

Effects of rations and seasons on milk yield and composition in small and medium dairy farms from a Tunisian northern area (Bizerte Region)

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Abstract

In Tunisia, dairy farming faced several problems limiting the improvement of the milk sector, mostly at the level of small farmers. These difficulties are related to the milk quality affected by the feed quality distributed throughout the year. This study aimed to evaluate the effect of rations and seasons on daily individual milk production (DIMP) and some physicochemical characteristics (Fat content: FC, Protein content: PC, Urea concentration: UC, Total Solids: TS). A survey and milk samplings were performed on 135 farmers. Collected data were treated by the variance analysis using the GLM procedure of the SAS system. This study allowed to identify four types of ration: TR1: Concentrate (CC)+Green Forage(GF), TR2: CC+Dry Forage (DF), TR3: CC+GF+DF and TR4: Diet containing Silage (S), used by farmers with the frequencies of 14.82, 37.19, 44.6 and 3.38 % respectively. The highest DIMP ($P<0.0001$) was obtained by TR1 (17.3 kg/day) and the lowest (13.6 kg/day) by TR2. TR4 allowed FC, PC ($P<0.05$) and TS ($P<0.01$) higher (3.84, 3.14 and 12.31 % respectively) than those obtained in the other rations. The UC ($P<0.0001$) was the highest in TR1 and TR3 (32.05 mg/dL) followed by TR4 (28.3 mg/dL) and TR2 (26.2 mg/dL). Concerning the season effect, the highest DIMP ($P<0.0001$) was obtained during spring (17.7 kg/day), the lowest was during autumn (13.1 kg/day). The FC ($P<0.05$) was the lowest in winter (3.52 %). The PC ($P<0.01$) was higher during autumn and winter (averaged 3.07 %). The UC ($P<0.0001$) was the highest in spring (32.23 mg/dL) and the lowest in autumn (25.67 mg/dL). It was concluded that milk parameters were in the acceptable ranges comparatively to the national averages.

Key words: dairy cow; milk; type of ration; season

Introduction

Since the 1960s, cattle farming in Tunisia has undergone significant transformations under the effect of various factors contributing to the dynamics of this sector, such as climatic conditions, forages availability, changes in farming systems and state assistance. Cattle breeding is an important component of the agricultural and national economy as it represents the major supply of milk and red meat. Indeed, the milk sector contributes up to 11 % of the total value of agricultural production, 25 % of animal production and 8.5 % of the food industry (IGRMM, 2018). It occupies an important place in the agricultural, economic and social sectors. Hence, milk productivity remains clearly below the genetic potential of animals for multiple and varied factors, mainly low diversified fodder resources and low feeding values, insufficient husbandry control of livestock and technicality, health problems and economic management difficulties. Also, several constraints are associated with this activity, such as the great increase in prices of raw materials and concentrate, mainly during the two last decades (33 % between 2010 and 2018; OLP, 2018), and the high cost of workforce and heifers imported or locally produced. These factors are more pronounced in small and medium-sized farms. IGRMM (2018) reported that 93 % of farmers have a herd that does not exceed 10 females, representing, thereby, almost 70 % of the national herd.

The governorate of Bizerte benefits from favourable conditions for the development of dairy cattle farming. Bizerte's cattle livestock represents 11.86 % of the national herd. During the last 10 years, this region has been involved in dairy production by about 11 % of the national production. It is considered as one of the major milk-producing regions. However, several constraints are limiting the development of the dairy sector. Indeed, a large proportion of livestock is owned by small farms with low productivity. In addition, produced conventional fodders, especially hay, are known for low nutritional value and there is a lack of diversity in the forage calendar characterizing small and medium-sized farms. All these technical and economic problems raise the issue of the sustainability of dairy farms.

In Tunisia, many studies were conducted in the dairy sector to evaluate the effects of environmental factors on milk yield (M'hamdi et al., 2012) and livestock practices on animal wellbeing and milk quality (Darej et al., 2019). Other research aimed to assess the profitability of dairy farms in the northwest (Hammami et al., 2017) and the centre of the country (Rejeb Gharbi et al., 2007; Ben Salem et al., 1998). Some other studies focused on the major constraints of bovine milk production of large farms from the organized sector (Ben Salem et al., 2006; Darej et al., 2010), but unfortunately, to our knowledge, very few studies have looked at small and medium breeding, despite their importance in the sector. In the current work, and in order to better understand and analyse the major constraints that limit the development of milk performance in small and medium breeders, we aimed to investigate the

effects of the type of used rations and the season on milk yield and composition within this category of breeders in a region of northern Tunisia. The results of this study could be helpful for decision-makers to diagnose the weaknesses associated with feeding behaviour throughout the year. Thus, they could develop policies for farm management practices that improve the quality of forages and thereby the quality of milk and can be adapted to the diverse farming systems.

