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ORIGINAL PAPER

PHYSICOCHEMICAL PROPERTIES OF DAIRY COW FEED RATIONS IN BLIDA, A REGION IN NORTHERN ALGERIA

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Abstract

The nutritional value of a feed ration for dairy cows depends on the values of forages and concentrates. The aim of this study was to determine the physicochemical properties of a dairy cow ration (hay, oats, clover, alfalfa, mature and premature barley and concentrate) in the region of Blida, in northern Algeria. Physicochemical analyses included: dry matter (DM), organic matter (OM), mineral matter (MM), total nitrogen (TN), fat (MG), insoluble ash (IA), major (Ca, P, Mg, K, Na) and minor minerals (Mn, Cu, Zn, Fe). The results showed that hay and concentrate were the richest in DM (86.60 ± 3% and 84 ± 0.62%, respectively) ($p < 0.001$). Alfalfa was characterized by a higher content of TN (21 ± 0.87%), while the lowest value of TN was found in hay (2.97 ± 0.02%) ($p < 0.001$). The concentrate contained the highest levels of MM (13.30 ± 0.42%), MG (5.26 ± 0.21%) and IA (2.11 ± 0.25%), and hence it was the poorest in OM (86.70 ± 0.42%) ($p < 0.001$). As for the minerals, hay was characterized by a higher Ca content (18.7 ± 0.48 g kg^{-1} DM) and lower in P (1.9 ± 0.09 g kg^{-1} DM), Na (32 ± 2.40 g kg^{-1} DM), Zn (31 ± 11.29 mg kg^{-1}) and Cu (4.69 ± 0.74 mg kg^{-1}). Oat was the lowest in Fe (19 ± 0 mg kg^{-1}) and the second richest in K (48 ± 0.79 g kg^{-1} DM) after clover (51.7 ± 1.11 g kg^{-1} DM) ($p < 0.001$). Alfalfa showed the highest Na content (63 ± 0 g kg^{-1} DM) ($p < 0.001$). As for Fe, premature barley showed the highest value (55 ± 4.30 mg kg^{-1}) ($p < 0.001$). The concentrate was found to be the richest in Mn (98 ± 5.64 mg kg^{-1}) and Zn (110 ± 1.32 mg kg^{-1}) ($p < 0.001$). The results of this study provide important support for the rationing of dairy cattle in Algeria. Acquisition of additional references on the nutritional properties of feeds is necessary in order to better predict the nutritional value of rations.

Keywords: feed, dairy cow, physicochemical analysis, nutritional value.

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INTRODUCTION

Diet is a key to the success or failure in reproduction because it provides the cow with all the energy, protein and minerals needed to meet its maintenance needs during gestation and production (Obese et al. 2013). The nutritional value of a ration for cows depends on the values of forages and concentrates. Good quality forage requires less concentrate to correct the ration (Cauty, Perreau 2003). In dairy cows, the nature of a ration appears to be a major factor in the milk composition of fatty acids, vitamins and carotenoids (Lucas et al. 2006, Couvreur, Hurtaud 2007). Forages contribute to an increase in milk fatty acids through the microorganisms that transform cellulose and hemicellulose into acetates and butyrates, precursors of milk fat (Mansbridge, Blake 1997). The mineral constituents of a ration play a very important part in animal reproduction and a critical role in the proper functioning of enzymes, hormones and cells (Yasothai 2014).

Research on the nutrition of ruminants requires sound knowledge of the chemical composition and value of feeds in a ration. Tables of chemical composition and food value are the main means for synthesizing and disseminating knowledge on the value of fodder for ruminants (Baumont et al. 2005), for example, the ADAS tables in the United Kingdom, NRC in the USA, CVB in the Netherlands, INRA in France (Baumont et al. 2005), Switzerland (Daccord et al. 1999), and those proposed in Germany in the Rostock Food Value System (Jentsch et al. 2003). However, more precise evaluation of the value of a feed can be obtained from physicochemical laboratory analyses.

The cattle stock in Algeria is 2 049 652 (MADR 2014) and 80% of milk production is provided by the dairy herds (Kacimi El Hassani 2013). However, physicochemical analyses of the rations given to the dairy cattle countrywide are still insufficiently few and need to be updated periodically (Zirmi -Zembri, Kadi 2016), which would allow sufficient but not excessive supplementation. Consequently, there is an acute need to assess the nutritional status of dairy cattle. In the present research, we studied the physicochemical content of rations fed to dairy herde in Blida region, northern Algeria.

