

ORIGINAL ARTICLE

## Feeding practices of dairy cows in Algeria: Characterization, typology, and impact on milk production and fertility

Said Boukhechem<sup>1</sup>, Nassim Moula<sup>2</sup>, Nedjoua Lakhdara<sup>1</sup>, Rachid Kaidi<sup>3,4</sup>

<sup>1</sup>Institute of Veterinary Science, University of Mentouri Constantine 1, 25017 Constantine, Algeria

<sup>2</sup>Department of Animal Production, Division of Genetics and Biostatistics, Faculty of Veterinary Medicine, University of Liege, 4000 Liege, Belgium

<sup>3</sup>Institute of Veterinary Sciences, Laboratoire des Biotechnologies liées à la Reproduction Animale (LBRA), University of Blida 1, PB270 Blida, Algeria

<sup>4</sup>School of Veterinary Medicine and Science, University of Nottingham, Nottingham, Leicestershire, UK

### ABSTRACT

**Objective:** To explore feeding strategies and identify eventual errors that could cause poor production and reproduction performances in dairy farms in the north of Algeria.

**Materials and Methods:** A survey was conducted among 211 farms of different sizes, from 2014 to 2018 to compose a database that is analyzed statistically.

**Results:** The results relative to the nutritive value of the rations showed an average dry matter intake of  $15.9 \pm 4.74$  kg/cow/day, providing  $13.2 \pm 4.34$  UFL (Feed Unit for Lactation) of net energy and  $1306 \pm 456$  gm of protein digested in small intestine (PDI)/cow/day. A high proportion of concentrate intake is observed, with an average of  $64.7\% \pm 17.4\%$  of energy intake and  $70.2\% \pm 16.2\%$  of nitrogen intake. Dairy cows performances were characterized by a low milk production regarding their genetic potential ( $14.2 \pm 4.73$  kg of milk/cow/day), a calving interval > to one year ( $397 \pm 20.4$  days), though the coverage rates of their nutrient requirements reached 120%. The typology of the dietary rations allowed grouping them into three categories: deficient rations cluster (DR), correct rations cluster, and excessive rations cluster (ER). DR and ER, which are not adjusted to animals' needs, were found in 57.8% of farms.

**Conclusion:** It is obvious that the feeding management in the dairy farms in the North of Algeria is not based upon scientific achievements, contributing to relatively low performances of cows as well as to important financial losses. This finding imposes the necessity to adopt a correct and accurate rationing of animals.

### ARTICLE HISTORY

Received August 07, 2019

Revised September 08, 2019

Accepted September 09, 2019

Published November 02, 2019

### KEYWORDS

Algeria; calving interval; dry matter; fertility; net energy intake; nitrogen intake



This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 Licence (<http://creativecommons.org/licenses/by/4.0>)

### Introduction

Algeria is considered as one of the largest consumers of milk, and its products with an annual average estimated to 150 l per capita recorded in 2015 [1], while international standards set by the World Health Organization evaluated at 90 l/capita/year. Consumption that the local production can only satisfy by 33% [2]; therefore, the shortfall is filled by imports of milk powder at around 67% (868 million dollars a year milk imports invoice [3]), which is obviously an important overhead cost on the Algerian state budget [3].

Although the milk production recorded a positive increase between 2009 and 2015 following the measures taken by the government in the context of several plans to develop and to improve the sector, it remains low considering the genetic potential of modern dairy cattle, which can grow on average between 5000 and 6000 kg per lactation in their country of origin [4].

The low productivity of dairy cattle is the result of several ecological, technical, and socio-economic obstacles, which limit the farms profitability [5], and bother the good expression of the genetic potential of the cows, which

**Correspondence** Said Boukhechem ✉ [said.boukhechem@umc.edu.dz](mailto:said.boukhechem@umc.edu.dz) 📧 Institute of Veterinary Science, University of Mentouri Constantine 1, 25017 Constantine, Algeria.

**How to cite:** Boukhechem S, Moula N, Lakhdara N, Kaidi R. Feeding practices of dairy cows in Algeria: Characterization, typology, and impact on milk production and fertility. *J Adv Vet Anim Res* 2019; 6(4):567–574.

show a drastic drop of their milk production (national milk production average estimated at 13.38 l/cow/day) [6]. In addition to the insufficiency of forage resources, an uncontrolled diet is undoubtedly the most incriminated reason for low production [4]. The aim of this study is to describe and evaluate the feeding management of dairy cows in Algerian farms and, thereby, identify possible errors of rationing that contribute to the fall in milk production of cows in order to correct them in the future.

## Materials and Methods

### Study area and choice of farms

The study was conducted in 211 farms of different sizes distributed in five regions of the north of Algeria (Fig. 1): 146 farms were located in the region of Relizane [35°74'N, 0°55'E at 85 m above sea level (ASL)], 59 farms in Souk-Ahras (36°28'N, 7°95'E at 683 m ASL), four farms in Constantine (36°34'N, 6°66'E at 703 m ASL), one farm in Tipaza (36°59'N, 2°68'E at 221 m ASL), and one farm in the region of Medea (36°22'N, 2°56'E at 687 m ASL). These farms gathering a total of 3758 dairy cows of different breeds were chosen for practical reasons of accessibility and availability of data (convenience sampling).