Materials and methods

Study area

Bizerte's governorate is a region in the north of Tunisia characterized by a large and diversified agricultural vocation. It benefits from favourable conditions for producing forage crops and dairy cattle breeding. Its area is 375,000 ha, including 207,000 ha (55 %) of Used Agricultural Areas (UAA) (RCAD, 2018). According to the last structural survey carried out by the GDSAD (2005), the area occupied by forage crops does not exceed 30 % of UAA. This region receives rainfall of around 600 to 800 mm per year and the annual temperature range between 2 to 41 °C. According to the RCAD (2018), Bizerte's dairy cattle herd is made up of 44456 dairy-producing cows. Thereby, we can cite as an indication that 14.4 % of this herd is in Utique, which is producing 15.5 % of milk production of Bizerte; 10.3 % in Southern Bizerte with 11 % milk production; 8.6 % in Ghazela with 10 % milk production and more than 6 % in El Alya and Ras Jbal with 6 and 5 % of milk production respectively (Figure 1).

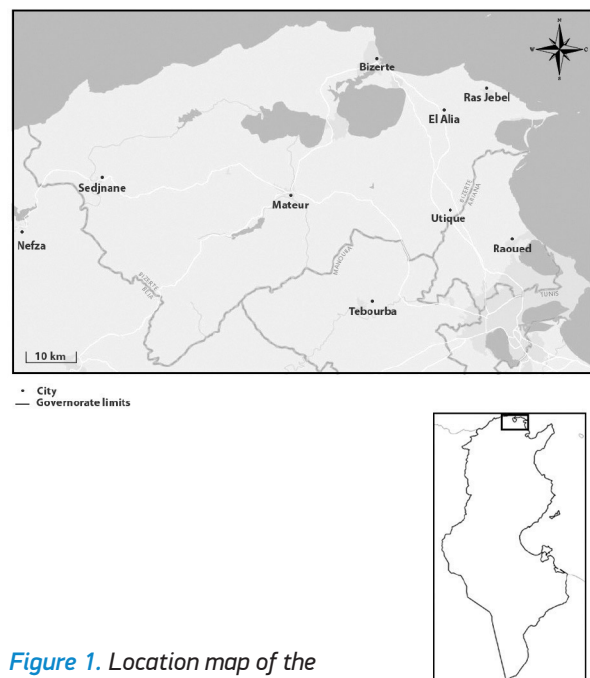


Figure 1. Location map of the Governorate of Bizerte

This study was carried out in 10 different zones of Bizerte where bovine production is the predominant activity in small and medium-sized farms. The studied farms' distribution is reported in Figure 2.

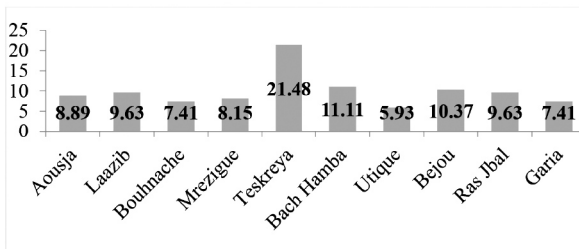


Figure 2. Studied farms' distribution in Bizerte

Descriptive analysis

Descriptive analysis, reported in table 2, showed that the studied farms were of medium size, with an average area and present dairy cows of 12 ha and 6.9 respectively. Holstein was the dominant bovine breed in the studied sample. We noted that 97 % of farmers are males and 33 % of them are old under 40 to 50 years. Also, 53 % of the breeders had primary education level, 26 % went to secondary school, 14 % were illiterate and only 7 % of them had high education. More than 90 % of breeders had farming as a profession for more than 10 years, but only 7 % of them had followed agricultural training. Also, 90 % of them are not interested in farmer organization, by integrating associations or cooperatives. Thereby, only 10 % of the farmers had been members or had an associative activity. Table 1 shows that 60 % of farmers owned their agricultural land. The other 40 % were tenants. Indeed, 16 % of them rented by 100 % and 30 % of them rented from 50 % of the UAA. In 81 % of the farm surface area, farmers practice irrigation, while in 19 % of the sampled farm area, they rely on rain-fed production. The workforce is relying on family members with a call for seasonal workers in 59 % of the cases and only 11 % of them are hiring permanent and seasonal workers. Along the year, the composition of dairy cows' diet is based on an average of 42.2 % of concentrate, 38.4 % of dry forage, 18.4 % of green forage and 1 % of silage of the overall diet.