MATERIAL AND METHODS

Study area

The study was conducted in Blida, a region which located in the Mitidja Plain, north-central Algeria, which has fertile lands with gentle slopes and an altitude ranging from 50 to 150 m. Agriculture is the main sector of economy, with the total agricultural land area equal 67 700 ha. The diversity of soil conditions determine the cultivation of different crops, e.g. citrus fruits are grown in the center of the plain mainly, the grapevine is cultivated everywhere, as well as cereals, forage and vegetable crops; there are also industrial crops (MADR 2006).

The minimum temperatures vary between 0°C and 9°C and the maximum temperatures range between 28°C and 38°C. Precipitation ranges from 900 to 1200 mm per year (ANGR 2003).

Samples

The study was carried out in March 2014, during the harvest of green fodder, and included physicochemical analyses of two groups of feed for dairy cows: forages (hay, oats, clover, alfalfa, mature and premature barley) and concentrate.

Samples were taken in plastic bags and transported immediately to the laboratory. The analyses included determinations of dry matter (DM), organic matter (OM), mineral matter (MM), total nitrogen (TN), fat (MG), insoluble ash (IA) and the minerals: macroelements (Ca, P, Mg, K, Na) and microelements (Mn, Cu, Zn, Fe).

Laboratory analysis

Determinations of DM, MO and ash were carried out according to Sauvant (1988). In the ash obtained according to Sauvant (1988), the IA was measured with the technique described by INRAT (1997). Briefly, ash was dissolved in a solution of hydrochloric acid (1N HCl) (5 ml of HCl for each gram of sample) and filtered on ash-free filter paper. The filter and residues are incinerated at 550°C for 8 hours. The IA represents the residue after the incineration.

The TN content was evaluated according to the Kjeldahl method (AOAC 1999). Determination of MG concentration was performed using a Soxhlet extractor (AOAC 1990).

Determination of macroelements (Ca, Mg, K and Na) and microelements (Cu, Mn, Zn and Fe) was performed according to Elmer (1994). For phosphorus (P) determinations, assays was carried out according to the technique described by Kamoun (2008).

Statistical analysis

Data were expressed as means ± SD. For multi-variable comparisons, one-way ANOVA was conducted, followed by the Tukey-Kramer testing using the program R software version 3.0.1 (R Core Team 2013). Differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

Physicochemical analyses showed that hay and concentrate were the richest in DM (86.60±3% and 84±0.62%, respectively $p < 0.001$ – Table 1. The lowest concentrations of DM were found in oats (12.70 ± 5.04), clover (14.50 ± 2.22%) and alfalfa (13.90 ± 3.42%) ($p < 0.001$) (Table 1).

Dry matter (DM) is important in animal nutrition because it establishes the quantity of nutrients available to an animal for health and production. The current or precisely estimated DM content is important for the formulation of diets so as to prevent underfeeding or overfeeding of nutrients and to promote efficient nutrient use (NRC 2001).

A dry matter (DM) content of 85% or more indicates that the plant is dead, its enzymes inactive and the development of mold becomes impossible because they do not have enough water to remain active and to multiply (Demarquilly et al. 1998). The INRA (1984, 1988) tables for feed composition for ruminants indicate that the DM content is 19.3% in alfalfa, 18% in clover, 85% in hay, 18% in oat, 42% in barley and 85-90% in concentrates.

The results reported in our research regarding the dry matter content (alfalfa, barley and oats) are low compared to the above standards (INRA 1984 1988). However, for hay (86.60 ± 3%), clover (14.50 ± 2.22) and concentrate (84 ± 0.62%), the values are close to the INRA (1984) standards. The study carried out by Arab et al. (2009) in Algeria showed dry matter percentages of 86.21%, 21.5% and 36.56% in hay, barley and oats, respectively. These values are comparable to our finding. Also, our results are close to the results shown by Demarquilly and Andrieu (1992) for clover and alfalfa.

The percentages of OM and MM revealed in our study are in agreement with those reported by Arab et al. (2009), who determined 93.29% of OM and 7.89% of MM in hay, 92.3% of OM and 7.7% of MM in barley, and 8.35% of MM and 91.65% of OM in oats. Forages (clover and alfalfa) contained 90.41% of OM and 9.59% of MM.

