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Effect of feed on the milk protein and fat composition

L. Abdellaoui[1,2], N.A. Khelifi-Touhami *[1], F. Mebkhout[1,2], D. Tarzaali[1], W.I. Yahiaoui[1], T.M. Hamdi[2], N. Ouchene[1]

[1]Institute of Veterinary Sciences, University of Saad Dahlab, Blida 1, BP 270, Street, Algeria
[2]HASAQ Laboratory, National Veterinary School of Algiers, 16000 Algiers, Algeria

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Abstract. *Feed is considered the most important factor affecting the composition of cow's milk of which the quality can be evaluated, essentially, through two parameters, the fat and protein content, because of their industrial interest. This study aims to evaluate the impact of seven different rations (R1-R7) on the protein and fat content of Prim'holstein cow milk in a cattle farm in Algiers. The results showed that the dry matter (DM) content of forages and concentrate was 72.74% (62.94% - 81.49%) and 27.25% (18.51% - 37.06%), respectively. The forage unit milk (FUM) and the digestible nitrogen matter (DNM) contents of forage were 60.50% (51.37% - 72.08%) and 61.15% (46.73% - 74.63%), respectively. In concentrate, the FUM and DNM contents were 39.50% (24.85 - 51.5%) and 38.85% (25.37 - 52.39%), respectively (Table 3). The forages showed significantly higher DM, FUM and DNM contents than the concentrate (p<0.0001). The type of ration showed a highly significant effect on the quantity of milk produced per day, protein content and defatted dry matter. However, no significant influence was observed for the fat content. The highest milk production (ranging from 17.31 to 19.64 liters/day) and the highest defatted dry matter (87.03 and 87.92 g/l) were recorded in cows which received rations R2, R3, R4 and R5 (p<0.0001). The highest protein content values (32.87 and 33.20 g/l) were observed in the milk of cows that were fed with rations R2, R3 and R4. The lowest levels were observed for rations R6 (31.80 g/l) and R7 (31.22 g/l) (p<0.0001). Protein to fat content ratio ranged from 0.79 to 0.84 and fat to protein content ratio ranged from 1.19 to 1.27. Good management of the diet and feeding practices of the dairy cows allow having an adequate protein and fat content in the milk. A diet composed of forages with an adequate supplementation in concentrate leads to the optimal results. Further studies are important to evaluate the effect of the physical form of the diet on the physicochemical quality of the milk.*

Keywords: composition, diet, fat, milk, protein

Introduction

Milk is considered a complete food because of its high content of essential nutrients for growth and maintenance of a healthy life for humans (Visioli and Strata, 2014; Park, 2009). Milk composition has a significant impact on the quality of dairy products and the cost-effectiveness of the dairy industry (Amenu and Deeth, 2007). This composition varies throughout the year (Chen et al., 2014) and depends on several factors

*e-mail: khelifinaa@gmail.com

including those related to the animal (genetic factors, physiological stage, health status), the season, milking and especially feeding (Hoden and Coulon, 1991). The quality of milk can be evaluated, essentially, through two parameters, fat content and protein content, because of their industrial interest (Chiofalo et al., 2000).

Many factors can influence the fat and protein content of milk (Garamu, 2019; Hoden and Coulon, 1991). The stage of lactation affects their percentage in a very similar way. However, they tend to decrease with the age of the animal probably due to higher production and more mammary infections (Stoop et al., 2009; Garamu, 2019). The season has a considerable impact; hot and humid months decrease fat and protein contents (Collomb et al., 2008; Bernabucci et al., 2015; Garamu, 2019). Among all the factors that affect milk composition, feed and feeding practices are the most likely to cause problems. Changes in diet are capable of rapidly altering fat and protein production other than through genetics (Garamu, 2019).

The ruminant livestock in Algeria in 2018 was composed of 36,013,296 heads of which 80% are sheep, 13.6% goats and cattle represent only 5% with a population of 1,816,280 heads including 942,828 dairy cows (MADR, 2019). The consumption of milk takes a very important place in the daily diet of the Algerian population in order to cover the lack of protein of animal origin and because of the reduced price, subsidized by the state (Makhlouf et al., 2015).

In order to consume quality milk, it is important to study the variation of the composition of milk according to different factors. In Algeria, few studies that have been conducted to investigate the effect of diet on the chemical composition of cow milk (Ghozlane et al., 2009; Ouchene-Khelifi et al., 2017).

In our study we have investigated the variation of fat and protein content of raw cow milk according to seven different rations.