### Survey

The descriptive investigation approach adopted involves the use of cross-sectional surveys. They were carried out for 4 years (from 2014 to 2018) and allowed to recover a large number of data. The questionnaire established to achieve these surveys covered the compositional aspects as well as the amount of daily food rations served to the cows, the amount of the milk collected daily, the data of the milk fat analyzes realized by the collector, and, finally, the dates of calvings.

### Data analysis

First, the nutritional values of the rations were calculated from the Ruminant Feed Nutritional Value, Tables of Institut



**Figure 1.** Geographic location of study sites (Algeria).

National de Recherche Agronomique (INRA) [7] to determine their total dry matter (DM), net energy, nitrogen, and mineral intakes (calcium and phosphorus). Afterward, the theoretical needs of cows were calculated. Maintenance needs were first estimated according to an average live weight of 600 kg, production needs were determined upon the daily milk yield average, which allows evaluating the coverage rates of different nutrient requirements of dairy cows per farm. The average dairy performances per cow, per farm, and per day were estimated for the month corresponding to the visit by dividing the total amount of the produced milk during this month by the number of the days and by the number of the lactating cows. Concerning the assessment of the fertility in the farms and the calving interval (CI), the most technico-economic criterion in dairy production [8,9] was deduced by calculating the average of the recorded intervals.

### Statistical analysis

Analysis of variance was performed with GLM procedure in SAS (Statistical Analysis System; SAS Release 9.1) to study the effect of certain factors (qualitatives). The used model form is:  $Y_{ijkl} = u + R_i + ST_j + SZ_k + FN_l + e_{ijkl}$

$u$  = general mean

$R_i$  = region effect ( $i = 1-5$ )

$ST_j$  = effect of the farm status ( $j = 1-2$ )

$SZ_k$  = effect of the season ( $k = 1-4$ )

$FN_l$  = effect of the forage nature ( $l = 1-4$ )

$e_{ijkl}$  = residual error

To study the effect of certain factors (quantitatives), the Pearson correlation coefficients were calculated using the CORR procedure by the R software (version 3.4.4).

To establish the typology of the distributed rations of the cows, a principal component analysis (PCA) was done by the R software.

## Results and Discussion

### Global characteristics of feeding practices

The studied diets were characterized by a total average dry matter intake varying from 5.2 to 29.7 kg per cow and per day with an average of  $15.9 \pm 4.74$  kg, equal to 2.65 kg per 100 kg of live weight. This value is slightly below the cited standards in the literature [10] and those observed by Ouarfli and Chehema [11] in Ouargla in the desert (19.5 kg), Ghozlane et al. [12] in Constantine ( $19.3 \pm 2.02$  kg/day) and Srairi and Kessab [13] in Morocco (19.4 kg/day).

In fact, in 3.3% of the farms, the rations were only composed of fodder, in 13.3%, the concentrate provided less than 30% of dry matter, whereas it has brought more than 50% in 39.8% of the farms.

Hence, the proportion of fodder in dry matter intakes varied from 17.95 to 100% for an average of  $55\% \pm 15.6\%$  per farm. In the majority of farms (56.9%), the fodder

distributed was in its dry form (hay or straw), while green fodder was present in 39.8% served alone (4.7%) or with dry roughage (35.1%). Silage was observed only in 3.3% of the farms.

As a result, the concentrate provided  $44.9\% \pm 15.6\%$  of the dry matter, ranging from 0% to 82.1%. This proportion is represented by a mean daily concentrate intake of  $8.47 \pm 3.71$  kg per cow, per day, and per farm. Concentrates were offered twice daily before or during milking. This value, which is comparable to that reported by Ghozlane et al. [12] in Constantine ( $41.9\% \pm 8.33\%$ ) and lower than that recorded by Ouarfli and Chehma [11] in Ouargla (58.6%), remains above the recommended standards [14]. It is due to a lack of fodder sources area and poor quality fodder. The high proportion of concentrate in the diets may cause an increase in risk of metabolic diseases and increase the production cost.

It was found that the amount of concentrate distributed, and thus, the forage/concentrate ratio varied upon the nature of the fodder composing the basic ration. When the latter consisted only of dry fodder (hay and/or straw), a proportion of concentrate of 51% was recorded comparing to 35.3% when the basic ration was composed of dry fodder mixed with green fodder.

#### **Nutritive value and equilibrium state of diets**

The total net energy average provided by the diets is evaluated at  $13.2 \pm 4.34$  UFL per cow per day, equal to 0.83 UFL per 1 kg of dry matter. This energy intake allows theoretically producing an amount of milk equivalent to 18.7 kg.