The feed composition tables for ruminants (INRA 1984) predicted a percentage of OM equal 90% to 92% in hay, 90% in alfalfa, 88.3% in clover, 87% in oats, 93% in barley and 84% to 87% in concentrate. Our results are comparable to these proportions and to ones indicated by other authors (Mauriès 2003, Amrane, Gaous 2010, Najar et al. 2011, Abidi, Benyoussef 2016).

As regards the TN content, the values described in the feed composition tables for ruminants (INRA, 1984) indicate a 20% level in alfalfa, 15.4 to 19% in clover, 8 to 20% in hay, 8.7 to 10.6% for oats and 8% for barley. In concentrates, TN varies from 8% to 47%, depending on their composition.

Comparing our results with the above proportions, we find that they are comparable for clover, alfalfa, barley and concentrate, slightly low for oats, and very low for oat hay.

Alfalfa is a plant characterized by its richness in TN (14 to 29% of DM)

Table 1

Physicochemical properties of different feeds (means% ± SD)

Foods	DM (%)	Moisture (%)	OM (%)	MM (%)	TN (%)	MG (%)	IA (%)
Hay	$86.60^a \pm 3$	13.4	$91.80^a \pm 2.68$	$8.20^b \pm 2{,}68$	$2.97^e \pm 0.02$	$0.47^c \pm 0.01$	$1.83^b \pm 0.19$
Oats	$12.70^d \pm 5.04$	87.3	$91.45^a \pm 2.19$	$8.55^b \pm 2{,}19$	$7.70^d \pm 0.12$	$2.12^b \pm 0.07$	$1.80^b \pm 0.18$
Clover	$14.50^d \pm 2.22$	85.5	$90.30^a \pm 3.53$	$9.70^b \pm 3{,}53$	$15.05^b \pm 0.17$	$2.26^b \pm 0.09$	$1.95^b \pm 0.009$
Alfalfa	$13.90^d \pm 3.42$	86.1	$89.35^a \pm 0.49$	$10.65^b \pm 0{,}49$	$21^a \pm 0.87$	$0.99^c \pm 0.01$	$1.96^b \pm 0.01$
Premature barley	$23.50^c \pm 2.49$	76.5	$92.60^a \pm 1.97$	$7.40^b \pm 1{,}97$	$12.25^c \pm 0.34$	$0.86^c \pm 0.01$	$2.03^b \pm 0.22$
Mature barley	$36.20^b \pm 2.68$	63.8	$91.10^a \pm 0.98$	$8.90^b \pm 0{,}98$	$8.22^d \pm 0.22$	$0.78^c \pm 0.02$	$1.83^b \pm 0.04$
Concentrate	$84^a \pm 0.62$	16	$86.70^b \pm 0.42$	$13.30^a \pm 0{,}42$	$17.85^b \pm 0.51$	$5.26^a \pm 0.21$	$2.11^a \pm 0.25$

^{a,b,c,d,e} Values not marked with the same letter in the same column are different at $p < 0.05$.

(Mauriès 2003). In our study, alfalfa was characterized by a higher content of TN (21 ± 0.87%), while the lowest value was found in hay (2.97 ± 0.02%, $p < 0.001$) Table 1.

Dietary fat should not exceed 6-7% of DM. Feeding higher concentrations of MG can result in reduced DM intake, even if MG has minimal effects on ruminal fermentation (Schauff, Clark 1992). In our study, the MG content was well above this value.

Arab et al. (2009) reported MG concentrations between 1.35 and 1.75% in hay, 1.81% in oats, 1.54% in barley and 1.88% in forages (clover and alfalfa). These concentrations are comparable to what we recorded in our study.

Arab et al. (2009) found an IA content of 1.91% in forage (clover and alfalfa), 2.78% in oats and 0.05% to 4.11% in hay. These values are close to what we observed. However, the IA content in barley found by Arab et al. (2009) was higher than in our study (4.5%).

The concentrate showed the highest concentrations of MM (13.30 ± 0.42%), MG (5.26 ± 0.21%) and IA (2.11 ± 0.25%) and consequently had the lowest MO (86.70 ± 0.42%, $p < 0.001$) Table 1.

Accordion to Baumont et al. (2009), the nutritive value of diet depends on the harvesting practice and type of conservation of fodder plants. In our study, the principal component analysis (PCA) revealed two groups of feeds: the first group included green fodders (clover, alfalfa, vetch-oats, mature and premature barley) and the second one consisted of hay and concentrate (Figure 1).