Material and methods

Study area

The study was conducted between December 15 and July 31 at a pilot farm, of dairy cows, located in Algiers (36°46'34"N, 3°03'36"E), north central Algeria. Algiers area is characterized by Mediterranean climate, with mild and rainy winters and hot and sunny summers. The average annual temperature is 18.2°C. The average annual rainfall is 615 mm.

Animals and feed

The feed distributed to the dairy cows was composed of different forages with a supplementation with concentrate (type VLB 17).

During the period of our study, seven different rations were distributed to the cows, which were the subject of our study (Table 1). The composition of the VLB17 concentrate is presented in Table 2.

The quantity of dry matter ingested/cow/day varied between 16.46 kg and 23.51 kg with an average of 19.36 kg (Table 1) and a dry matter intake of 3.8 kg per 100 kg of live weight.

Fat and protein content in cow milk

A lot of 27 Prim'holstein dairy cows were selected for milk sampling. All these cows were in the second stage of lactation.

Milk was collected from each cow after morning milking once a week for three weeks from each ration. A total of three samples per cow were taken for each ration.

The milk samples were analyzed using an EKOMILK (Bulgaria) milk analyzer for physicochemical analysis. Defatted dry matter was determined. The fat content was measured according to the Gerber method applied to milk (AFNOR, 2011) and the protein content according to the Kjeldahl method applied to milk (IDF, 2014).

Forage analysis

Forages and concentrates in each ration were analyzed according to AFNOR (2009) standards. The analyses concerned the dry matter DM, the digestible nitrogen matter DNM and the forage unit milk FUM.

The dry matter DM was determined after complete drying of the feed in an incubator at 105 ± 2°C for 24 hours.

Table 1. Distribution period, composition and quantities of feed and dry matter distributed in each ration

Rations	Distribution period	Composition of each ration	Quantity of feed ingested (Kg/day/cow)	Quantity of DM ingested (Kg/day/ cow)
R1	15 December-15 January	- Barley hay	6	5.09
		- Barley silage	12	3.32
		- Meadow grass	22	2.49
		- Concentrate VLB17	7	6.10
		Total	47	17
R2	16 January -15 February	- Barley hay	6	5.09
		- Barley silage	15	4.14
		- Green bersim	22	2.52
		- Concentrate VLB17	7	6.10
		Total	50	17.8
R3	16 February -15 March	- Barley hay	6	5.09
		- Barley silage	10	2.76
		- Bersim covered with green barley	22	2.51
		- Concentrate VLB17	7	6.10
		Total	45	16.5
R4	16 March - 30 April	- Barley hay	4	3.39
		- Green bersim	20	2.29
		- Green oat	60	11.5
		- Concentrate VLB17	5	4.35
		Total	89	21.6
R5	01 - 31 May	- Barley hay	2	1.69
		- Green bersim	28	3.21
		- Barley green	35	8.26
		- Concentrate VLB17	5	4.35
		Total	70	17.5
R6	01 – 30 June	- Barley hay	10	8.46
		- Green alfalfa	40	8.80
		- Concentrate VLB17	5	4.35
		Total	55	21.6
R7	01-31 July	- Barley hay	10	8.46
		- Green sorghum	60	10.7
		- Concentrate VLB17	5	4.35
		Total	75	23.5

Table 2. Composition of the VLB 17 concentrate

Composition	%
Corn	58
Soybean meal	20
Milling products	16.5
CMV vitamin complex	1
Dicalcium phosphates	0.5
Salt	1
Calcareous	3

Data analysis

R i386 3.0.2 for Windows GUI front-end was the statistical program used in this study. ANOVA, Chi square and multiple range tests were used for the statistical analysis. The threshold value of different tests was $p<0.05$.

Results

The results showed that the DM content of forages and concentrate was 72.74% (62.94% - 81.49%) and 27.25% (18.51% - 37.06%), respectively. The FUM and DNM contents of forage were 60.50% (51.37% - 72.08%) and 61.15% (46.73% - 74.63%), respectively. In concentrate, the FUM and DNM contents were 39.50% (24.85 - 51.5%) and 38.85% (25.37 - 52.39%), respectively (Table 3).

The forages showed significantly higher DM, FUM and DNM contents than the concentrate ($p<0.0001$) (Table 3).

The type of ration showed a highly significant effect on the quantity of milk produced per day, protein content and defatted dry matter. However, no significant influence was observed for fat content.