It is important to note that concentrate gives the cows nearly 2/3 of this energy:  $64.7\% \pm 17.4\%$ . This ratio is higher than those recorded by Ouakli and Yakhlef [15] in the dairy basin of Mitidja ( $56\% \pm 0.25\%$ ), Madani et al. [16] in the semi-arid region of Sétif (42% to 53%), Ghozlane et al. [12] in Constantine ( $56.0\% \pm 7.42\%$ ), and El-Khattar [17] and Srairi [18] in the region of Rabat-Salé in Morocco (51% and 55%, respectively). On the other hand, it is lower than that reported by Ouarfli and Chehma [11] in the saharien region of Ouargla (71%) and Srairi and Kessab [13] in six specialized farms in Morocco (73.1%).

The yield of the net energy of concentrate per kg of the produced milk is  $0.66 \pm 0.39$  UFL/kg. It is higher than those reported by Madani et al. [16] in three farms in Sétif (0.32 to 0.53 UFL/kg) and lower than those observed by Kadi et al. [19] in Tizi Ouzou ( $0.80 \pm 0.14$ ) and Srairi and Kessab [13] in Morocco (0.75 UFL/kg). This situation is caused by the poor quality of the fodder but especially by the small quantities consumed.

Regarding nitrogen rationing, the average total intake of nitrogenous matter was  $1306 \pm 456$  g PDI per cow per day, with a mean difference recorded between protein digested in the small intestine when rumen-fermentable nitrogen is

limiting (PDIN) and protein digested in the small intestine when rumen-fermentable energy is limiting (PDIE) of  $138 \pm 142$  g PDI. The theoretical amount of milk allowed by this intake is 19.1 kg/day.

The proportion of concentrate in the total nitrogen intake is  $70.2\% \pm 16.2\%$ , lower than 75.6% reported by Ouarfli and Chehma [11] in Algeria's desert.

This high proportion of concentrate in energy and nitrogen intakes may indicate that this one also covers some of the maintenance needs, while the latter is supposed to be covered by the basic ration composed of fodder [10].

Excessive use of concentrate may increase the risk of metabolic disorders, particularly the subclinical form that constrains both production and fertility of cows [20] and increases production costs and, therefore, causes considerable economic losses.

This finding was made earlier by several researchers [21,22]. It is due, according to them, to the fodder deficit that characterizes the whole farms in Algeria with a low production (poor exploitation of the available agricultural area and low irrigation) and/or the insufficiency of the supply of fodder resources. In most farms, the fodder is of poor quality and is only used for its filling effects.

The nitrogen/net energy ratio of the diet presents an average of  $99 \pm 13.3$  gm of PDI/UFL. It is close to recommendations (95 gm) and just below the upper tolerated limit (100–105 gm) to cover the needs of animals while avoiding nitrogen wastes and their negative environmental impacts and controlling the food cost [23]. A quarter of farms (25.1%) have a nitrogen/net energy ratio greater than 105 gm.

The microbial ratio (Rmic), which determines a tolerable deficit in PDIN relative to the PDIE, compensated by PDIN from salivary urea [23] ranged from -79.2 to +35.6 gm of PDI/UFL. It was below the threshold value (-8 for a production level ranging from 15 to 25 kg milk/d/cow) in 26.5% of farms. Nevertheless, there are not very high Rmic values that may be detrimental from an environmental point of view (higher urinary nitrogen release) and economic (nitrogen concentrates are often expensive).

The mean difference between the theoretical milk yield allowed by the net energy and that allowed by the nitrogen of the ration was  $2.89 \pm 3.22$  kg of milk reflects an imbalance of the rations. This gap between the energy and protein intakes of the ration (energy wastage) is a limiting factor that determines the resultant production of a compromise between the two factors. Body reserves would serve as a buffer, at least for relatively short periods and allow cows to be in good body condition [24].

The coverage rates of energy and nitrogen requirements were estimated with mean values ranging from  $120\% \pm 43.4\%$  and  $120\% \pm 46.5\%$  consecutively. Energy requirements were covered in 68.1% of rations, while in

31.9%, these needs were not covered. Similarly, nitrogen requirements were covered in 65.4% of farms.

Regarding the contributions of mineral materials, they were deficient with a total average calcium intake of  $41.4 \pm 22.1$  gm and, therefore, an overall coverage rate of  $48.2\% \pm 28.3\%$ . Rations in which calcium requirements were covered accounted for only 5.76% of the total, while phosphorus requirements were covered in 66.5% of the visited farms with an average total intake of  $135 \pm 68.3$  gm per cow and per day and an average coverage rate of phosphorus requirements of  $124\% \pm 51.4\%$ .

Phosphocalcic requirements were not covered in most farms. This may be due to low inputs of forages considered as the main source of ingested minerals. These phosphocalcic deficiencies and imbalances can have multiple consequences (sterility, low milk production, milk fever, less resistance to microbial and parasitic diseases, etc.), inducing serious economic impact [23].

The variations of the nutritional values of these rations according to different factors have been disparate. The statistical study shows that a large variability in the nutrient intakes of rations from one region to another ( $p < 0.01$ ) with an increase in DM, net energy, nitrogen, calcium, and phosphorus intakes has been observed starting from the east to the west of the country. This is probably due to the increase in the proportion of the concentrate in the diet that has varied in the same way. The coverage rates of different nutrient requirements of the cows remain, however, independent of the effect of the region factor ( $p > 0.05$ ). The feeding practices were not therefore specific to the regions.

