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in

Ben Salem H. (ed.), Nefzaoui A. (ed.), Morand-Fehr P. (ed.).
Nutrition and feeding strategies of sheep and goats under harsh climates

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 59

2004
pages 227-232

Valorisation of date-palm by-products (DPBP) for livestock feeding in Southern Tunisia. II – Characteristics and digestibility of DPBP-based silages

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SUMMARY – The cultivation of the date-palm in Tunisia and the sorting of dates leave important quantities of date-palm by-products (DPBP) which are wasted dates (dried dates, parthenocarpic dates, etc.), stones, stems and leaves. The use of wasted dates and stones as a complementary feed source for livestock by oasian people can improve the feeding calendar of livestock during a long period of the year. However, these by-products are unbalanced. The present work aims at the conservation of DPBP as silage to enhance the use of readily available by-products of date-palm, to expand the period of their use and to suggest complements or more balanced diets. Two types of silage were prepared. Silage 1 (S1) was composed of chopped stems (45%), wasted dates (35%), wheat bran (15%) and urea (5%). The urea was dissolved in water (10% volume/weight of the mixture before humidification). In silage 2 (S2), stems were replaced by chopped palm-leaves. Ingredients were mixed carefully and silages were preserved at ambient temperature in hermetic bags for 2 months. The 2 silages had a characteristic and typical good silage smell. The neutral detergent fibre was 50.3 ± 3.2% and 46.5 ± 1.2% for S1 and S2, respectively. For *in vitro* digestibility studies, rumen liquors were taken from 3 animal species (sheep, goat and camel) killed in slaughterhouses. *In vitro* dry matter digestibility (DMD) of S1 and S2 were 55.5 ± 0.6 vs 50.3 ± 2.2% and 48.6 ± 1.1 vs 50.1 ± 4.7% and 53.0 ± 0.1 vs 53.4 ± 4.2% respectively in sheep, goat and camel. In order to determine *in vivo* digestibility of the two silages, 4 local kids were used during 2 successive periods. *In vivo* DMD of S1 were significantly higher ($P < 0.05$) than S2 (51.5 ± 1.2 vs 47.9 ± 2.5) and *in vivo* organic matter digestibility (OMD) were not different ($P > 0.05$) for the two silages (54.9 ± 2.1 vs 58.1 ± 2.6). The mean daily dry matter intake averaged 46.0 ± 8.8 and 65.5 ± 8.7 g/kg $W^{0.75}$ respectively for S1 and S2. This technique seems to be appropriate for DPBP conservation and enhancement use.

Key words: Date-palm by-products, nutritive value, storage, arid zone.

RESUME – *"Valorisation des sous-produits du palmier dattier (SPPD) dans l'alimentation des animaux au Sud de la Tunisie. II – Qualité et digestibilité des ensilages des sous-produits du palmier dattier". La culture du palmier dattier est très répandue dans le Sud tunisien. L'opération du tri de la production laisse une importante quantité de déchets de dattes (dattes sèches, fruits parthénocarpiques, etc.). L'entretien annuel du palmier laisse aussi une quantité non négligeable de palmes vertes ou sèches. L'intégration des sous-produits du palmier dattier (SPPD) comme complément dans les rations des animaux peut améliorer le calendrier fourrager des élevages dans les oasis au cours de l'année. Toutefois, ces SPPD sont déséquilibrés lorsqu'ils sont pris individuellement. Ce travail a pour objet la conservation par ensilage des SPPD pour étendre la période de leur utilisation ainsi que la proposition de complément ou de rations plus équilibrées. Pour cela, 2 types d'ensilages ont été préparés. L'ensilage 1 (S1) est composé de hampes hachées (45%), déchets de dattes (35%), son de blé (15%) et urée (5%). L'urée a été dissoute dans l'eau (10% volume/poids du mélange avant humidification). Dans l'ensilage 2 (S2), les hampes ont été remplacées par les palmes vertes hachées. Les ingrédients ont été mélangés soigneusement et les ensilages ont été conservés dans des sacs en plastique dans une chambre à température ambiante pendant 2 mois. A l'ouverture des sacs, les 2 ensilages avaient l'apparence et l'odeur d'un bon ensilage. Les teneurs en NDF des ensilages S1 et S2, ont été de 50,3 ± 3,2 et 46,5 ± 1,2% respectivement. Pour la détermination de la digestibilité* in vitro *des ensilages, le jus du rumen de 3 espèces animales (ovin, caprin, dromadaire) a été prélevé à l'abattoir. La digestibilité de la matière sèche (DMS)* in vitro *de S1 et S2 a été de 55,5 ± 0,6 contre 50,3 ± 2,2% ; 48,6 ± 1,1 contre 50,1 ± 4,7% et 53,0 ± 0,1 contre 53,4 ± 4,2% respectivement pour les ovins, les caprins et les dromadaires. Pour déterminer la DMS* in vivo *des ensilages, 4 boucs de race locale ont été utilisés au cours de 2 périodes successives. La DMS* in vivo *de S1 a été significativement plus élevée ($P < 0,05$) que celle de S2 (51,5 ± 1,2 contre 47,9 ± 2,5%). Cependant, la digestibilité de la matière organique (DMO)* in vivo *des 2 ensilages n'a pas été significativement différente ($P > 0,05$) (54,9 ± 2,1 contre 58,1 ± 2,6% pour S1 et S2 respectivement). L'ingestion moyenne de la matière sèche de S2 a été significativement plus élevée que celle de S1 (65,5 ± 8,7 contre 46,6 ± 8,8 g/kg $P^{0,75}$ respectivement). La*

