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Quantitative and qualitative response of dairy production of cattle herds to husbandry practices

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Investigations on dairy performances and feeding controls of Holstein breed dairy cattle located in Constantine were carried out for a period of 12 months to find the quantitative and qualitative response of milk production to the livestock practices. Thus, samples of cow milk were made monthly, analyzes of physical, chemical and bacteriological composition were made. In total, 144 samples were used to build a typology of milk into 3 classes. Females produce an average of 4747 kg milk in 297 days of lactation. This result was obtained from rations where the proportion of concentrates in the total energy intake averaged 60.40%. Increase of this contribution in the diet does not lead to significant changes in the quantity of the produced milk. Beyond 12 kg of milk, cows are able to produce 34% of the expected milk. It seems that much of the concentrates was not valued in milk production. In any case, the majority of the collected milk can be described as satisfactory quality in terms of physico-chemical parameters. However, the hygienic quality was bad. No class doses combine rich milks in useful materials with low contamination and absence of antibiotic residues.

Key words: Milk, production, quality, concentrates, breeding, cattle.

INTRODUCTION

Countries where milk consumption is much lower than the recommendation of the World Trade Organization (WTO) are the countries of North Africa.

In Algeria, the consumption of milk is growing since independence with an average of 100 liters/capita/year (Sraïri et al., 2013). Nevertheless, consumption remains modest due to the high price of milk and the purchasing power of consumers. Thus, the government is trying through actions of fiscal interventions and management to improve the situation of cattle breeding and consequently the local milk production. This has been noticed through the adoption of a series of incentives to increase raw milk production (0.14 US $ per kg), collection (0.06 US $ per kg) and industrial processing (0.07 US $ per kg) (DRDPA, 2011). In addition, State authorities have adopted other incentives to promote cattle rearing (19 US $ per conception through AI, a subvention of 30% of the investments in milking machine, ensiling material, etc.) and milk collection (up to 30% of the investments in cooling devices). However, Algeria continues to import large quantities of milk powder and dairy products to meet the growing demand of the population. Between 2001 and 2009, Algeria has imported an average of 779.18 million U.S. dollars of milk and its products per year (CNIS, 2009).

Indeed, milk powder imports have constituted a significant constraint for the local development of raw milk production and collection. They have also hindered the connexion between agricultural services and dairy cattle farms. Milk imports have also induced an

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insufficient interest in animal recording systems (Benyoucef and Abdelmoutaleb, 2010).

On the one hand, the dairy chain is challenged the cost of one kg of milk where milk production is often ensured by concentrate feed which creating uncompetitive production (Ghozlane et al., 2009) and on the other hand on milk composition and especially on his physico-chemical and bacteriological quality where milk is often criticized during its conversion by dairy plants (Mekroud and Bounechada, 2011). This poor quality causes a decrease in the contribution of local production in the process of industrial production where local production has contributed with a percentage of 10% (Sraïri et al., 2013). The purpose of this study was to establish the relationships between implemented farming practices, including those related to the use of concentrate feed in the diet of cows, and the quantitative and qualitative changes in production dairy.

MATERIALS AND METHODS

Presentation of the study area

This study was conducted in the region of Constantine located in North-eastern Algeria (36° 17 'lat. N. and 6° 37' long. E.) characterized by a Mediterranean semi-arid continental climate.

Survey and collection of milk samples

A survey was conducted with 12 dairy farms members to milk control, with herds of 32 to 115 cows (47 average) located throughout the study area to provide a representative sample of farms in the region. This choice was made based on the availability of reliable and balanced information, the stability in the activity of dairy cattle and the quantity of milk delivered.

A review of technical operations management of dairy cows has been established for each farm during the period between September 2011 and August 2012, according to the method of Cordonnier (1986). On each of the farms, livestock information about herd composition, characteristics of dairy cows and their feeding management were collected during each monthly passage (passage / month) or from monthly milk recording totaling 114 passages for all farms during the period of investigation. In parallel, samples in tanks containing mixed milk of several dairy herds belonging to the same farm have been made 12 times during each passage, or a sample per month per operation.