Milk sampling and data collection

Milk sampling and data collection concerned 135 small and medium-sized bovine farms. The choice of farmers was made in order to have a representative sample of the area, taking into account the diversity of farm types and accessibility and their receptivity. Milk sampling was performed monthly from March 2017 to February 2018 in duplicate. Samples were added a conserving agent (0.5 mg of bronopol (C3H6BrNO4) in a bottle of 30 mL) and then

Table 1. Descriptive statistics of studied farms (n=135)

Variables	Mean	SD
Structural variables		
Farm surface area (ha)	12	23.5
Used agricultural area (ha)	10.4	18.1
Propriety surface area (%)	65.4	42.9
Rented surface area (%)	30.7	41.3
Land parcel	2.4	2.1
Irrigated area (%)	47.8	41.4
Cereal area (%)	7.7	17.4
Hay and green forages area (%)	71.3	28.6
Vegetable cropping area (%)	14.1	21.7
Arboriculture area (%)	0.5	4.1
Olive area (%)	2.1	5.1
Flock size and composition		
Cattle, % LU	84.1	19.4
Present cow (head)	6.9	6.9
Cow in lactation (head)	6.5	6.4
Sheep, % LU	14.4	18.5
Goat, % LU	0.8	2.1
Breeds		
Holstein, LU	6.9	7.3
Brown Swiss, LU	1.8	3.9
Tarentaise, LU	0.4	2.5
Montbeliard, LU	0.2	1.1
Others, LU	0.3	1.03
Feeding variables (n=1538)		
Concentrate, %DM	42.2	14.2
Dried Forage (straw, hay), %DM	38.4	24.6
Green Forage, %DM	18.4	18.5
Silage, %DM	1	5.2

LU: Livestock unit, DM: dry matter.

stored at 4 °C pending analysis. Chemical composition (fat content (FC) protein content (PC), urea concentration (UC), lactose (L), solids-not-fat (SNF) and totals solids (TS)) were analysed using MilkoScan (CombiFoss, FT +).

Data collection was performed within farmers' investigation from 2017 to 2019. A first survey focusing on dairy cows' diets, was conducted monthly (from March 2017 to February 2018), while sampling milk simultaneously. The survey investigated the rations given at the current period and composition of the flock and daily milk yield. This survey allowed us to identify 4 types of ration based on the combinations of the different feeds. The defined types of ration and their frequency within farmers are presented in Table 2.

The second survey (conducted between 2017 and 2019) was composed of two sections. The first one included questions about the farmer's characteristics (age, edu-

Table 2. Identified types of ration and their frequency

Type of ration	Ingredients' combination	Use frequency, %
TR1	CC+ GF	14.82
TR2	CC+DF	37.19
TR3	CC+GF+DF	44.6
TR4	TR2+S and/or TR3+S	3.38

CC: concentrate, GF: green forage, DF: dry forage, S: Silage

cation level, gender, etc). The second section focused on-farm data (farm surface area, principal cultures, irrigation, flock size, composition and breed categories) and dairy cow farming.

Statistical analysis

The analysis of the effects of type of ration and season on dairy performances and physicochemical parameters was carried out by analysis of the variance using the GLM procedure of the SAS system (version 9.0, 2002), according to the following linear model:

$$Y_{ij} = \mu + TR_i + S_j + (TR_i \times S_j) + e_{ij} \quad (1)$$

where:

μ : general average; TR_i: type of ration (i = 1, 2, 3, 4); S_j: control season (j = autumn, winter, spring, summer); TR_i × S_j: interaction season and type of ration; e_{ij}: residual error.

The factor levels were compared two by two using the SNK test.

Results and discussions

This study aimed to identify the feeding behaviour adopted by small and medium farmers in the north area of Tunisia. This characterization aimed to assess the effect of ration types and seasons on milk performance which allows identifying the deficiencies of this feeding conduct.