technique d'ensilage semble appropriée pour la conservation et l'amélioration des SPPD en alimentation animale dans les oasis.

Mots-clés : *Palmier dattier, sous-produits, valeur nutritive, conservation, zones arides.*

Introduction

While widely utilised for livestock feeding in mixed oasian farming systems of southern Tunisia, date-palm by-products (DPBP) (wasted dates, stones, stems, leaves) present two main limiting factors. The first one is that, individually, they constitute unbalanced forages being highly fibrous in the case of stems and leaves, or with high soluble carbohydrate content in the case of wasted dates. In both cases nitrogen content is low [crude protein (CP) content between 3 and 6.6%; Genin *et al*., this volume]. The second limiting factor of DPBP refers to their availability restricted to the date harvesting period (November to March). In Tunisia, DPBP are fed to livestock without any processing. In other countries attempts have been made in order to valorise these feed sources by implementing feed blocks or by physico-chemical treatments (Al-Youssef *et al*., 1986). However, these techniques are difficult to perform at farm level. Silage is a technique which is widely utilised because it allows a forage harvesting at an optimal vegetative stage and conservation. As far as we know, only one study reported the use of DPBP (in this case leaves) in silage for lactating cows feeding (Narendran *et al*., 1986). Other studies reported the use of date palm leaves and stems for feeding lactating cows (Bahman *et al*., 1997) and goats (Pascual *et al*., 2000).

The present work aimed at the conservation of DPBP as silage to enhance the use of readily available DPBP, to expand the period of their use and to suggest complements of more balanced diets. It involved digestibility trials of two DPBP-based silages, using wasted dates, floral stems (lignified tissues supporting dates fruits) and leaves.

Material and methods

Preparation of silages

Two types of silage have been prepared using DPBP of Deglet Nour variety (Table 1).

Table 1. Composition of silage (% DM)

Ingredients	Stem silage (S1)	Leaves silage (S2)
Chopped stems	45	0
Chopped palm leaves	0	45
Wasted dates	35	35
Wheat bran	15	15
Urea	5	5

Leaves and stems were chopped by a Professional Perruzo T5 machine. In the first stage, wasted dates, previously mixed with wheat bran, were ground with a Promill grinder at the experimental station of the Arid Lands Institute (IRA). Chopped leaves and stems were directly poured in a mixer and watered with urea solution [10% dry matter (DM) v/w]. The whole ingredients were mixed during 20 min and then packed in black plastic bags (length: 90 cm × width: 50 cm). Bags were hermetically closed to ensure anaerobic conditions and were stored in a room at ambient temperature (20-25°C) during 2 months.

Chemical analyses

One sample from each silage was taken and was sub-sampled for DM determination at 104°C, or

for chemical analyses after drying at 60°C. Samples for chemical analyses were ground in a laboratory mill fitted with a 1 mm screen, and were analysed to determine their content of ash, CP and crude fibre (CF) according to the AOAC (1975). Ash free neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) were determined according to Georing and van Soest (1970) using the automated ANKOM fibre analyser.

pH, soluble nitrogen and ammonia-nitrogen in silage

To determine the pH, the soluble nitrogen and ammonia nitrogen; 500 g (whole matter) of silage were steeped in 1 l of distilled water during one night at 4°C (Dulphy and Demarquilly, 1981). Juice was obtained by filtration using 4 layers of surgical gauze and centrifugation at 3500 r/min during 15 min, then, it was preserved by adjusting pH to 4 using HCl (N).