Analyses are focused on 612 female Holstein with a 3.5 as rank of lactation (ranging from 1 to 8). Calving was distributed throughout the year. Lactations are characterized by:

1. The average duration of lactation in days (DL);
2. Total Milk Production (TMP) in (Kg / cow / lactation);
3. Technical average (TA) = the average daily production, defined as the ratio of the total milk production at calving interval (kg / cow / day);

The evaluation of the recorded data was calculated over one year as the economic average (EA) at the level of farm:

EA = (total milk production / Σ present days) x 365 (kg / cow / year). During each of these passages, feed controls have been made. The amount of consumed feed (forage and concentrates) were converted into dry matter (DM), net energy expressed in milk feed unit (UFL) and in digestible nitrogen (MAD) based on the nutritional value of used feed according to tables published by Alibes and Tisserand (1990) and Chibani et al. (2010).

All studied farms practicing zero grazing, and all distributed feed (forage and concentrates) were weighed. The raw data were used to determine the quantities of dry matter (DM) and UFL from concentrates consumed per cow per year (UFL cc / C / year), and the percentage of concentrates in the ration on the basis of their contribution to total energy intake. Similarly, the number of UFL made by the concentrates per liter produced was calculated (UFL cc / kg milk).

The criteria for the complementation of the cows were determined as follows:

1. UFL cc / C / year = Σ energy intake of concentrates / present cows (Cows present: VP = Σ $VP_{control,\ i}$/12 (i ranging from 1 to 12:12 pass / farm / year),
2. UFL cc / kg = Σ milk energy intake of concentrates / TMP.

The expected milk production (DP exp) calculated on the basis of the nutritional value of rations were compared to milk production observed (DP obs) to identify the degree of enhancement of concentrates in milk production. The body condition (BC) of dairy cows proves a reliable and useful tool available to all to judge the nutritional status. Indeed, we evaluate the body condition score of the animals according to the rating scale ranging from 0 (very thin) to 5 (very fat) based on the guidelines of the body condition score proposed by Edmonson et al. (1989) and Bewley and Schutz (2008). Indeed, twenty cows per farm were monitored and recorded by the same observer four times during the study period.

Analysis of samples of milk

Analyzes performed were generally those used to evaluate the physico-chemical and bacteriological milk that have been adopted locally by the official journal of the Republic of Algeria (JORA, 1998). This analysis was complemented by several criteria taken into account in the concept of quality of milk reported by Cauty and Perreau (2003). Indeed, eight tests have been performed on 144 samples.

The fat contents (FC), protein rate (PR), lactose, solids (S) analysis and cryoscopic analysis (°C) were measured according to the method of infrared spectrophotometry. The degree of Dornic acidity (lactic acid decigram per liter) was titrated according to AFNOR (1993). The presence or absence of antibiotics in milk samples was also checked by the Delvotest® (DSM Food Specialties, Dairy Ingredients, The Netherlands), official method used in the countries of the European Union to detect the presence of inhibitors of the milk flora (Navratilova, 2008). Cell counts of total mesophilic aerobic flora (TMAF) which reflects the microbiological quality of the milk was made on the basis of an analysis by two months for each operation. Bacteria are recorded and converted into CFU (Colony Forming Units) (AFNOR, 1993).

Statistical analysis

Statistical analyzes were performed using the following steps:

1. A descriptive analysis to calculate averages, standard deviations (Means ± SE), coefficient of variation (CV), the maxima and minima of the studied parameters to characterize the operation of the dairy barns,
2. To better clarify the relationship between the variables of herd management and technical performance, simple regression equations linking these parameters have been established. The strength of association between each pair of variables was