Dairy performance variation

Effect of the type of ration

Table 3 illustrates the variation of dairy performance according to the different types of ration distributed. Concerning milk production, TR1 presented the highest level (P<0.0001) which is associated with the highest (P<0.0001) milk to concentrate ratio (MCR). This type composed of green forage and concentrate (41 and 54 % DM respectively) allowed about 17.3 kg/cow/day. However, the lowest milk yield (13.6 kg/cow/day) which was associated with the lowest MCR (1.96) was obtained by TR2. This ration was composed of more than 50 % of dry forage and 39% of concentrate.

Our results were in agreement with those of Darej et al. (2019), who found the same trend of milk production.

Table 3. Effect of rations 'type on dairy performances

Type of ration	DIMPp	DIMPL	MCR	GF (%DM)	CC (%DM)
TR1	14 ^a	17.3 ^a	2.47 ^a	41.5 ^a	54.4 ^a
TR2	10.7 ^c	13.6 ^c	1.96 ^c	0 ^d	39.3 ^c
TR3	13 ^{ab}	16.2 ^b	2.29 ^{ab}	26.5 ^b	40.2 ^c
TR4	12.6 ^b	15.3 ^c	2.12 ^{bc}	7.8 ^c	45.5 ^b
SEM	0.14	0.13	0.02	0.06	0.47
p	<.0001	<.0001	<.0001	<.0001	<.0001

a, b, c, d: Means with different letters in the same column are statistically different, SEM: Standard Error Mean

DIMPp: average daily individual milk production per present cows (kg)

DIMPL: average daily individual milk production per lactating cows (kg)

MCR: milk to concentrate ratio

Indeed, they reported that the highest milk yield (16.94 kg/cow/day) was recorded for cows receiving a ration based on green forage and concentrate in the North of Tunisia. The lowest amount of milk (9.16 kg/cow/day) resulted from a ration consisting mainly of dry forage and concentrate. In our study, this milk production remained below the potentialities of Holstein's breed. It may indicate a failure in breeding management, particularly in terms of ration formulation and feeding distribution. Also, this result might reflect the low quality of forages cultivated in these farms as reported by Srairi et al. (2005). A high significant effect (P<0.0001) of the ration types on MCR was recorded. Indeed, the highest value (2.47) corresponded to TR1, followed by TR3 (2.29), TR4 (2.12) and lastly TR2 (1.96). Our highest obtained MCR was below the level of 2.77 reported by Kamoun et al. (2011) in the Tunisian context. These found ratios obtained for TR1, TR3 and TR4 were higher than the accepted value of "2" cited by Hammami et al. (2011) for the breeding conditions in Tunisia. It's to note that the variation in the MCR values followed the same trend as milk yield variation in the four types of ration. In addition, in the current study, the same amount of distributed concentrate (an average of 7.55 kg) resulted in non-similar milk yields. This can be explained by the diversity of forages and then basic rations. Also, it showed that the rations were of low nutritional or unbalanced potential and may cause concentrate wastes. These observations on significant use of concentrate were generally characterizing low-quality forage or unbalanced rations (Darej et al., 2010) and led to produce milk on the base of concentrate, with low or moderate yields, recalling situations often observed in the southern Mediterranean (Srairi et al., 2005).

Effect of seasons

Results (Table 4) show that generally, a significant influence of the season on dairy performance parameters was observed. Indeed, high season significant effect (P<0.0001) on DIMP and (P<0.01) on MCR were recorded. Thus, the highest DIMP was obtained during spring (17.8 kg), followed by summer and winter which were significantly equivalent (up averaged: 15.25 kg), while the lowest DIMP

was obtained in autumn with an average of 13.1 kg. The MCR followed the variation of milk yield. Thereby, the highest ratio was recorded for spring (2.49) and the lowest for autumn (1.88).