On the other hand, the status of the farm (public or private), the herd size, and the ration season had no significant effect on different nutrients intakes of the rations ( $p > 0.05$ ), while the ration season had a significant effect only on the coverage rates of net energy and nitrogen requirements ( $p < 0.05$ ). In addition, rations of winter period had the best coverage rates compared to spring and summer periods. This can be explained by the high intake of concentrate during the wintering.

### **Farms performances**

The milk yield represented by the average daily production was  $14.2 \pm 4.73$  kg per cow and per farm, ranging from 2.68 to 27.2 kg. This value is comparable to the national average (13.38 l) [6] and that recorded by Ghoulane et al. [12] in Constantine ( $14.9 \pm 2.74$  kg/cow/per day) but higher than those reported by Ouarfli and Chehma [11] in Ouargla (11.5 kg/cow/day) and by Kadi et al. [19] in Tizi Ouzou ( $12.78 \pm 3.67$  l).

An extrapolation permitted to estimate a production in 305 days of approximately  $4333 \pm 1444$  kg/cow. Despite the net energy and nitrogen intakes, which in theory allow

to produce higher quantities, this performance remains low and far from the performances recorded in the developed countries [25]. It reflects a poor expression of the genetic potential of cows. This can be explained by a deviation of the metabolism according to the composition of the ration and/or the existence of other stress sources (livestock buildings, temperature, hygiene), where, any deficiency, excess or imbalance in the diet may reduce milk production, degrade its quality, or even more cause nutritional diseases [10].

Dairy production was highly influenced ( $p < 0.01$ ) by dry matter, net energy, nitrogen intakes, the coverage rates of energy and nitrogen requirements, and to a lesser degree by the forage/concentrate ratio ( $p < 0.05$ ).

A large difference ( $p < 0.01$ ) was also observed between private and public farms, where the best production means were observed (Table 2).

Similarly, improvement in dairy performance was observed with the increase in the herd size ( $p < 0.05$ , Table 2). This can be explained by variations in practices between traditional and industrial livestock farming.

On the other hand, the average of the farms milk production was independent of the influence of the region, the ration season, and the nature of forages, the phosphocalcic intake and the lactation stage ( $p > 0.05$ ).

The produced milk fat (MF) was estimated at  $33.8 \pm 1.63$  gm/kg. It was highly influenced by farm status, regions, dry matter, net energy and nitrogen intakes, forage and concentrate proportion in the diet ( $p < 0.01$ ), and to a less degree by ration season, calcium, and phosphorus intakes ( $p < 0.05$ ). It should be noted that there was no significant effect ( $p > 0.05$ ) of the herd size, the nature of forages, and the lactation stage on the variations of the fat matter contained in the produced milk.

Concerning the fertility of the cows represented by the calving interval, it was estimated meanly of  $397 \pm 20.4$  days per cow and per farm. Knowing that the accepted standard for this parameter is around 365 days [8], only 3.66% of farms had a CI average less than or equal to 365 days.

Fertility was not influenced by diet composition and intakes with the exception of nitrogen and calcium intakes ( $p < 0.05$ ). All other factors including milk performance had no significant influence on fertility ( $p > 0.05$ ).

### **Typology and factors of variation**

In order to establish a typology of dietary rations of the sample, a PCA of 211 rations was applied to 15 quantitative variables contributing to a total inertia of the three first axes of 62.4%. The main plan (defined by axes 1 and 2) allowed a good graphic discrimination (Fig. 2): on the x-axis, the nutrient intakes of the rations (total DM, net energy intake, nitrogen intake, and coverage rates of



