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Factors of Variation in Milk Production in the Semi-arid Region of Eastern Algeria

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ABSTRACT

Background: Algeria has taken many important steps to develop the dairy sector, but these have not produced the expected results. Production potential is only sufficient to cover 42% of national milk needs. This prompted us to carry out a study with the aim of diagnosing the various individual, environmental and management factors affecting milk production.

Methods: The survey was conducted in 2022 on 18 farms spread across different agro ecological zones of the semi-arid region of Setif, with a total cattle population of 619 heads. Data was collected from registration documents available on the farms. In addition, a questionnaire was developed and administered directly to farmers to better characterize the study environment, identify current practices and understand the dairy farming practices on the farms.

Result: The results show a variability in average milk production (10.00±3.56 to 17.81±2.16 kg of milk/cow/day) between the farms studied, which is linked much more to feeding techniques and the presence of technical supervision. The effect of breed is observed by a superiority in milk production of the Holstein breed compared with the Montbeliarde breed of 1.6 kg of milk/cow/day. The quantity and quality of fodder (green or dry) and concentrate distributed (2.92±0.76 kg to 10.5±1.08 kg) had a direct influence on milk production (12.56±0.29 to 17.01±0.57 kg of milk/cow/day). Also, the season of the year had very significant effects on milk production.

Key words: Breed, Dairy cows, Milk production, Semi-arid region, Variation factors.

INTRODUCTION

In Algeria, milk is part of the citizens diet, with an average consumption of 152 liters per capita per year (FAO, 2022). National milk needs are estimated at approximately 5.5 billion liters, while national production is only 3.2 billion liters in 2021 (ONS, 2023), remaining insufficient to meet this demand.

National milk production is mainly provided by livestock imported from temperate countries and their locally bred offspring. According to ONIL (2019), the genetic structure of the dairy herd is composed of approximately one-third modern dairy cows and two-thirds local and crossbred breeds, with modest milk yields. It should be noted that the majority of dairy farms are small, often using landless systems and have fewer than 10 dairy cows, which limits the scale of production.

To cope with this situation and to fill this deficit, Algeria has resorted massively to imports. It ranks fifth in the world among the largest importers of milk and dairy products and also occupies second place in the world in terms of imports of milk powder, just behind China, with nearly 220 000 tonnes imported each year (Indexmundi, 2023).

This work aims to study the influence of several factors, including breed, season, geographical area and livestock management method on the milk production of cows in the semi-arid region of Setif, ranked first in terms of milk production on a national scale.

MATERIALS AND METHODS

Presentation of the study region

The province of Setif is located in the high plains of eastern Algeria, at an altitude of between 900 and 2000 meters. It has a semi-arid continental climate characterized by harsh, cold winters and hot, dry summers. Annual rainfall varies by region; the northern mountainous areas have precipitation exceeding 700 mm, while the central and southern high plains have precipitation of 400 mm and 200 mm, respectively.

On the agro-economic level, the province of Setif plays a leading role in national milk production, with an estimated annual of 281.865 million liters from a herd of 74 335 dairy cows (MADR, 2019). The dominant production system in this region is based on a complementarity between cereal crops and sheep farming, thus constituting an integrated agro-sylvo-pastoral model, adapted to local pedoclimatic conditions.

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Animal material

Our study is conducted on eighteen farms, including four pilot farms and fourteen private farms. The farms were chosen randomly. These farms have a total of 619 heads, including 309 dairy cows of different breeds (Montbéliarde, Holstein and local breeds) (Fig 1 and Fig 2).

Working method

Data were collected from recording documents available on the farms, such as the barn schedule, the forage calendar and the reproduction monitoring register. In addition, a survey was developed and conducted directly with the farmers in 2022 to characterize the study environment and better understand the practices and methods of dairy farming on the farms.

Statistical analysis

The data were analyzed using appropriate statistical methods, including analysis of variance (ANOVA), to evaluate the effects and structure of the studied variables. The effect of the genetic group on milk production was examined using a general linear model estimated by the method of least squares. All statistical analyses were performed using SPSS software (version 26).