Our results were in total agreement with those of Černý et al. (2016) in a study conducted on Czech Fleckvieh cattle. They reported that the highest milk yield was reached with dairy cows in spring (29.27 kg) and the lowest in autumn (24.58 kg), and there was no significant difference between milk yield in winter and summer. This milk yield fluctuation could be explained by the seasonal variation of forage availabilities. Therefore, our highest milk production corresponds to the highest distributed-forage rate in the ration (about 33.7 % DM) and the lowest one, which is in autumn corresponded to the lowest forage rate in the ration (about 10 % DM). According to Czyszter et al. (2012), this seasonal distribution of the milk yield is due to the milk secretion stimulation by the green fodder, which is fed to cows during the warm season of the year. Similarly, Singh et al. (2015) reported that the milk production potential of animals reaches the highest level when green forages and grazing grasses are abundant. Furthermore, high temperature and humidity index above critical thresholds cause a decrease in milk yield and efficiency of milk production (West, 2003). In our case, this was observed during the low production period that begins at the end of summer and continues during autumn. As reported by Cappa (1998), the climate changes related to different seasons may affect the neuroendocrine system in animals, affecting the influence of hormonal equilibrium, energy balance, water balance, body temperature and eventually disturbing growth, reproduction and milk production. Indeed, our study revealed that milk yield decreased by about 14.6 % between spring and summer when the mean temperature varied from 18 to 28 °C and by about 13.8 %, between summer and autumn, due to hot weather (averaged 25.9 °C) and non-abundance of forages.

Milk chemical composition variation

Effect of type of ration

The results on the variation of milk chemical composition were presented in table 5. Fat and protein content had the same season variation. Values were similar between

TR1, TR2 and TR3 (averaged 3.61 and 3.01 % respectively). TR4 presented the highest ($P < 0.05$) values (3.84 and 3.14 % respectively). The highest UC ($p < 0.001$) was recorded for TR1 and TR3 (averaged 31.95 mg/dl) and the lowest was noted in TR2 (26.2 mg/dL). Lactose content ($p < 0.01$) recorded the highest value in the case of TR1 (4.89 % vs an average of 4.66 % for the other ration types). Value relative to TS was the highest ($p < 0.01$) in TR4 (12.31 %). For the SNF ($p < 0.05$), TR1 and TR4 presented an average content of about 8.59 % followed by TR3 and TR2.

Our results showed that FC, in all types of ration, was higher than 30g/l (NT 14.141, 2004), which is the acceptance threshold of the Tunisian standard. The highest FC was associated with the ration containing a high and diversified forage proportion (TR4, about 8 % GF, 20 % DF and 28 % S based on DM). Indeed, FC was in general positively correlated to the fibre content and strongly affected by nutrition or ration formulation changes (Tyasi et al., 2015). Thus, it was recommended a minimum of 26 to 28 % neutral detergent fibre (NDF) and about 19 to 21 % acid detergent fibre (ADF) in diets to maximize milk production and fat percentage Tyasi et al. (2015). According to Dixon et Ernst (2001), fibre digestion might generate an acetic fermentation trend in the rumen, associated with higher synthesis of acetate and butyrate milk fatty acids (about 60 % of milk fat). Broderick (2003) reported that fat yield was higher at 32 % NDF than at 28% NDF by about 16.5 % (fat varied from 3.22 to 3.86 %).

In opposite to our results, Darej et al. (2019) found that the ration composed of forage, silage and concentrate, resulted in the lowest FC (35.2 g/L). This confirmed that differences between authors in the literature should be rather attributed to concentrate rate in the ration.

Concerning milk protein, the obtained PC were higher than 28 g/L (NT 14.141, 2004) which complied with the quality's determinants of Tunisia. The energy level intake remained the main factor of dietary variation in PC. Thus, ration type 4 was composed of 7 % GF, 20 % DF, 28 % S and 45 % CC that allowed the highest PC (3.14 %). Our result was in concordance with Darej et al. (2019) who found that the ration composed of forage, silage and concentrate, resulted in the highest PC (31.9 g/L). In addition to its probable high energy level, these rations (TR4) seemed to generate a suitable nutrient balance in the rumen allowing high microbial synthesis. Broderick (2003) reported that increasing the fermentable energy content of the diet by reducing NDF (from 36 to 28 % NDF) stimulated greater microbial protein that increased linearly protein percentage by about 4 % (from 2.95 to 3.08 %). Indeed, increasing dietary energy content stimulates microbial protein synthesis. Rumen microbes convert dietary protein into microbial protein, which is a primary source of essential amino acids for the cow. These amino acids are absorbed by the mammary gland and used to synthesize milk protein (Cadorniga et al., 1993).