Concentrations of mineral elements in both concentrate and forage feedstuffs vary greatly (NRC 2001). Concentrations among samples of the same feed type may be quite variable, depending on such factors as fertilization and manure application doses, soil type and plant species (Baumont et al. 2009).

In our study, the mineral levels differed depending on the type of feed. For example, hay was characterized by a higher Ca content (18.7 ± 0.48 g kg^{-1}) and lower P (1.9 ± 0.09 g kg^{-1}), Na (32 ± 2.40 g kg^{-1}), Zn (31 ± 11.29 mg kg^{-1}) and Cu levels (4.69 ± 0.74 mg kg^{-1}, $p < 0.001$) Table 2.

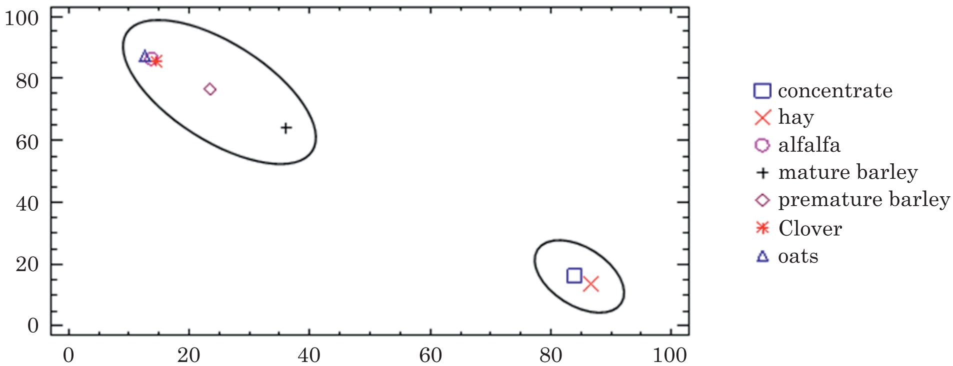

Fig. 1. Principal component analysis of physicochemical properties of the different feeds

Table 2

Mineral content in different foods (means ± SD)

Foods	Mineral major (g kg^{-1} DM)						Mineral minor (mg kg^{-1} DM)			
	Ca	P	Mg	K	P/Ca	Na	Mn	Zn	Cu	Fe
Hay	$18.7^{a} \pm 0.48$	$1.9^{b} \pm 0.09$	$2.2^{a} \pm 0.81$	$41.7^{b} \pm 4.16$	0.10	$32^{e} \pm 2.40$	$19^{c} \pm 2.36$	$31^{e} \pm 11.29$	$4.69^{e} \pm 0.74$	$37^{c} \pm 0$
Oats	$14.2^{b} \pm 4.99$	$2.5^{a} \pm 0.41$	$2.1^{a} \pm 0.47$	$48^{a} \pm 0.79$	0.17	$58^{b} \pm 4.16$	$50^{b} \pm 3.46$	$56.1^{b} \pm 3.23$	$15^{c} \pm 0.74$	$19^{e} \pm 0$
Clover	$10.1^{c} \pm 1.23$	$2.2^{a} \pm 0.014$	$2.5^{a} \pm 0.012$	$51.7^{a} \pm 1.11$	0.22	$40^{d} \pm 2.40$	$21^{c} \pm 2.72$	$36.5^{d} \pm 6.60$	$30.8^{a} \pm 1.28$	$47^{b} \pm 10.34$
Alfalfa	$9.21^{c} \pm 3.4$	$2.1^{a} \pm 0.014$	$2.6^{a} \pm 0.092$	$43.4^{b} \pm 2.13$	0.22	$63^{a} \pm 0$	$23^{c} \pm 1.68$	$47.9^{c} \pm 5.67$	$29.1^{a} \pm 3.91$	$40^{c} \pm 0$
Premature barley	$8^{c} \pm 1.81$	$2^{a} \pm 0.084$	$1.6^{b} \pm 0.12$	$14.3^{c} \pm 0.16$	0.25	$32^{e} \pm 4.81$	$22^{c} \pm 2.24$	$42.1^{c} \pm 7.41$	$23.1^{b} \pm 2.22$	$55^{a} \pm 4.30$
Mature barley	$5.51^{d} \pm 0.15$	$2.2^{a} \pm 0.014$	$1.5^{b} \pm 0.10$	$13.7^{c} \pm 0.06$	0.40	$25^{e} \pm 0$	$15^{d} \pm 1.50$	$35.5^{d} \pm 6.42$	$9.39^{d} \pm 0.74$	$25^{d} \pm 4.30$
Concentrate	$9.29^{c} \pm 2.17$	$2.8^{a} \pm 0.07$	$2.8^{a} \pm 0.049$	$12.9^{d} \pm 0.41$	0.30	$49^{c} \pm 2.40$	$98^{a} \pm 5.64$	$110^{a} \pm 1.32$	$29.1^{a} \pm 0.74$	$47^{b} \pm 11.39$

$^{a.b.c.d.e}$ Values that are not marked with the same letter in the same column are different at $p < 0.05$.