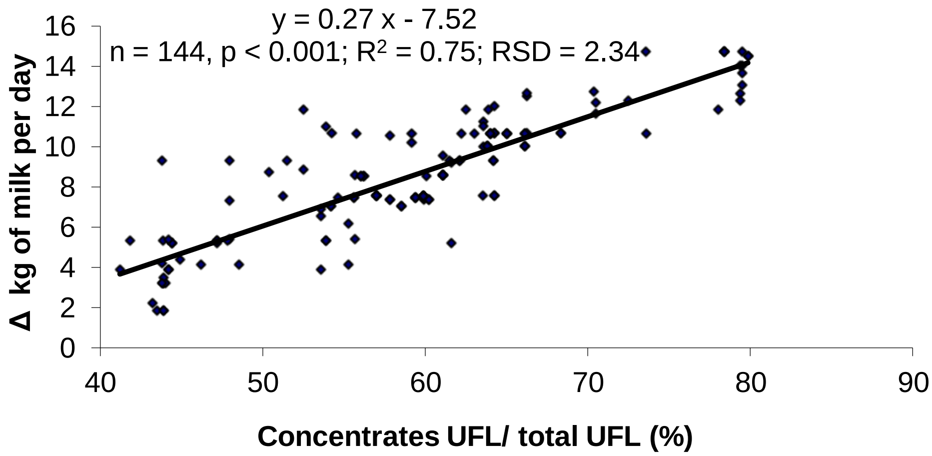

Figure 1. Relationship between the differences of expected milk production and observed milk production per day and the proportion of concentrates in the total energy intake. Δ = the difference of expected milk production and observed milk production per day.

estimated by the coefficient of determination R ², between 0 and 1. This leads to an equation: Y = a X + b. The software used was SPSS (18),

3. A multivariate analysis to establish the relationship between milk characteristics and farming practices has been made, by creating milk classes with similar characteristics and analyzing the relationships between these classes and the characteristics of animals and their conduct. Classes of milks were developed using a Hierarchical Ascending Cluster, using the criteria aggregation of Word for Hierarchical Cluster (Benzecri, 1982) (HAC, SPAD version 5.0 software) analysis. It is constructed from the results of a Principal Component Analysis (PCA, standardized) on the variables of centered and reduced milk quality. For each sample, seven continuous active variables (fat content, protein content, lactose, solid, cryoscopy, acidity and total germ) were selected. Subsequently, the comparison of the average of the studied parameters was done by Student's t test. The significance level was at P <0.05.

RESULTS

Performance of dairy production

The (DL) average was 297 days or shorter compared to the norm. The average of (TMP) is 4747 ± 1047 kg for all lactations. This average varies from one farm to another with a CV of 22%. The amount of daily produced milk per cow was 15.86 kg with a CV of about 10%. The effect of season on the TA is significant ($p < 0.05$). This study area was characterized by highly seasonal production. The relationship between production during the high period and the low period was about 1.4.

Feeding management and response of milk production to energy intake from concentrates

The proportion of concentrates in the total energy intake for dairy cows averaged 60.40% for a range min/Max from 43.87 to 79.48%. The UFL cc / kg milk ranged from 0.39 to 1.15. The average value was 0.72 UFL / kg milk with a CV of 39%, the largest CV compared to other criteria complementation studied.

A simple regression was performed between the economic mean of each unit of production and the number of UFL of concentrates per kg of produced milk (n = 12). The regression equation is significant and EA prediction is as follows: EA (kg) = - 4597.9 cc UFL / kg milk + 6735.9, ($p < 0.001$, $R^2 = 0.83$, residual standard deviation (RSD) = 0.26 kg). This equation shows a reciprocal relationship between the EA and UFL cc / kg milk. In addition, farms that have a high consumption of concentrate does not necessarily lead higher production of dairy cows.

The proportion of concentrates in the total energy intake for dairy cows has been linked with the difference between the expected and observed productions. The difference between (DP exp) in kg (DP obs) in kg is moving in the same direction as the proportion of concentrates in the total energy intake (Figure 1). Indeed, the highest differences (Δ) are associated with higher energy intakes from the concentrates. Furthermore, (DP exp) was always higher (up +14.73 kg / cow / day) to (DP obs), suggesting an energy excess of nutrients not valued.

To generalize this observation, milk observed production (DP obs) in kg is described in terms of milk expected production (DP exp) by the following equation: DP obs = 7.24 + 0.34 DP exp (Figure 2). Beyond 12 kg of milk, cows are able to produce 34% of the expected milk.