The UC in milk varied according to the distributed ration. It resulted from the degradation of protein into ammonia and could be measured either in the blood or in the milk. A high urea rate in milk may traduce an excess of

Table 4. Effect of seasons on dairy performances

Season	DIMPP	DIMPL	MCR	GF (%DM)	CC (%DM)
Autumn	10.4 ^c	13.1 ^c	1.88 ^c	10.1 ^d	40.2
Winter	11.8 ^b	15.3 ^b	2.24 ^b	16.5 ^b	40.2
Spring	14.5 ^a	17.8 ^a	2.49 ^a	33.7 ^a	48.3
Summer	12.3 ^b	15.2 ^b	2.13 ^b	12 ^c	39.6
SEM	0.14	0.13	0.02	0.47	0.36
p	<.0001	<.0001	0.01	<.0001	NS

a, b, c, d: Means with different letters in the same column are statistically different, NS: non-significant, SEM: Standard Error Mean

ammonia in the rumen, then an unbalanced energy and nitrogen supplies. Wolter and Ponter (2012) reported that UC increased when dairy cows were fed with forages and decreased when they receive a balanced ration containing more dry matter. However, Darej et al. (2019) found that the lowest UC was associated with cows receiving green and dry forage (25.27 mg/dL). Animals are considered in a comfort zone when urea levels are between 18 and 33 mg/dL. In our results, the high average of UC recorded for TR1 and TR3 (32 mg/dL) may be due to the combination of an excess of degradable nitrogen in the rumen and/or a deficit of fermentable energy. Thereby, the ration ingested could not optimize microbial activity in the rumen. In our study, no UC values below 20 mg/dL were found. Such situation may express a limited availability of degradable nitrogen with reduced activity of the ruminal microflora.

Lactose is one of the milk components least subject to variation due to osmotic regulation that attracts water into the milk (Jenkins and McGuire 2006). However, a variation of about 4.7 % was recorded between TR1 (containing 54 % of concentrate) and the other rations. Okine et al. (1997) found that lactose yield was increased by 11 % in cows fed 50 % concentrate diets compared with cows fed 35 % concentrate diets. Malossini et al. (1996) found also a small but significant increase following the increase in feeding level (1.6 % with diet high feeding level (7 % of UFL above the allowances) and 1.4% with diet very high feeding level (14 % of UFL above the allowances) comparatively to normal feeding level.

TS content was an important parameter when evaluating milk quality. It represented the amount of water contained in milk. The higher TS content reflected the better nutritional quality of milk, meaning that it contained more valuable compounds including proteins, fats, minerals, and other micronutrients. Thereby, TS, SNF, PC, and FC had almost the same variation trend, which reflected a higher content of more valuable compounds by about 3.6 % in TR4 compared to the other rations. Our results are higher than those obtained by Gargouri et al. (2014) who found 10.82 % of TS in a central region of Tunisia. Indeed, Baset et al., (2012) registered an increase by about 3 and 4 % for SNF and TS respectively by ameliorating the distributed ration. However, Sucak et al. (2017) reported that

TS were not significantly affected by increasing the protein level in the diet. Similarly, Colmenero and Broderick (2006) found that SNF showed a linear trend with increasing CP content of the diets but statistically there was no significant effect.

Effect of seasons

Table 6 shows the seasonal changes in milk components. FC in milk produced in winter was lower by about 3 % compared to the other seasons ($p < 0.05$). Autumn and winter increased ($p < 0.01$) milk PC (an average of 3.075 %) compared to spring and summer. All the seasons were significantly different ($p < 0.0001$) for UC and the lowest (25.7 mg/dL) was in autumn-produced milk followed by which in summer, winter and spring. The highest ($p < 0.0001$) lactose content was noted in spring (4.91 %) followed by summer, autumn and then winter (averaged: 4.52 %). Milk produced in winter and spring were the most ($p < 0.05$) provided with SNF (averaged 8.55 %). Milk produced in summer and autumn were lower ($p < 0.05$) in SNF by about 0.2 and 0.1 % than those in spring and winter.

Seasonal variation affected milk composition in several ways, such as consumed diets, photoperiod, and temperature (Heck et al., 2009). Results of FC were in line with the values of the Tunisian standard NT 14.141 (2004) but were lower than that found by Kamoun (2011) which were around 41.1 g/L. The FC decrease in winter could be explained by the high linolenic acid content in fresh grass. These high levels, as reported by Baumgard et al. (2000), are associated with the production of specific long-chain unsaturated fatty acids that inhibit fatty acid synthesis in the mammary gland and reduce the milk fat content. Furthermore, during summer and autumn, hot weather influenced cows to produce less milk, but higher milk fat content (Yoon et al., 2004).