**Table 1.** Total intakes means of the studied rations.

Parameter	Total DM (kg)	Concentrate proportion (%)	Net Energy (UFL)	Nitrogen (gm of PDI)	Ca (gm)	P (gm)	
Mean ± standard deviation	15.9 ± 4.74	44.9 ± 15.6	13.2 ± 4.34	1306 ± 456	41.4 ± 22.1	61.4 ± 23.4	
Status	Public (1.4%)	12.7 ± 0.99	42.9 ± 10.2 <sup>a</sup>	11.3 ± 2.46	1236 ± 283	55.8 ± 19.1	57.1 ± 10.2
	Private (98.6%)	16 ± 4.75	45 ± 15.6 <sup>b</sup>	13.2 ± 4.36	1307 ± 458	61.5 ± 23.5	55.0 ± 15.6
Herd size	< 5 (1.4%)	19.3 ± 1.70	48.8 ± 6.83	18 ± 5.57	1869 ± 595	64.2 ± 21.3	51.2 ± 6.83
	5–9 (34.6%)	16 ± 4.69	42.1 ± 16.8	12.9 ± 4.23	1267 ± 440	59.8 ± 23.1	57.9 ± 16.8
	10–19 (45%)	15.9 ± 4.88	46.6 ± 15.7	13.3 ± 4.37	1292 ± 460	62.7 ± 24.1	53.4 ± 15.7
	20–49 (14.2%)	15.6 ± 5.19	44.4 ± 13.0	13.1 ± 4.78	1302 ± 464	61.3 ± 25.3	55.6 ± 13
	50–99 (2.4%)	16.7 ± 3.60	43.5 ± 6.28	14.3 ± 3.20	1536 ± 373	57.3 ± 14.2	56.5 ± 6.28
	≥ 100 (2.4%)	15.6 ± 2.37	56.6 ± 11.5	14.2 ± 2.13	1577 ± 393	63.3 ± 19	43.3 ± 11.5
Season	Winter (22.8%)	18.8 ± 3.67	49.7 ± 11.5	15.8 ± 3.51	1585 ± 400	72.8 ± 22.8	50.3 ± 11.5
	Spring (21.8%)	13.8 ± 3.42	42.2 ± 17.2	11.9 ± 3.53	1213 ± 369	61.2 ± 20.0	57.8 ± 17.2
	Summer (43.6%)	15.1 ± 4.98	42.8 ± 17.2	12.2 ± 4.46	1176 ± 466	54.4 ± 23.4	57.2 ± 17.2
	Autumn (11.8%)	17.4 ± 4.97	48.7 ± 9.10	14.5 ± 4.38	1417 ± 419	65.8 ± 22.1	51.2 ± 9.10
Typology clusters	Cluster 1 (30.8%)	11.3 ± 3.50 <sup>a</sup>	30.1 ± 15 <sup>a</sup>	8.48 ± 2.51 <sup>a</sup>	823 ± 255 <sup>a</sup>	44.6 ± 20.1 <sup>a</sup>	69.8 ± 15 <sup>a</sup>
	Cluster 2 (42.2%)	16.4 ± 2.75 <sup>b</sup>	55.1 ± 9.20 <sup>b</sup>	14 ± 2.3 <sup>b</sup>	1385 ± 258 <sup>b</sup>	63.7 ± 20.4 <sup>b</sup>	44.9 ± 9.20 <sup>b</sup>
	Cluster 3 (27%)	20.4 ± 3.66 <sup>c</sup>	46.1 ± 10.1 <sup>c</sup>	17.5 ± 3.13 <sup>c</sup>	1731 ± 369 <sup>c</sup>	77 ± 19.1 <sup>b</sup>	53.9 ± 10.1 <sup>b</sup>

<sup>abc</sup>The values on the same column with different letters in superscript are different in  $p < 0.05$ .

**Table 2.** Performances means of the surveyed farms.

Parameter	Milk production (kg)	Milk fat (gm/kg)	CI (day)	
<b>Total sample</b>	14.2 ± 4.73	34.7 ± 1.68	397 ± 20.4	
Status	Public	16.5 ± 1.44 <sup>a</sup>	34 ± 00 <sup>a</sup>	392 ± 6.66 <sup>a</sup>
	Private	14.2 ± 4.75 <sup>b</sup>	34.7 ± 1.68 <sup>a</sup>	397 ± 20.5 <sup>a</sup>
Herd size	< 5	11.0 ± 1.61	36 ± 00 <sup>a</sup>	393 ± 5.66 <sup>a</sup>
	5–9	14 ± 5.09	34.6 ± 1.77 <sup>a</sup>	401 ± 16.6 <sup>a</sup>
	10–19	14.1 ± 4.58	34.9 ± 1.56 <sup>a</sup>	396 ± 23.6 <sup>a</sup>
	20–49	14.8 ± 3.92	34.6 ± 1.93 <sup>a</sup>	392 ± 20.3 <sup>a</sup>
	50–99	18.1 ± 3.17	34 ± 00 <sup>a</sup>	390 ± 7.97 <sup>a</sup>
	≥ 100	16.2 ± 8.90	32 ± 00 <sup>a</sup>	390 ± 2.83 <sup>a</sup>
Season	Winter	15.1 ± 5.71 <sup>a</sup>	35.4 ± 1.27 <sup>a</sup>	401 ± 13.8 <sup>a</sup>
	Spring	14.9 ± 4.78 <sup>a</sup>	34.1 ± 1.68 <sup>a</sup>	393 ± 18.1 <sup>a</sup>
	Summer	13.5 ± 4.37 <sup>a</sup>	34.3 ± 1.87 <sup>a</sup>	398 ± 25 <sup>a</sup>
	Autumn	13.5 ± 3.47 <sup>a</sup>	35.5 ± 1.15 <sup>a</sup>	397 ± 17.2 <sup>a</sup>
Typology clusters	Cluster 1	13.2 ± 4.49 <sup>a</sup>	33.3 ± 1.54 <sup>a</sup>	395 ± 23.8 <sup>a</sup>
	Cluster 2	16.5 ± 4.59 <sup>b</sup>	35.3 ± 1.34 <sup>a</sup>	402 ± 21.5 <sup>b</sup>
	Cluster 3	12.4 ± 4.00 <sup>c</sup>	35.0 ± 1.58 <sup>a</sup>	392 ± 10.9 <sup>a</sup>

<sup>abc</sup>The values on the same column with different letters in superscript are different in  $p < 0.05$ .

energy and nitrogen requirements), on the ordinate level of performances (milk production, calving interval) as shown in Table 3.