The mean values of body conditions (BC) during different physiological stages were less than 3.00 (Table 1) which does not meet the recommendation of the authors and especially during early lactation stage

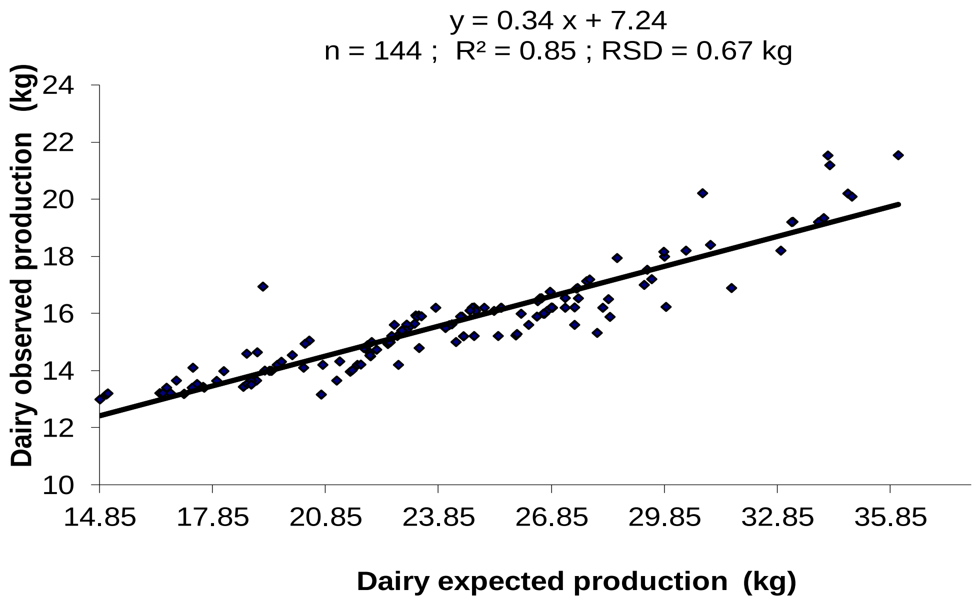

Figure 2. Relationship between observed and expected milk production in dairy cows.

Table 1. Average scores (in points) of cow's body condition participating to the scoring according to de different lactation stages.

Physiological stage	Recommandation	N	BC
Calving	3.0 à 3.5	240	2.53 ± 0.20
Begining of lactation	2.5 à 3.0	240	1.74 ± 0.63
Mid-lactation	2.5 et 3.0	240	2.23 ± 0.32
End of lactation	3.0 et 3.5	240	2.73 ± 0.21

Table 2. Physical, chemical and hygienic quality of mixed milk collected from 12 studied farms.

Variable	N [1]	Mean	SE	Min.	Max.	CV %
FC (g/kg)	144	40.43	5.64	24.3	60.1	13.95
PR (g/kg)	144	31.88	1.67	28.1	44.3	5.23
Lactose (g/kg)	144	16.72	0.72	33.9	49.9	4.3
Solids (g/kg)	144	124.77	7.69	108.8	152.3	6.19
Cryoscopic (°C)	144	- 0.546	0.001	- 0.59	- 0.42	1.83
Acidity (Dornic degree)	144	16.72	0.72	16	19.2	4.23
TAMAF (10^6 UCF//ml)	144	5.5	3.3	2.2	12	70

[1] N, Number of milk sample.

(Chagas et al., 2007). The maximum values do not exceed 4 and the minimum values were very low as they were going up to 1.50. Indeed, 35% of cows have a score higher than 2.5 for most of their lactation.

Characteristics of milk production

The results of the physico-chemical and bacteriological quality recorded are reported in Table 2.

The annual average of freezing point of milk collected from the surveyed farms was - 0.546 (°C), while most of the values are consistent with the recommended standards. Average, analyzed milks contained 124.77 g / kg of total dry extract, 40.43 g / kg of fat, 31.88 g / kg of protein, 44.90 g / kg of lactose and 16.72 acidity expressed in Dornic degrees. These values correspond

