucerne hay indicate that the average moisture content of the material at the average drying time (μ = 30.65 h after cutting) was 39.5 and 36.8%, respectively; with values tending to differ (P = 0.08). The linear regression coefficients were 0.79

Table 1 The chemical composition of freshly cut, field dried, and artificially dried lucerne hay (DM basis)

Parameters	Freshly cut lucerne	Field dried lucerne hay	Artificially dried lucerne hay	s.e.m.	P
Number of samples	12	12	12		
Crude protein	20.0^a	17.3^b	17.6^b	0.4	0.02
Total digestible nutrients	64.0^a	55.0^b	55.5^b	0.6	0.01
Digestible organic matter	65.2^a	60.0^b	61.3^b	0.8	0.04
Acid detergent fibre	35.4^a	41.2^b	40.6^b	0.7	0.01
Neutral detergent fibre	41.6^a	48.0^b	47.3^b	0.8	0.01
Ash	9.6^a	9.4^a	9.2^a	0.5	0.51

s.e.m. - standard error of the mean; P - significance level.
^{ab} Values with different superscripts differ significantly (P <0.05).

and 0.87 for natural and artificial drying, respectively. The material in the FABD lost moisture at a faster rate (P <0.05) than the material in the field.

The chemical composition of fresh lucerne and lucerne hay dried in the field or in the FABD is presented in Table 1. The freshly cut material and material dried either way differed (P <0.05) in terms of CP, total digestible nutrients, acid detergent fibre (ADF) and neutral detergent fibre (NDF) content. The lower values for dried lucerne compared to freshly cut lucerne is probably related to DM losses during the drying process. In the current study there was no difference (P >0.05) in chemical composition between the lucerne hay dried in the field or in the FABD. The CP content of the naturally and artificially dried lucerne hay was 17.3 and 17.6%, respectively. No mould occurred in the lucerne hay dried in the FABD.

The study showed that good quality lucerne hay can be produced in a FABD. Appropriate equipment should, however, be used to reduce manual labour. The chemical composition of lucerne hay cut at a mid-bloom stage and dried in the FABD was similar to lucerne hay dried in the field. In this study, the reason was probably because of the ideal field drying conditions with high day and night time temperatures on most harvesting days. Predicting weather conditions accurately is difficult; therefore, local weather risk levels should be taken into account before investing in equipment for artificially drying hay crops. It was concluded that under good hay making conditions, sun-cured lucerne hay is just as good as artificially dried lucerne hay, the only difference being that the artificially dried hay dried at a faster rate than the field dried hay.

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