Results relative to PC content were in the same trends to those reported by Bernabucci et al. (2002) indicating that milk protein percentages were 9.9 % lower in the summer than in the spring (our case 8.7 % lower). Wangdi et al. (2016) reported that no significant differences in the mean PC between seasons were found in cow's milk produced in Bhutan. However, Yoon et al. (2004) affirmed that summer and autumn increased milk PC by over 0.06 and 0.08 % respectively, compared to spring and winter. Indeed, our highest PC recorded in autumn and winter could be explained by their association to the highest concentrate-to-forage ratio with lower levels of fiber and higher levels of starch in the diet, which gives rise to an increased production of propionic acid in the rumen and an increased microbial protein supply (Bannink et al., 2006). Jenkins and McGuire (2006) reported that propionic acid is the major precursor of glucose, followed by amino acids that result in an increased milk protein concentration. Our findings concerning UC were in line with those of Yoon et al. (2004). They reported that the UC of milk produced in summer and autumn were significantly lower up to 1.43 and 1.64 mg/dL, respectively than those in spring and winter. According to Doska et al. (2012), this variation could be explained by the seasonal variations in pasture protein

Table 5. Effect of type of rations on the chemical composition of milk

Type of Ration	FC	PC	UC	L	TS	SNF
TR1	3.64 ^b	3.03 ^b	32.8 ^a	4.88 ^a	11.9 ^b	8.56 ^a
TR2	3.63 ^b	2.99 ^b	26.2 ^c	4.62 ^b	11.84 ^b	8.38 ^b
TR3	3.56 ^b	3.01 ^b	31.1 ^a	4.69 ^b	11.88 ^b	8.49 ^{ab}
TR4	3.84 ^a	3.14 ^a	28.3 ^b	4.61 ^b	12.31 ^a	8.62 ^a
SEM	0.017	0.008	0.213	0.009	0.024	0.014
p	0.05	0.05	<.0001	0.01	0.01	0.05

a, b, c: Means with different letters in the same column are statistically different, SEM: Standard Error of Mean

and energy components. Spring pasture is rich in protein (more than 20 % of CP) and poor in soluble carbohydrates, thus creating an increased protein-energy ratio. Consequently, high protein levels in the diet cause unbalance with more available ammonia in the rumen, which can increase UC (Sucak et al., 2017). In our study, high UC during the winter and spring were probably due to the greater availability of Berseem grass (*Trifolium alexandrinum*) high in protein mainly soluble (15-25 % DM according to Sharma and Murdia (1974)), which is very frequent at this period of the year in Tunisia. Seasonal changes affected also milk lactose content. Indeed, we found the same variations trend as Heck et al. (2009). Thus, the authors reported that the lactose concentration in milk remains barely variable throughout the same season. It was the most stable parameter with an average value of 4.51 %, a minimum value of 4.46 % in autumn and a maximum value of 4.55 % in spring (Heck et al., 2009). Indeed, Wangdi et al. (2016) found that lactose content was not affected by the seasonal variation and they recorded a higher mean lactose content (5.48 %).

On the other hand, seasonal changes had a significant effect on SNF and the highest content was recorded in winter and spring (8.55 %). Indeed, Sahu et al. (2018) found that the mean value of SNF percentage was significantly higher in winter (8.65 %) followed by summer (8.26 %). According to the authors, this variation could be attributed to the availability of adequate quality and quantity of green fodder in the winter season. Furthermore, Bernabucci et al. (2015) found that the SNF content was 2.8 % lower during summer than winter. Broderick (2003), explained this variation by the increasing of the ratios of energy feeding, and this increase in the SNF content was due mainly to an increase in the protein fraction. Hence, Kadzere et al. (2002) reported that heat stress reduced SNF content in milk of dairy cows. These observations were controverted by the results of Wangdi et al. (2016), who reported that seasonal variation had no effect on SNF content and that they recorded a mean value of about 8.59 %.