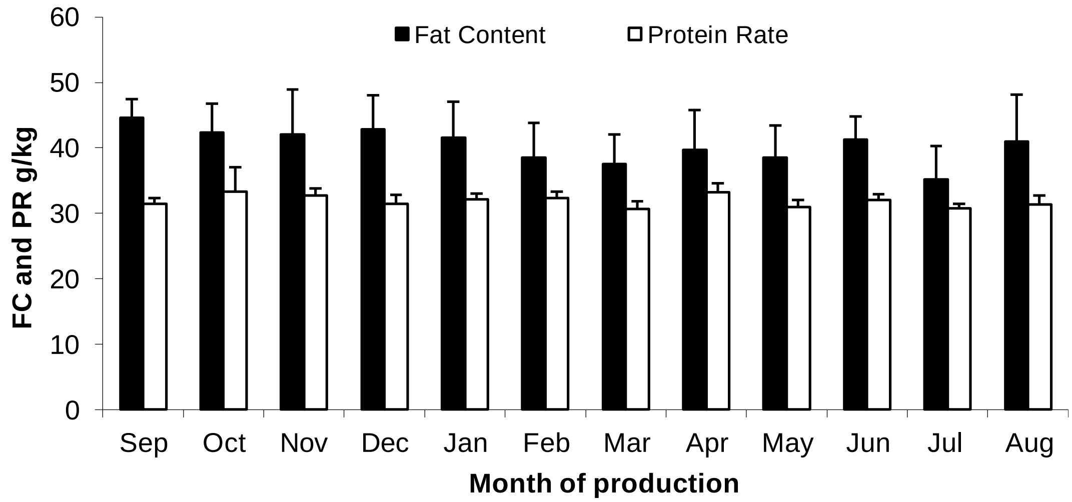

Figure 3. Changes in annual average fat and protein level in function of the farms surveyed.

to the accepted standards. Variability was very different regarding: total solids, protein content, lactose content and acidity showed low variation (CV < 7%). In contrast, the fat content was very variable in comparison with the protein rate. This variability depends largely on the season which affects the level of production unstable from one season to another. It is during the fall and winter season (September to January) that milks were significantly ($p < 0.01$) richer in fat. The high milk production season (March-May) was characterized by an average that does not exceed 40 g / kg. The protein rate is much more stable than the fat content during the year (Figure 3).

Detection of inhibitors of growth of microbial milk flora by the Delvotest ® showed an average of 42% of contamination. At the level of hygienic quality, 98% of collected milk samples may be qualified as poor because they greatly exceed the standard of 10^5 CFU / ml. Mean counts of farms range from 2×10^4 to 12×10^6 resulting in a CV of approximately 70% showing a high variability. Counts appear significantly weaker ($P < 0.01$) in winter and higher in summer.

Typology of milk according to their characteristics

The principal component analysis of the indicator of overall quality criteria of the milks reveals that the first 3 components gathered 81.96% of total inertia (respectively 50.03% for the first principal component, PC1, PC2, and 17.31% for 14.62% for PC3). The criteria are highly correlated (r> 0.7) to the first axis (fat and protein levels and lactose). Indeed, this axis characterizes the useful materials in the milk. It separates the milk according to their composition in useful materials. The second axis is strongly correlated (r> 0.8) with the cell count. It expresses the hygienic quality of milk, and it opposes the high cell count milks that have above-average values of the total sample and milk with low cell count below the sample average. The last axis is highly dependent on the Dornic acidity of milk (r> 0.6). It characterizes the milk in their natural or developed acidity. The classification of milk after the PCA has identified three classes whose characteristics are described in Tables 3 and 4.

Milks of Class 1 are the richest in fat, protein and lactose. In fact, they contain the highest content in useful matters. They are characterized by acidity and the highest cell count (TMAF) compared to other classes. More than half of these milks are produced in the autumn. Corresponding rations were characterized by an average intake of silage that exceeds 7 kg DM/D associated with the highest energy intake (more than 16 UFL/D) where the share of concentrates in total energy intake averaged of 68.51%, which allows a moderate milk yield not exceeding 15 kg / cow / D.

Milks of Class 2 are slightly less rich in fat, protein and lactose. They are characterized by the lowest cell count (TMAF). It is therefore the milk samples over good hygienic quality compared to other classes with the lowest acidity. They are produced throughout the year or 14, 31, 34 and 20% in autumn, winter, spring and summer respectively, from rations very marked by the use of silage with an average intake of 7.75 kg DM / D leading to the largest nitrogen supply compared to other classes or MAD 1566 g / D. Energy intake from concentrates in the ration was about 62.21%.

Milks of Class 3 are the poorest useful materials milks because of their low fat and protein content as well as their lactose content. They also have a cell count just above the average of sampled milk. These milks have the particularity to be produced throughout the year from rations where the proportion of concentrate in the total dry matter was lowest compared to other classes or 51.40% energy and nitrogen intake are thus low in

Table 3. Comprehensive descriptions of the classes of raw milk typology.