RESULTS AND DISCUSSION

General characterization and organization of the surveyed farms

The farms surveyed are distributed across the different agroecological zones of the Setif region. 28% of the farms are located in the north and the same percentage in the south; however, 44% of the farms studied are located in the center. The cattle population on the farms studied ranges from 11 to 93 head, with an average of 34±21 head per farm. This average is higher than the average (25 head) obtained by Bir *et al.* (2015) and Guedjal *et al.* (2023) in the same region, who recorded average herd sizes of 25 and 7.16 head per farm, respectively, as well as those obtained by obtained by Eulmi *et al.* (2023), in the Souk-Ahras and Biskra region (≤15 head) and Cherfaoui-Yami (2021), in the Tizi-Ouzou region (17.72 head). Dairy cows represent 48.43% of cattle herds.

The Montbeliarde and Holstein breeds are found on most farms. 50% of the farms studied have both breeds and 44.44% have only the Montbeliarde breed. However, a low proportion of 5.56% is observed on farms that have the local breed.

Technical supervision is only available on pilot farms, compared to private farms.

Eating behavior

On the pilot farms, during the stabling phase (winter and fall), when grazing is very rare, dairy cows are fed a diet based on hay and silage, with supplemental concentrate, which is distributed throughout the year in varying quantities depending on the cows' physiological condition. However, during the spring and summer, the cows are fed straw and grazed on natural meadows and on cereal stubble and fallow land.



Fig 1: Montbéliarde and Holstein breeds in some of the farms studied.



Fig 2: Improved breed and local breed.

By examining the forage systems of various private farms, three types of forage calendars can be identified, varying in their diversity depending on feed availability. Concentrate supplementation is provided throughout the year on all farms, with quantities adjusted according to the cows' physiological condition.

- The first type (14.29%): In winter and autumn (stall period), the cows are fed exclusively on hay and concentrate, without grazing. In spring, they graze on natural meadows, cereal stubble and fallow land.
- The second type (14.29%): This type has a varied diet depending on the season. In winter and autumn, the cows consume mainly oat hay and straw in the stable, without grazing. In spring, they graze on natural meadows and in summer on stubble, while receiving a little alfalfa in the stable.
- The third type (71.42%): In spring, the cows graze on natural meadows. In winter and autumn, they consume hay (meadow and oats). In summer, their diet is based on straw with supplemental grazing.

For watering, the quantity of water drunk varies according to the season from one farm to another from 20 to 70 liters/day in winter and autumn, from 50 to 100 liters/day in summer and spring.

Breeding management

The criteria for female breeding are weight and growth in 22.22% of farms and age and the onset of heat in 44.45% and 11.11% of units, respectively. Heat detection is performed by daily observation on all farms.

Artificial insemination is practiced on 5.56% of farms, while natural breeding is practiced by 77.78% of farms. However, there are farms that apply both methods, at a rate of 16.66%. These results are consistent with those reported by Benidir *et al.* (2017), in the same region and Meskini *et al.* (2023), in the Mostaganem region, where heat detection was practiced occasionally by breeders and natural mating was the main insemination method, with a rate of 63% (80.33% for the first region and 63% for the latter). Similarly, Cherfaoui-Yami (2021), in the Tizi-Ouzou region, recorded that 36% of farms use artificial insemination and 57% of farms practice natural mating and only 7% of farms practice both methods of reproduction.

Milking

Milk is extracted twice a day (morning and evening) using a milking machine on 38.89% of farms, with an average production of 15.5 liters/cow/day. Milking is done manually on 61.11% of farms, with an average production of 13.78 liters/cow/day.

Milk production on the study farms

The results recorded in Fig 3, show the variability in average milk production (10.00 to 17.81 liters/cow/day) across different farms. This difference in production is largely related to feeding techniques and the presence of technical supervision.

The average daily milk production per cow in the farms surveyed is 14.34±3.63 l/cow/day, this average is lower than that obtained by Bir *et al.,* (2015), in the region of Setif (15.01±3.70 l/cow/day) and that obtained by Cherfaoui-Yami (2021), in the region of Tizi-Ouzou (17.4 l/cow/day), Kechroud *et al.,* (2024), in the region of Souk-Ahras (16.1 kg/Cow/day) and Meskini *et al.* (2023), in the region of Mostaganem (18.19 l/cow/day). Eulmi *et al.* (2023), in the region of Souk-Ahras and Biskra (15 l/cow/day). This quantity of milk produced is slightly higher than that obtained (14.2±4.73 kg of milk/cow/day) by Boukhechem *et al.* (2019), in different farms in northern Algeria.