In vitro dry matter digestibility

The first stage technique (Tilley and Terry, 1963) for *in vitro* digestion of silages was used to determine their dry matter digestibility (IVDMD). For this purpose, rumen liquors were taken from 3 animal species (sheep, goat and camel) killed in slaughterhouses and triplicate assays were performed for each sample.

In vivo digestibility trials

Animals

Four 2-year-old kids [average live weight (LW) 29.3 ± 6.6 kg] were used to determine *in vivo* digestibility of silages. They were housed in metabolism cages during 2 measurement periods.

Feed

Two digestion trials of stem (trial 1) and leaves (trial 2) silages were undertaken. Each trial consisted of 2 weeks of adaptation to silage and collection faeces bags and a 6 day period for total faecal collection. Silage was offered daily in two meals at 08:00 h and 16:00 h, whereas water was distributed 3 times/day. Refusals were collected and weighed before each morning meal. For each animal, distributed silage quantity was adjusted, to obtain a refusal quantity averaging 10%.

Statistical analysis

Parameters of chemical composition (DM, ash, CP, CF, NDF, ADF and ADL), pH, soluble nitrogen, ammonia-nitrogen and IVDMD of silages were studied with descriptive analysis using SPSS Software (SPSS, 1999). Dry matter intake (DMI), DM digestibility (DMD), organic matter digestibility (OMD), CP digestibility (CPD) and NDF digestibility (NDFD) of the two silages were analysed with one way ANOVA using the same Software.

Results and discussion

Chemical composition of silages

Chemical composition of the two silages are shown in Table 2. DM was higher in S2 than in S1; 52.2 and 59.7%, respectively. High level of DM and the length of shopped shoots can reduce the packing of silage and increase development of moulds if silo is not hermetic (Vanbelle *et al*., 1981). In our study, no moulds were observed and silages had a good characteristic smell.

CF contents were similar in the two silages (22.4 and 21.7% for S1 and S2, respectively). S1 had a

higher NDF content than S2 (50.3 and 46.5%, respectively). This difference is related to the high NDF content of stems compared to leaves (Genin *et al*., this volume). NDF content in S1 was similar to that reported for alfalfa hay (50.54% DM) (Muñoz, 1991) but lower than olive pulps NDF content (Molina and Aguilera, 1991).

ADF contents of the 2 silages were comparable (33.2 against 33.1%, for S1 and S2, respectively). However, ADL content was higher n S2 than in S1. This finding could be attributed to the higher ADL content of leaves (Genin *et al*., this volume). ADL content in S2 was comparable to that in alfalfa hay (Muñoz, 1991) but lower than that in olive pulp (Molina and Aguilera, 1991).

Table 2. Chemical composition of silages

	Silage	n	Mean	SD
DM (%)	S1	5	52.2	1.3
	S2	5	59.7	1.1
Chemical composition DM (%)				
Ash	S1	5	6.4	0.2
	S2	5	8.5	0.8
CP	S1	5	22.2	2.0
	S2	5	22.4	0.9
CF	S1	5	22.4	0.77
	S2	5	21.7	1.2
Ash-free NDF	S1	5	50.3	3.2
	S2	5	46.5	1.2
ADF	S1	5	33.2	1.8
	S2	5	33.1	1.3
ADL	S1	5	6.1	0.4
	S2	5	9.2	0.9

The two silages presented CP contents higher than 20% of DM due to the addition of urea (5% DM). This contribution also resulted in elevated proportions of soluble nitrogen (58.4 against 69.4% for S1 and S2, respectively) and ammonia-nitrogen (15.5 against 18.4%) (Table 3). According to Vanbelle *et al*. (1981), the conservation of proteins in silage is considered satisfactory as long as the ammonia-nitrogen ratio is lower than 15%. This assumption will require further studies in the case of use of non-protein nitrogen (NPN).

Table 3. pH, soluble nitrogen and ammonia nitrogen (% total N) of silages†

	pH	$N_{soluble}$	$N\text{-}NH_3$††
Stem silage (S1)	5.56 (0.25)	58.4 (5.3)	15.5 (1.1)
Leaves silage (S2)	6.38 (0.47)	69.4 (3.7)	18.4 (0.7)

†Values between parenthesis correspond to standard deviation.
††$N\text{-}NH_3$: ammonia nitrogen.

pH of silages S1 and S2 were significantly different (5.56 and 6.38 respectively) (Table 3). In the literature, for an excellent classic silage, the pH must be lower than 4.0, except if the DM content is higher than 30% (Dulphy and Demarquilly, 1981; Vanbelle *et al*., 1981; Demarquilly and Andrieu, 1988). Suiting this criteria, DPBP silages would be poor quality forages. However, more detailed studies are needed to evaluate non conventional stored feeds, because if the pH is considered a simple means to appreciate the quality of non pre-dried silages, it is a bad classification criteria for pre-dried or treated silages (formalin, formic acid, etc.) (Vanbelle *et al*., 1981).