The hierarchical ascending clustering (HAC) was performed on 15 variables. In this case, three clusters (ration types) were identified (Table 4) keeping a variance between the clusters of 62.42% of the total variability (Fig. 3).

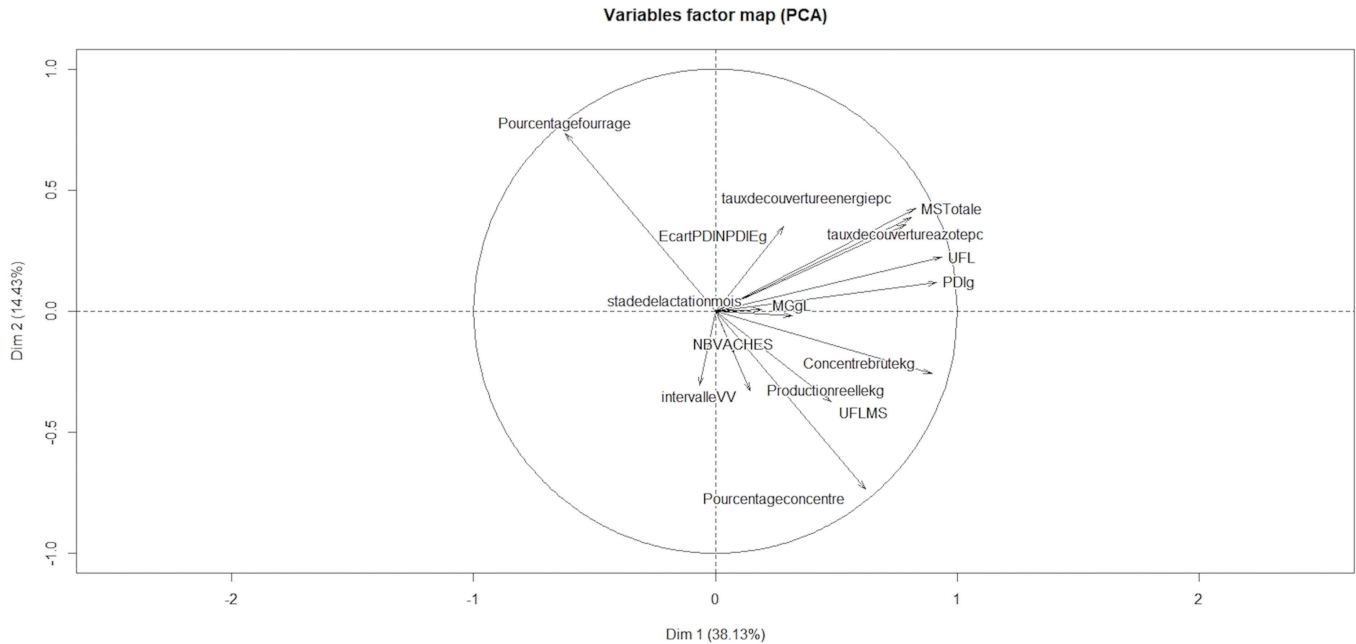


Figure 2. HAC of the individuals.

Table 3. Statistical links of variables with the first three axes.

Variables	Symbol in the factor map	Dim1 (%)	Dim2 (%)	Dim3 (%)
Total Dry Matter	MSTotale	65.7	15.0	10.4
Forage percentage	Pourcentagefourrage	38.4	54.0	01.7
Concentrate percentage	Pourcentagecentre	38.4	54.0	01.7
Energetic intake	UFL	87.8	05.0	03.6
Nitogenous intake	PDlg	83.7	01.4	01.3
Energy coverage rate	Tauxdecouvertureenergiepc	68.4	18.0	07.9
Nitrogen coverage rate	Tauxdecouvertureazotepc	62.0	12.9	15.0
Milk production	Productionreellekg	02.1	10.8	75.4
MF	MGgl	10.0	0	0.9
Calving Interval	intervalleVV	0.5	09.4	0.3

Table 4. Degree of statistical signification of axes with the clusters.

	Cluster 1	Cluster 2	Cluster 3
Dim 1	$p < 0.001$	$p < 0.001$	$p < 0.001$
Dim 2	$p < 0.05$	$p < 0.01$	$p < 0.001$
Dim 3	$p < 0.01$	$p < 0.01$	$p < 0.01$

Finally, three types of rations were identified:

- The **Cluster 1** (deficient rations) is the group of the deficient rations found in 30.8% of farms. These diets