Factors affecting variation in milk production

Variation in milk production is influenced by several factors.

Technical support

The presence of technical expertise on farms plays a very important role in the success of cattle management (feeding, watering, hygiene and health). This factor explains why dairy cows on pilot farms are the highest milk producers, with an average of 17.01±0.57 l/cow/day, higher than that obtained on private farms (13.58±1.8 l/cow/day).

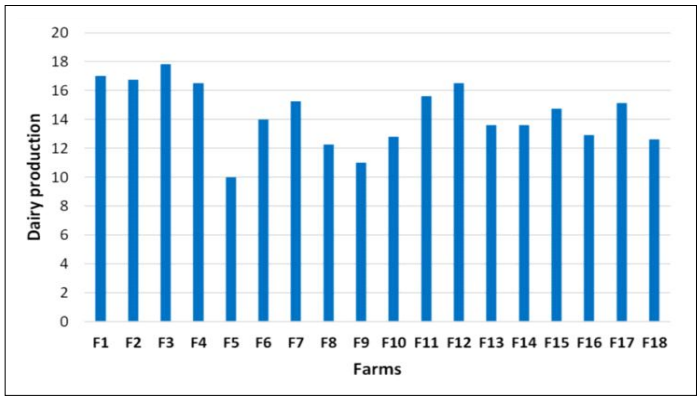


Fig 3: Average milk production (liters/cow/day) on the farms studied.

The effect of feeding

The basic ration

The nature of the basic ration (preserved fodder (dry, silage), green fodder) determines the variation in production between pilot farms and private farms and even between the latter.

The distribution of the ration is linked to the season of the year, the region and the cultivated areas used; the latter are on average different (1708±611.10) ha and (67.75± 103.57) ha on pilot and private farms, respectively. According to Ghozlane *et al.* (2010), large farms produce and deliver the largest quantities of milk.

At the pilot farm level, feeding cows silage allows them to produce 3.43 l/cow/day more milk than cows on private farms. Brocard *et al.* (2019), reported that early grass silage increased milk production by +1.9 kg of milk/cow/day. Similarly, Coulon *et al.,* (1995), reported that cows fed grass silage produced 0.4 and 1.9 kg/d more milk, respectively, than those fed corn silage or hay. According to Cuvelier and Dufrasne (2005), when grass is available in sufficient quality and quantity, grazing can indeed allow an average production of 20 kg of milk/day (around 25 kg in spring and 15 kg in the late season). Silage provides a higher energy content than hay, making it ideal for increasing milk yields. Cows fed silage generally produce more milk due to its higher digestibility and nutrient availability. Hay, while beneficial for maintaining fiber intake, may not support peak milk production as efficiently as silage (Kimd Group of Company, 2025).

The effect of concentrate feeding

All farmers use supplemental feed. It varies depending on the season and market prices. Concentrate supplementation can be simple (wheat bran) or composed of a mixture of wheat bran plus barley, corn, or soybean meal, phosphate, mineral salts and vitamins.

Table 1 shows the significant effect (P<0.01) of concentrate feed on milk production. The amount of concentrate distributed varies from one farm to another. In class one, a significant amount of milk is produced compared to other classes due to the consumption of a good amount of concentrate feed, averaging 10.5±1.08 kg/cow/day, with a milk production of 17.01±0.57 kg/cow/day and good quality (barley, bran, CMV).

These results are close to those obtained by Cherfaoui-Yami (2021), in the Tizi-Ouzou region (17.4 l/cow/day) with an average concentrate intake of 9.98±2.32 l/cow/day. and higher than those reported by Eulmi *et al.* (2023), in the Souk-Ahras and Biskra region, the average production is 15 l/cow/day with an average concentrate intake of 8 Kg/cow/day and lower than those obtained by Meskini *et al.,* (2023), in the Mostaganem region, an average concentrate intake of 9.85±0.32 Kg/cow/day and a milk production of 18.19±0.45 l/cow/day.