Oat was found to be the lowest in Fe (19 ± 0 mg kg^{-1}) and the second highest in K (48 ± 0.79 g kg^{-1} DM) after clover (51.7 ± 1.11 g kg^{-1} DM, $p < 0.001$) Table 2. Alfalfa showed the highest Na content (63 ± 0 g kg^{-1} DM, $p < 0.001$) Table 2.

Many plant species have different capacity to accumulate mineral elements, even if they are grown under the same conditions (Bengtsson et al. 2003, Warman, Termeer 2005).

The content of macrominerals in our study is comparable to that reported by Arab et al. (2009), except for the Mg content of hay and oats, K in forages (clover and alfalfa) and Na in barley and oat, which were low in our research. On the other hand, Arab et al. (2009) reported higher levels of K in barley and oats than our results. The values reported by Mauriès (2003) for the content of Mg, Ca and P in alfalfa are comparable to those shown in our study. As for K and Na, our values are higher.

With repect to microminerals, the Zn levels of feeds in our results are comparable to those given by Arab at al. (2009). As regards Mn, our results are very low compared to the results of Arab et al. (2009) and Mauriès (2003).

According to Rollin (2002), an ideal concentration of Cu in a diet should be 10 mg kg^{-1} but this value is likely to be doubled in high production animals. The Cu levels reported in our study in oats, clover and alfalfa are superior to those reported by Arab et al. (2009). On the other hand, in hay, the content was low. Similar values were reported for barley.

The content of Cu and Zn in alfalfa reported by Mauriès (2003) is lower than determined in our study. The content of microminerals in premature barley was higher than in mature barley ($p < 0.001$) – Table 2. The influence of the stage of development on levels of microminerals observed in our study is consistent with the observations made by Schlegel and Wyss (2013). On the other hand, both and mature premature barley showed the lowest values of in Mg: 1.6 ± 0.12 g kg^{-1} DM and 1.5 ± 0.10 g kg^{-1} DM, respectively ($p < 0.001$) – Table 2. The concentrate was found to be the richest in Mn (98 ± 5.64 mg kg^{-1}) and Zn (110 ± 1.32 mg kg^{-1}) ($p < 0.001$) – Table 2. Mature barley showed the highest value of the P/Ca ratio (0.40) while hay gave the lowest value of this ratio (0.10) – Table 2.

Finally, the nutritional value of a dairy cattle diet varies as a function of several factors, which are important to know so as to gain better understandig and to predict more accurately the contribution of a diet to the nutritional properties of animal products (Martin et al. 2009, Graulet et al. 2008). Indeed, the nutritive value of a diet depends on cultivation practice (choice of species and varieties, fertilization, irrigation), harvesting management (dates and frequency of harvests, grazing management) and conservation (types of silage and hay) (Baumont et al. 2009). An increase in forage productivity (dilution phenomenon), soil fertilization practices, and the fact that plant breeding focuses on organic matter (energy and nitrogen) can all act to the detriment of the mineral content of a diet (Baumont et al. 2009). An increase in the frequency of forage cutting has the consequence of keeping them at a younger age, with a higher proportion of leaf blades or leaves and therefore a higher forage feed value. Good pasture management is based on this principle (Pontes et al. 2007).

CONCLUSION

Determination of the physicochemical content of a ration allows for its sufficient but not excessive supplementation. An excess represents a financial loss, a risk of environmental pollution (copper and zinc in particular) and a possible deficiency of other minerals (antagonism). The results of this study provide an important support for the rationing of dairy cattle in Algeria. The acquisition of additional references on the nutritional value of dairy cattle ration is necessary in order to better predict their value. For the future, further studies are required to propose equations for predicting the nutritional value of diet and, it is important to study the content of diet according to the stage of the plant, the type of soil and conservation (silage).

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