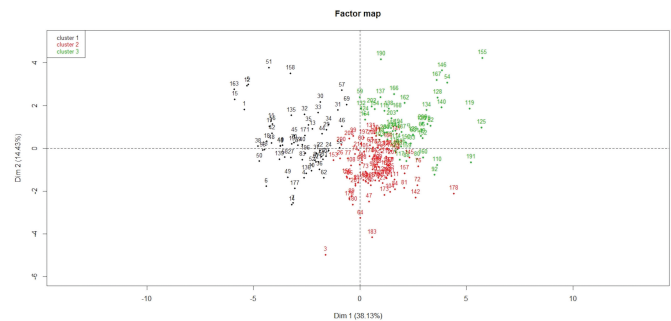


Figure 3. Variables factor map (PCA).

are characterized by lower DM, net energy, and nitrogen intakes (Table 1), and therefore, all cows nutrient requirements are not covered in this cluster. The coverage rate is estimated on average at  $80.7\% \pm 22.8\%$  for energy needs;  $80.2\% \pm 25.5\%$  for nitrogen needs;  $37.1\% \pm 17.7\%$  for calcium needs, and  $92.3\% \pm 39.6\%$  for phosphorus needs. The average milk yield in this group is  $13.2 \pm 4.49$  kg/cow/day/farm, close to the overall mean, while the calving interval of  $395 \pm 23.8$  days is below the overall average.

- The **Cluster 2** (correct rations) gathers the so-called correct rations, distributed in 42.2% of the farms with DM, net energy, and nitrogen intakes comparable to total averages (Table 1) where the majority of the nutrient needs are covered. These rations cover  $116\% \pm 16.2\%$  of energy needs;  $114\% \pm 21.5\%$  of nitrogenous requirements;  $120\% \pm 43.4\%$  of phosphorus requirements, and  $37.4\% \pm 14.9\%$  of calcium

requirements. The amount of milk recorded in cows fed these rations was the highest among the groups with an estimated average of  $16.5 \pm 4.59$  kg. On the other hand, the mean calving interval of  $402 \pm 21.5$  days is the highest of the groups. This finding could be attributed to the antagonism between milk production and fertility [25].

- The **Cluster 3** (excessive rations) corresponds to excessive rations found in 27% of farms with DM, net energy and nitrogen intakes were higher than the overall averages (Table 1), where all nutrient requirements are fully covered. These rations cover  $171\% \pm 33.5\%$  of energy needs,  $172\% \pm 38.4\%$  of nitrogen requirements,  $74.6\% \pm 33.6\%$  of calcium requirements, and  $164\% \pm 46\%$  of phosphorus requirements. Despite the high intakes, the amounts of milk recorded in cows consuming rations of this group were the lowest among the clusters with an average of  $12.4 \pm 4$  kg (lower than the overall average). In addition, fertility in this group was better with an average CI of  $392 \pm 10.9$  days below the overall mean.

## Conclusion

The study of the characteristics of the served rations in some farms allows emphasizing the following points:

- Lack of a food strategy based on covering the nutrient requirements of cows according to scientific rules. Observed feeding practices are conditioned by other constraints, including forage availability and food prices. This had led to the excessive use of concentrate to cover the needs of cows despite its negative impact on health status, profitability, and production cost.
- Production values that do not deviate from the national average reflecting technical management problems of farms.
- Food wastage was observed in 50.2% of farms (where coverage rates of nutrient requirements were greater than 110%). This is in addition to production costs.

Regardless of the other aspects of breeding, it is necessary to provide technical support to breeders based primarily on the control and the improvement of forage production techniques and forage preservation in addition to technical and economic controls of feeding for a good use of the available resources, as well as for a good profitability.

## Acknowledgment

The authors wish to thank infinitely all the people who facilitated their access to the farms, especially Dr. MECHMACHE, Dr. ZOUAOU, and Dr. AMARA.

## Conflict of interest

The authors would like to declare that there is no conflict of interest related to the publication of this paper.

## Authors' contributions

SB designed the study, led the surveys, interpreted the data, and draft the manuscript. NM did the statistical analysis. NL took part in preparing and critical checking of this manuscript. RK oversaw the study and reviewed the manuscript.