Classes of milk	**1**	**2**	**3**	**Significance [(1)]**
N [(2)]	**27**	**55**	**62**	
Cryoscopic (°C)	- 0.559[b]	- 0.544[a]	- 0.540[a]	**
Solids (g/kg)	134.24[a]	126.70[b]	118.95[c]	***
FC (g/kg)	46.27[a]	41.09[b]	37.31[c]	***
PR (g/kg)	33.65[a]	32.24[b]	30.80[c]	***
PR/FC	0.78[b]	0.79[b]	0.84[a]	*
Lactose (g/kg)	46.76[a]	45.81[a]	43.28[b]	**
Acidity (Dornic degree)	17.10[a]	16.60[b]	16.66[b]	**
TAMAF(Log UCF/ml)	6.92[a]	6.54[b]	6.77[a]	***

[(1)] *** P <0,001 ; **P <0,01. Values with different letters in the same row are significantly different. N[(2)] number of samples of milk.

Table 4. Characteristics of livestock practices and performance of dairy cows according to the classes of milk.

Classes of milk	**1**	**2**	**3**	**Significance**
Number [1]	**27**	**55**	**62**	
Season [2]				***
September to November (Fall)	15	8	13	
December to February (Winter)	4	17	15	
March to May (Spring)	3	19	14	
June to August (Summer)	5	11	20	
Detection of antibiotics [2]	8	12	18	*
Feed intake (kg DM / day)				
Basal ration of silage	7.45[a]	7.75[a]	6.95[b]	**
Concentrate	10.88[a]	9.22[b]	8.48[b]	**
% of total concentrate DM	58.55[a]	56.32[a]	51.40[b]	*
Energy intake (UFL / day)	16.70[a]	15.89[b]	14.22[c]	***
Nitrogen intake (g MAD / day)	1482[ab]	1566[a]	1330[b]	**
% concentrate UFL in% total UFL	68.51[a]	62.21[b]	56.85[c]	***
Production performance				
Milk production (kg / d)	14.95[a]	16.62[b]	16.33[b]	***
Lactation rank	3.62	3.51	3.23	NS
Duration of lactation (days)	299.54	311.21	304.4	NS

[1] Number of samples per cluster class; [2] Number of milk sample, *** P <0.001, ** P <0.01, * P <0.05; NS: Not significant; values with different letters in the same row are significantly different.

comparison with the other classes. These rations allow milk production of poor quality in chemicals. However, they allow one of the highest milk production with an average of 16.33 kg / D.

DISCUSSION

The quantitative performances of dairy production are comparable with those reported by several authors in similar conditions of environment in Algeria (Madani and Mouffok, 2008). These performances are characterized by variations due to the effect of environment combined with husbandry practices.

The share of concentrate in the proportion of total energy intake for dairy cows was higher than those found by Ouakli and Yakhlef (2003) (60.4 > 56%). They have the characteristics of zero land dairy cattle husbundary. Although, the importance of the useable agricultural area of these farms. The same observation was made by numerous studies (Kadi et al., 2007). This observation was very common in dairy farms in southern Mediterranean areas (Sraïri, 2004).

The concentrate feed was poorly valued by dairy cows.

The analysis of the relationship between the amount of UFL cc / kg and EA milk shows a negative and highly significant correlation. This allows us to deduce that the most productive cows require a liter of milk less of UFL of concentrates compared to bad dairy cows. This corresponds to previous findings made by Wolter (1994), which indicate a decrease in food costs reported per kg of milk in high producing cows. This also joined the observations of Srairi and Kessab (1998). On the other hand, it is surprising that there is a little relationship between the amount of consumed concentrate and the amount of produced milk. Indeed, the increased intake of concentrates in the ration of cows does not lead to an increase in milk production. The difference between (DP exp) and that (DP obs) increase with the level of energy intake from concentrates. This was explained by the gradual decrease in the efficiency of energy supply concentrates, as and as concentrate supplementation increases and the maximum of milk production is approached. This is accompanied by a decreasing proportion of the extra energy actually available to the udder (Broster and Broster, 1984).