According to Tranvoiz *et al.* (2018), the addition of concentrate leads to a rapid response on milk production. Furthermore, Vergonjeanne (2014) indicates that increasing the concentrate can produce up to 15% more milk with a maximum of 4 kg of milk/cow/day depending on the initial feeding situation and provided that the risks of acidosis and metabolism are controlled.

The effect of season

Cow milk production varies according to the seasons. Table 2, illustrates the significant effect of season on milk production (p<0.001).

The highest milk production (18±1.71 l/cow/day) is recorded in spring, this increase being due to feed availability. Furthermore, the lowest milk production (10.92±3.34 l/cow/day) is recorded in winter. These results indicate that the highest production coincides with the period of green fodder availability and they are lower than those obtained by Habibi *et al.* (2021), with an average of 18.45±33 and 17.06±34.5 l/cow/day in the spring and summer seasons, respectively. While the lowest milk production obtained in winter 16.39±31.5 L.

According to Legarto *et al.* (2014), milk production is minimal from July to December and maximal from March to May, the difference between these two periods being 1.3 kg/day in Holstein, 1.7 kg/day in Normande and 2.8 kg/day

Table 1: Milk production according to the level of concentrate distributed.

Classes	Concentrated feed intake	Dairy production	Meaning
1(F1.2.3.4)	10.5±1.08	(a)17.01±0.57	p = 0.0017
2(F11.12.13.15)	6.75±0.74	(ab)15.12±1.23	
3(F5.6.7.9.14.16.17)	4.14±0.20	(b)13.14±1.99	
4(F8.10.18)	2.92±0.76	(b)12.56±0.29	

(a - b - ab): Significantly different.

Table 2: Results of the variability of milk production according to the seasons.

Seasons	Spring	Summer	Autumn	Winter	Meaning
Dairy production (liters/cow/day)	(a)18±1.71	(b)15.44±2.19	(c)13.01±2.58	(c)10.92±3.34	p<0.001

(c): Non-significant difference for means followed by the same letter.

(a - b - c): Significantly different.

in Montbeliarde. For their part, Hachana and Bousselmi (2018), report that milk controls carried out in winter showed a difference in average milk production compared to controls carried out during the autumn season despite the quantities of milk produced being very similar. Thus, summer and spring controls showed comparable average milk productions of around 23.95 kg/day and 23.96 kg/day respectively. Furthermore, Lim *et al.* (2021), indicate that milk production was significantly reduced (Holstein 29.02 kg/day and Jersey 19.75 kg/day) in autumn compared to other seasons (Holstein 30.14 kg/day and Jersey 20.96 kg/day).

Azimi *et al.* (2022), in their study recorded that the seasonal variation and milk performance of the three breeds (Holistan, Garai and Crossbreeds) were found to be very significant, as the production in other seasons was low. The average milk production was 2 470±37 liters in spring, followed by 2427±41 liters in summer and a minimum in winter, respectively 2 403±82 liters.

Breed effect

Milk production also varies by breed. According to our results (Table 3), the average daily milk production of Holstein cows is 14.62±2.06 l/cow/day, higher than that of Montbéliarde cows (13.02±1.96 L/cow/day), a difference of 1.6 kg/cow/day, representing 10.94% of production. Least squares analysis showed a significant effect of genetic group on milk production ($p<0.05$). Pie Noire cows had higher adjusted averages than Pie Rouge cows, confirming the superior milk production of the Pie Noire breed under the conditions studied.

Ce résultat est supérieur à celui obtenu par Belhadia and Yakhlef (2013), who recorded a production of 11.37 liters/cow/day for the Montbéliarde and 11.90 liters/cow/day for the Holstein Friesian in the semi-arid region of Chlef and that indicated by Boujenane et Aïssa (2008), qui ont constaté une différence de 9,98 % dans la production laitière entre les deux races. Par ailleurs, notre résultat est inférieur à ceux de Balandraud *et al*. (2018), qui ont observé que les vaches Montbéliardes produisent environ 12 % de lait en moins que les vaches Holstein, avec des taux de matières grasses et de protéines plus élevés.