## References

- [1] Chemma N. La dépendance laitière: où en est l'Algérie?. *Revue d'Études en Management et Finance d'Organisation* 2017; (5):1-19.
- [2] MADR. Ministère de l'Agriculture et du Développement Rural, Statistiques agricoles, superficies et production, Séries A et B 2013; 2014:2015.
- [3] Makhlouf M, Montaigne E, Tessa A. La politique laitière algérienne: entre sécurité alimentaire et soutien différentiel de la consommation. *New Medit* 2015; 14(1):12-23.
- [4] Kalli S, Saadaoui M, Ait Amokhtar S, Belkheir B, Benidir M, Bitam A, et al. Éléments d'enquête générale sur la filière lait en Algérie. *Int J Innov Financ Strateg* 2018; 1:12-9.
- [5] Herbut P, Angrecka S, Walczak J. Environmental parameters to assessing of heat stress in dairy cattle—a review. *Int J Biometeorol* 2018; 62:2089; <https://doi.org/10.1007/s00484-018-1629-9>
- [6] Adem R. Les exploitations laitières en Algérie: structure de fonctionnement et analyse des performances technico-économiques: cas des élevages suivis par le CIZ. 4th edition, journées de recherches sur les productions animales. Tizi-Ouzou, 13 p, 7 au 9 décembre 2003..
- [7] Agabriel JL. Alimentation des bovins, ovins et caprins. Besoins des animaux-Valeurs des aliments: tables Inra. Edition remaniée--Quae éditions 2010; 312
- [8] Grimard B, de Boyer des Roches A, Coignard M, Lehébel A, Chuiton A, Mounier L, et al. Relationships between welfare and reproductive performance in French dairy herds. *Vet J* 2019; 248:1-7; <https://doi.org/10.1016/j.tvjl.2019.03.006>
- [9] Dalcq A, Beckers Y, Mayeres P, Reding E, Wyzen B, Colinet F, et al. The feeding system impacts relationships between calving interval and economic results of dairy farms. *Animal* 2018; 12(8):1662-71; <https://doi.org/10.1017/S1751731117003020>
- [10] Kleefisch MT, Zebeli Q, Humer E, Gruber L, Klevenhusen F. Effects of feeding high-quality hay with graded amounts of concentrate on feed intake, performance and blood metabolites of cows in early lactation. *Arch Anim Nutr* 2018; 72(4):290-307; <https://doi.org/10.1080/1745039X.2018.1474004>
- [11] Ouarfli L, Chehma A. Étude critique de la pratique de l'alimentation des bovins laitiers dans la région d'Ouargla. *Revue des Bioressources* 2011; 1(2):13-18.
- [12] Ghozlane F, Bousbia A, Benyoucef MT, Yakhlef H. Technical-economic impact of the concentrate/fodder ratio on the bovine dairy production: case of the farming of constantine. *Livest Res Rural Dev* 2009; 21(6); <http://www.lrrd.org/lrrd21/6/ghoz21094.htm> (Accessed on August 01, 2019)
- [13] Srairi MT, Kessab B. Performances et modalités de production laitière dans six étables spécialisées au Maroc. *INRA Prod anim* 1998; 11(4):321-6.
- [14] Alstrup L, Søgaard K, Weisbjerg MR. Effects of maturity and harvest season of grass-clover silage and of forage-to-concentrate ratio

- on milk production of dairy cows. *J Dairy Sci* 2016; 99(1):328–40; <https://doi.org/10.3168/jds.2015-9802>
- [15] Ouakli K, Yakhlef H. Performances et modalités de production laitière dans la Mitidja. *Recherche Agronomique INRA Algérie* 2003; 1(13):15–24.
- [16] Madani T, Mouffok C, Frioui M. Effet du niveau de concentré sur la rentabilité de la production laitière en situation semi-aride algérienne. 11th edition, *Rencontres de la Recherche sur les Ruminants*, Paris, France, p 11, 2004.
- [17] El Khattar K. Élaboration d'une stratégie d'appui technique aux éleveurs bovin laitier de la région de Casablanca, cas de quelques unités pépinières. Mémoire de 3<sup>ème</sup> cycle Agronomie, option production animale, IAV Hassan II, Rabat, Morocco, p 215, 1994.
- [18] Srairi MT. Conduite technique de cinq unités de production dans la wilaya de Rabat-Salé. *Actes de l'Institut Agronomique et Vétérinaire Hassan II (Maroc)* 1998; 19:41–51.
- [19] Kadi SA, Djellal F, Berchiche M. Characterization of feeding practices of the dairy cows in Tizi-Ouzou area, Algeria. *Livest Res Rural Dev* 2007; 19(4); <http://www.lrrd.org/lrrd19/4/kadi19051.htm> (Accessed on August 01, 2019)
- [20] Valente T, Sampaio C, da Lima E, Deminicis B, Cezário A, Santos W. Aspects of acidosis in ruminants with a focus on nutrition. *J Agric Sci* 2017; 9(3):1916–9760; <https://doi.org/10.5539/jas.v9n3p90>
- [21] Houmani M. Situation alimentaire du bétail en Algérie. *Recherche agronomique--INRA Algérie* 1999; (4):35–45.
- [22] Abdelguerfi A, Zeghida A. *Utilization des engrais par culture en Algérie*. Food and Agriculture Organization, Rome, Italy, Edition, 56 p, 2005.
- [23] Brocard V, Brunschwig P, Legarto J, Paccard P, Rouille B, Bastien D, et al. *Guide pratique de l'alimentation du troupeau bovin laitier*. 1st edition, l'institut de l'élevage, Éditions Quae - 78026 Versailles Cedex, France, p 264, 2010.
- [24] Humer E, Gruber L, Zebeli Q. Effects of meeting the requirements in energy and protein, and of systemic inflammation on the interval from parturition to conception in dairy cows. *Czech J Anim Sci* 2018; 63(6):201–11; <https://doi.org/10.17221/13/2017-CJAS>
- [25] Coffey EL, Horan B, Evans RD, Berry DP. Milk production and fertility performance of Holstein, Friesian, and Jersey purebred cows and their respective crosses in seasonal-calving commercial farms. *J Dairy Sci* 2016; 99(7):5681–9; <https://doi.org/10.3168/jds.2015-10530>