The elevated rates of soluble nitrogen and ammonia nitrogen found in this study could induce an

important loss in urine. However, this loss might be lower than expected because of a staggered intake of silage along the day. In addition, the fermentable carbohydrates of dates (35% of the DM) combined with ammonia nitrogen enhance microbial protein synthesis in the rumen (Wilkinson, 1999). This hypothesis should be confirmed by the measurement of urinary nitrogen losses.

On the basis of the chemical composition, silages of date-palm by-products (S1 and S2) are relatively comparable to an alfalfa hay with the exception of their CP content.

In vitro dry matter digestibility

The IVDMD for S1 and S2 in the sheep, goat and camel are given in Table 4. S1 was more digestible ($P < 0.01$) in sheep and camel than in goat. IVDMD in S2 was comparable in sheep and goat but it was slightly more important in camel. The two silages had a comparable IVDMD value in camel. However, S1 had high IVDMD ($P < 0.05$) than S2 in sheep species.

Table 4. *In vitro* dry matter digestibility of silages[†]

	Sheep	Goat	Camel
Stem silage (S1)	55.5 (0.6)^{ax}	48.6 (1.1)^{b}	53.0 (0.1)^{a}
Leaves silage (S2)	50.3 (2.2)^{y}	50.1 (4.7)	53.4 (4.2)

[†]Values between parenthesis correspond to standard deviation.
^{a,b}In the same row, values are statistically different at $P < 0.01$.
^{x,y}In the same column, values are statistically different at $P < 0.05$.

Intake and *in vivo* digestibility

The intake of silage S2 was significantly higher than S1 ($P < 0.05$) (Table 4). This variation seems to be related to the physical aspect of the silages. Intake of S2 is slightly higher than that of a mixed diet composed of 75% of date stones and 25% of clover hay (61.5 g DM/kg $BW^{0.75}$) (Gihad *et al*., 1989).

The *in vivo* digestibility of DM of silage S1 was higher ($P < 0.05$) compared to silage S2 (51.5 against 47.9% respectively) (Table 5). This difference could be explained by the high level of intake in the case of S2, this trend should result in a rapid transit and a decrease in the time for microbial digestion in the rumen. The digestibility of the OM of the 2 silages was not significantly different ($P > 0.05$) although it is slightly more elevated in the case of S2 (54.9 and 58.1%, respectively for S1 and S2). These values of digestibility (DMD and OMD) are characteristic of an average quality forage that could be distributed to animals at maintenance or low-production. This was confirmed by an absence of LW change during the 2 experimental periods (42 days).

Table 5. Intake and *in vivo* digestibility of silages

	DMD (%)	OMD (%)	CPD (%)	NDFD (%)	Intake (g DM/kg $LW^{0.75}$)
Silage 1	51.5*	54.9	76.8**	26.4	46.0*
Silage 2	47.9*	58.1	71.0**	27.7	65.5*

*,**For the same parameter, digestibilities of the 2 silages are significantly different.
*$P < 0.05$, **$P < 0.01$.

Most ingredients of this fodder have the advantage to be produced at the level of the oasis, with the exception of wheat bran which was incorporated at a limited level (15% of the DM). It has a relatively low cost compared to commercialised hays coming from the north of the country.

The high values of CP digestibility found in the current work (76.7 and 70.9% for S1 and S2, respectively) do not necessarily reflect a good nitrogen absorption but are linked to the addition of urea which is highly fermentable. NDF digestibility values of the two silages (S1 and S2) were comparable (26.4 and 27.7%, respectively).

Conclusion

The present work showed that ensiling could be an alternative technique to conserve DPBP for animal feeding. Thanks to this technique the period of the utilization of these by-products could be extended. The mixture of DPBP (stems or leaves, and wasted dates) and integration of other ingredients (bran, urea) resulted in a more balanced forage. DPBP-silages investigated in this study provide medium quality forages which, should be given as sole diet only to animals at maintenance or low production. They can also be an interesting substitute to hay or straw when these products are not available. Finally, increasing proportions of wasted date in the silage could improve its nutritive value.

Acknowledgments

Authors are grateful to "Groupement Interprofessionnel des Dattes (GID)", CRDA of Kébili and regional directions of IRA at Gabès and Kébili for plant material processing.

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