The energy balance of the cows was significantly negative during different stages of lactation compared with recommendations of many authors (Enjalbert, 1995; Chagas et al., 2007). The objectives does not confirm the suggestion of obesity cows despite the usage of highly concentrate food, however it is possible that animals which feed on more energy rich diets should have a concentrate positive energy balance (Petit and Stephane, 1999). The energy from the concentrate food is not utilized in milk production as well as does not translate into weight gain but losing the undigested energy. And this could explain that highly concentrate starch foods which are considered as an important indicator of wasting and non exploitation of the resulted energy from this concentrate food by the dairy cows (Cabon and Soulard, 2005). However, the evaluation of body condition it is also strongly influenced by many environmental factors (Rastani et al., 2001). The combined effect of the environment for farming practices have led to a decrease in body condition. This could express the difficulty of the exotic animals of European origin to adapt to the Algerian context.

All analytical results tend to show that the mean values for the criteria describing the physico-chemical quality of different milks analyzed are within the framework of values used as normal for cow's milk (JORA, 1998; Packard and Ginn, 1990). These values reflect acceptable physico-chemical quality. The fat content was very variable. Several factors could be the cause of this variation namely feeding which was heavily influenced by the season thus confirming the observations of Jensen (1995). In addition, amounts of fat more important were recorded during the fall and winter season, which is accompanied by a low milk production. This is explained by the fact that the chemical composition of milk varies inversely with the quantity produced. This is in agreement with Alais (1984). This seasonal variation would thus mean a dilution of the fat by increasing milk production (Jensen, 1995). However, protein rate was less variable compared to fat content during the year, and in all the farms studied. The type of feed has weaker effects on the protein rate than the fat content (Coulon and Remond, 1991). This observation is in agreement with the results of other studies that have shown that massive intake of concentrate is a stabilizing factor of protein level (Jensen, 1995).

The results for the presence of antibiotics in raw milk emphasize very common contamination were 38% of samples tested were positive. There are a significantly higher percentage of positive samples compared to countries of the European Union (Navratilova, 2008).

The total aerobic mesophilic flora represent the most sought in microbiological analyzes. This study has enabled to demonstrate that the product leaving the farm was heavily contaminated. Indeed, contamination by TMAF was very important because 98% of analyzed milk show flora more than 10^5 CFU / ml. This reflects a lack of hygiene control, either during processing or in the overall environment of livestock buildings.

The examination of all the characteristics of livestock practices in function of three classes of identified milk leads us to conclude that feeding factors are listed first among the factors of variation in the composition of milk, as is commonly observed by Agabriel et al. (1993). Among these, the most advanced feeding factors to explain the variation in the chemical composition of milk is the proportion of concentrate in the ration (Journet and Chilliard, 1985). The milk fat and protein levels in Class 1 may be linked to high energy intake of rations. Indeed, the protein passes an average of 30.80 g / kg (Class 3) to 33.65 g / kg (Class 1) when the proportion of concentrate in the ration increased from 52 to 58%. Fat percentage increased an average of 41.09 g / kg (Class 3) to 46.27 g / kg (Class 1) (Journet and Chilliard, 1985). This can be explained by the significant increase (P <0.01) of silage intake that goes from 6.95 kg DM / D (Class 3) to 7.45 kg DM / D (Class 1), confirming the observations of other authors (Coulon and Remond, 1991).

The examination of all the characteristics of milk shows that there is no one ideal class, which cumulates both the best criteria describing the overall quality of raw milk. In contrast, Class 3 has the lowest levels in useful materials but higher milk yield compared to Class 1. These results show that the proportion of concentrates in the ration is an effective lever action to increase the nutritional quality of milk through its content useful materials.

Conclusion

The quantitative and qualitative fodder shortage imposes excessive use of concentrate where the milk was produced from concentrates. However, much of the concentrate was not valued in milk production leading to a waste of undigested energy. Rations have a greater impact on the chemical quality than quantity when milk production is moving in the opposite direction of the composition of milk. The majority of collected milk can be described as satisfactory in terms of physico-chemical quality. However, this result is acquired with a strong use of concentrates, which affects the sustainability of the dairy chain; in addition, a very poor quality in terms of health.

The concentrate feed was used by farmers as a criterion of efficiency of production. However, it seems more than necessary to find a new feed system based on good quality forages designed on nutritional parameters that take into consideration the digestive and metabolic interactions to help farmers to minimize these losses.

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