The observed milk yields remain below the genetic potential of the exploited breeds, mainly Montbéliarde and Holstein. This situation can be explained by the fact that the studied cattle are the result of several generations raised locally, although their ancestors were originally imported several decades ago. Despite a certain adaptation to local conditions, their milk performance remains lower than that of recently imported breeds, notably due to constraints related to local farming systems and to feeding that is often insufficient or inadequate with regard to their nutritional requirements.

Regional effect

The results presented in Table 4 show that milk production in the northern region (15.26±2.25 l/cow/day) is higher than in the southern region (14.60 ± 1.52 l/cow/day).

With a difference (4.32%) that is not significant at the 5% probability level. This variation can be explained by the effect of climate and forage availability (plant cover) in both regions.

The northern climate is characterized by harsh winters, which can begin as early as autumn and moderately warm summers. The cold stimulates the appetite of dairy cows, leading to increased feed consumption and, consequently, higher milk production. In the south, however, high temperatures and drought lead to low feed consumption, which results in lower production. According to Charron (1988), an animal exposed to cold adjusts its heat resistance by consuming more available feed. Otherwise, it uses nutrients to the detriment of milk production, depleting its body reserves. As a result, milk production decreases with decreasing temperature while fat and protein levels increase.

Eulmi *et al.* (2023), in a study conducted in two distinct bioclimatic zones “Souk-Ahras (semi-arid region) and Biskra (arid region) “found that there was no significant difference ($p>0.05$) between the two regions in terms of milk production. However, a significant difference was noted in terms of lactation duration, favoring farms located in semi-arid zones.

For his part, Dawod (2022) showed in his study that a high temperature-humidity index, combined with low rainfall, is associated with a decline in dairy performance, including a decrease in daily milk production and a reduction in protein and fat contents.

Furthermore, a 28% reduction in average monthly precipitation could lead to a decrease in milk production estimated at between 1 000 and 12 000 liters per year. In

Table 3: Variability of milk production according to breeds.

Breeds	Holstein	Montbeliarde	Meaning
Dairy production (liters/cow/day)	(a)14.62±2.06	(b)13.02±1.96	$p < 0.05$

(a.b) : Significantly different.

Table 4: The effect of region on milk production.

Region	North	South	Meaning
Dairy production (liters/cow/day)	(a)15.26±2.24	(a)14.60±1.52	$p = 0.1$

(a): Non-significant difference.

addition, a 4°C increase in average monthly temperature could also cause a decrease in production, estimated at between 8 000 and 12 000 liters per year. In contrast, a 4°C increase in maximum temperature could lead to a much more marked drop, reaching up to 14 000 liters per month (Somoza *et al.,* 2018).

CONCLUSION

This study has highlighted the great variability of reproduction parameters depending on certain studied and well-identified factors (technicality, concentrate intake, season of the year, region, breed) at the level of dairy farms in the Setif region.

Among these factors, we found that diet, breed and season have a large part in the variation of milk production of all the factors studied, with the exception of regional factors, the effect of which is not very marked.

This study shows that the best production is in pilot farms, where livestock management is considered quite good compared to private farms. This is justified by the presence of technology and the availability of significant fodder resources (green, dry, silage) by pilot farms. In private farms, management is almost poor compared to that in pilot farms.

The contribution of concentrate in the feed ration causes a variation in milk production, the distribution of which is at its maximum in critical periods (case of stabling) due to the insistence of food resources (not pasture).

Regarding the season, its effect is highly significant on milk production, the latter is better in the spring and summer seasons with averages of 18±1.71 l/cow/day and 15.44±2.19 l/cow/day respectively. This production is better compared to that obtained in winter and autumn with respective productions of 13.01±2.58 l/cow/day and 10.92±3.34 l/cow/day. This variation in milk production between seasons is explained by the availability of fodder during the spring and summer periods.

As for the breed factor, there is a slight variation in milk production between the Holstein and Montbeliarde breeds, with the average production of the first breed being 14.62± 2.06 l/cow/day and 13.02±1.96 l/cow/day produced by the Montbeliarde breed.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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