The highest milk production (ranging from 17.31 to 19.64 liters/day) and the highest defatted dry matter (87.03 and 87.92 g/l) were recorded in cows which received rations R2, R3, R4 and R5 ($p<0.0001$) (Table 4).

However, the cows that were fed with rations R6 and R7 produced less milk (varied between 13.08 and 14.16 liters/day) and defatted dry matter (82.49 and 84.06 g/l) ($p<0.0001$) (Table 4).

Table 3. DM, FUM and DNM rates between concentrate and forages

	DM (%)		DNM (%)		FUM (%)	
Rations	Concentrate	Forages	Concentrate	Forages	Concentrate	Forages
R1	35.89	64.11	48.63	51.37	52.39	47.61
R2	34.18	65.82	46.51	53.49	48.43	51.57
R3	37.06	62.94	51.5	48.5	52.27	46.73
R4	20.18	79.82	27.92	72.08	28.04	71.96
R5	24.85	75.15	24.85	67.6	29.19	70.81
R6	20.13	79.87	31.93	68.07	25.37	74.63
R7	18.51	81.49	30.53	69.47	35.24	64.76
Mean	27.25	72.74*	39.50	60.50*	38.85	61.15*

DM: Dry matter, FUM: Forage Unit Milk, DNM: digestible nitrogen matter

Table 4. Quantity of milk produced, fat, protein and defatted dry matter content of milk

Rations	Milk quantity/ cow/day (L)	Fat content (g/l)	Protein content (g/l)	Fat to protein ratio	Protein to fat ratio	Defatted dry matter (g/l)
R1	15.88^{bc}	40.97^{a}	32.37^{cd}	1.27	0.79	85.62^{b}
R2	18.17^{ab}	40.99^{a}	33.20^{a}	1.23	0.81	87.92^{a}
R3	17.46^{ab}	41.61^{a}	32.87^{ab}	1.27	0.79	87.03^{a}
R4	19.64^{a}	39.33^{a}	33.04^{ab}	1.19	0.84	87.50^{a}
R5	17.31^{ab}	39.41^{a}	32.71^{bc}	1.20	0.83	87.05^{a}
R6	14.16^{c}	39.75^{a}	31.80^{d}	1.25	0.80	84.06^{c}
R7	13.08^{c}	39.03^{a}	31.22^{d}	1.25	0.80	82.49^{d}

Values that do not have the same letters in the same column vary significantly.

The highest protein content values (32.87 and 33.20 g/l) were observed in the milk of cows that were fed with rations R2, R3 and R4. The lowest levels were observed for rations R6 (31.80 g/l) and R7 (31.22 g/l) ($p<0.0001$) (Table 4).

Protein to fat content ratio ranged from 0.79 to 0.84 and fat to protein concentration ranged from 1.19 to 1.27. No significant variation of these ratios was observed according to ration type (Table 4).

Discussion

Milk composition and quality depend on many genetic and non-genetic factors, such as animal breed, lactation period, lactation length, health status and maintenance conditions, but most importantly on feeding (Nowak et al., 2012; Zachwieja et al., 2013; Hyrslova et al., 2016). The first priority of feeding should be to enable the production of excellent milk quality and to ensure the best health of the cow (Wolter, 1997). In this study, we investigated the effect of seven different rations on milk fat and protein content of Prim'holstein dairy cows.

The amount of DM ingested/cow/day varied between 16.46 kg and 23.51 kg with an average of 19.36 kg which is consistent with the results of Ghozlane et al. (2009) in Algeria and Lessire et al. (2015) in Belgium.

The amount of DM ingested/100 kg of live weight, in our study, was 3.8 kg. This result is similar to that reported by Jarrige (1988) and Ghozlane et al. (2009).

In our survey, the forages showed significantly higher DM, FUM and DNM contents than the concentrate ($p<0.0001$). This could be due to the fact that an excess of concentrate in the ration leads to a decrease in fiber digestion and acetic acid production, which increases propionic acid production encouraging a fattening metabolism that is in opposition to milk fat (Mehra and Brein, 1999).

Dairy cow rations must contain sufficient dry matter from forage. Low forage intake can result in a significant reduction in milk fat content due to low fiber levels and contributes to acidosis and laminitis (Garamu, 2019). Wattiaux (1996) recommends that no more than 45% DM should be supplied from concentrate. This is coherent with our study where the DM intake is less than 45% for all rations.

In our survey, the highest quantity of milk produced was observed with the rations R2, R3, R4 and R5 which corresponds to a spring period. The lowest quantities produced are recorded with rations R6 and R7 which corresponds to the summer period. This is in agreement with Azad et al. (2007).

The fat content of milk recorded in our study, for all rations, corresponds to the standards (Hurtaud et al., 2010; Boutry et al., 2014).

The fat content recorded here is higher than that recorded in Prim'Holstein cows by Bouamra et al. (2019), Matallah et al. (2015) and Ouchene-Khelifi et al. (2017), in Algeria, and by Bousselmi et al. (2010) and Houchati et al. (2016), in Tunisia.

In our investigation, no significant variation was revealed with regard to fat content of milk from cows that were fed with different rations. This is because all rations fed contained fibrous components (hay, silage and green forages) essential for fat content stability (Garamu, 2019). The stability of the fat rate can also be justified by the rate of DM provided by the concentrate in our experiment which does not exceed 37.06%. According to Jaakamo et al. (2019), the increase in the proportion of concentrate in the ration has a negative impact on the fat rate.

However, a slight but insignificant increase was observed in the milk of cows fed R1, R2 and R3 rations, which corresponds to the winter period. This observation has been confirmed by other researchers (Bony et al., 2005; Garamu, 2019). Azad et al. (2007) investigated milk seasonal variations, the results showed that summer milk had slightly less fat content being consistent with our data.

As for its nature, the concentrate used (VLB17) is a balanced production supplement whose composition is favourable to the synthesis of milk fat. Indeed, for Wolter (1997) a positive influence on the fat content is linked to the whole dietary balance, especially in proteins (degradable nitrogen), minerals and vitamins.

Protein content investigated in our survey was within the recommended values (Hurtaud et al., 2010; Boutry et al., 2014). This result is probably related to the positive energy balance recorded under the specific conditions of our experiment.

The protein content of milk recorded is comparable to that reported in Holstein cows by Bousselmi et al. (2010) and Houchati et al. (2016), in Tunisia, and was higher than that recorded by Matallah et al., (2015), Ouchene-Khelifi et al. (2017) and Bouamra et al. (2019) in Algeria.

In contrast to the fat content, a highly significant difference was recorded for the protein rate between the different rations. The lowest values were observed in cows fed with rations R6 and R7 which correspond to the summer period. The same was observed elsewhere (Bernabucci et al., 2015; Bony et al., 2005).

Cows fed with rations R2, R3, R4 and R5 showed the highest milk protein content, which corresponds to the winter and spring period. This result is in agreement with those received from Bony et al. (2005), Matallah et al. (2015) and Garamu (2019).

The stability of the fat content in relation to the protein content can be explained by the quality of the seven rations distributed, which have some similarities, so that they do not generate sudden variations in the mechanisms of digestion (Jarrige, 1988).

In Holstein cows, Čejna and Chládek (2005) have indicated that the optimum fat to protein ratio was between 1.2 and 1.4 which is in agreement with our findings. An increase in this ratio to more than 1.5 leads to a risk of metabolic problems such as ketosis, and if it is <1, a risk of subacute ruminal acidosis occurs (Heur et al., 2000; Eicher, 2004).

Increasing the protein level in the ration causes an improvement in milk production (Verité and Delaby, 1998) and a high protein to fat ratio is an indicator of a good energy and nitrogen ration and a good rumen activity (Wolter, 1997), which is the case in our study (varies between 0.79 and 0.84).

Among the indicators of milk composition, the defatted dry matter, which represents the solid constituents of milk without fat, of which a legal minimum must be required. A lower value suggests that the milk has been wet (Hamidi et al., 2020). The European Union standards require a minimum of 85 g/l (Junior et al., 2019). Our findings are within the standards and comparable to those found by Murta et al. (2016).

In addition to mastitis, which can lead to a decrease in defatted dry matter levels (Alessio et al., 2016; Junior et al., 2019), protein content is one of the most important factors of variation in milk defatted dry matter levels (Wolter, 1997; Rosa et al., 2012) which is in agreement with our results in which a positive correlation between protein content and defatted dry matter was revealed.

Conclusion

Ration composition showed a highly significant effect on the amount of milk production per day and its protein and defatted dry matter content in Prim'holstein cows. A ration composed of forages with adequate supplementation of concentrates allows to obtain optimal results and in order to avoid any digestive disorders in the cow, forages must contain more DM, FUM and DNM than concentrates. The lowest protein and fat content of the milk was observed during the hottest months of the year (summer), which corresponds to the period of forage deficiency. A progressive and well-studied modification of the ration allows to avoid digestive disorders and alterations of the milk quality.

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