At the end of this study and for a better valorisation of the results, it would be interesting to continue the re-

Table 6. Effect of season on the chemical composition of milk

Season	FC	PC	UC	L	TS	SNF
Autumn	3.68 ^a	3.08 ^a	25.7 ^d	4.53 ^c	12.03	8.46 ^b
Winter	3.52 ^b	3.07 ^a	30.9 ^b	4.51 ^c	12.04	8.56 ^a
Spring	3.63 ^a	3.02 ^b	32.2 ^a	4.91 ^a	11.88	8.55 ^a
Summer	3.61 ^a	2.89 ^c	28.9 ^c	4.81 ^b	11.62	8.31 ^c
SEM	0.017	0.008	0.213	0.009	0.024	0.014
P	0.05	0.01	<.0001	<.0001	NS	0.05

a, b, c: Means with different letters in the same column are statistically different, NS: non-significant, SEM: Standard Error of Mean

search and to develop a characterization of the nutritive value of the forages for a better explanation of the factors of dietary variations throughout the year.

Conclusions

This study showed that the parameters of milk composition are in the acceptable ranges, comparatively to the national averages. Both milk and milk components were influenced by the types of ration and seasons and the highest results were obtained when diets were based on forages either green or silage. The dairy performances were influenced by the level of concentrate in the diet (TR1) and chemical composition was affected by the source of forage (TR4). Also, the effect of season was highly significant on milk yield and all the milk constituents except total solids. The milk FC (%), UC (mg/dL), lactose (%) and SNF (%) were significantly higher in the spring whereas milk PC (%) was significantly higher in autumn and winter. In order to ensure the development and sustainability of the dairy sector in the region, it is necessary to improve productivity. This requires mainly all efforts to master the exploitation of the available fodder potential and the development of breeders' capacities through organization and extension.

Učinci obroka i godišnjih doba na mliječnost i sastav mlijeka na malim i srednjim mliječnim farmama iz sjevernog područja Tunisa (regija Bizerte)

Sažetak

U Tunisu se mljekarstvo suočilo s nekoliko problema koji ograničavaju poboljšanje mliječnog sektora, uglavnom na razini malih poljoprivrednika. Te su poteškoće povezane s kvalitetom mlijeka na koju utječe kvaliteta hrane koja se distribuira tijekom cijele godine. Cilj ovog rada bio je procijeniti učinak obroka i godišnjih doba na dnevnu individualnu proizvodnju mlijeka (DIMP) i neke fizikalno-kemijske karakteristike (sadržaj masti: FC, sadržaj proteina: PC, koncentracija uree: UC, ukupna suha tvar: TS). Istraživanje i uzorkovanje mlijeka provedeno je na 135 mliječnih farmi, a prikupljeni podaci obradeni su analizom varijance korištenjem GLM postupka SAS sustava (verzija 9.0, 2002). Ova studija utvrdila je utjecaj četiri vrste obroka: TR1: koncentrat (CC)+zeleni krma (GF), TR2: CC +suha krma (DF), TR3: CC+GF+DF i TR4: obrok koji sadrži silažu (S). Najviša DIMP ($P<0,0001$) dobivena je korištenjem TR1 (17,3 kg/dan), a najmanja (13,6 kg/dan) kod TR2. TR4 povezan je sa većim sadržajem FC, PC ($P<0,05$) i TS ($P<0,01$) (3,84, 3,14 i 12,31 %) od vrijednosti uočenih u ostalim obrocima. UC ($P<0,0001$) bio je najviši kod TR1 i TR3 (32,05 mg/dL), zatim kod TR4 (28,3 mg/dL) i TR2 (26,2 mg/dL). Kada je riječ o sezonskom učinku, najveća DIMP ($P<0,0001$) je tijekom proljeća (17,7 kg/dan), a najmanja tijekom jeseni (13,1 kg/dan). FC ($P<0,05$) bio je najniži zimi (3,52 %). PC ($P<0,01$) bio je veći tijekom jeseni i zime (u prosjeku 3,07 %). UC ($P<0,0001$) bio je najveći u proljeće (32,23 mg/dL), a najmanji u jesen (25,67 mg/dL). Zaključeno je da su parametri mlijeka u prihvatljivim rasponima u usporedbi s nacionalnim prosjecima.

Ključne riječi: mliječna krava; mlijeko; tip obroka; sezona

References

1. Baset, M.A., Huque, K.S., Sarker, N.R., Hossain, M.M., Islam, M.N. (2012): Effect of season, genotype and lactation on milk yield and composition of local and crossbred dairy cows reared under different feed base region. *Bangladesh Journal of Livestock Research* 19 (1-2), 50-65.
<https://doi.org/10.3329/bjlr.v19i1-2.26427>
2. Bannink, A., Kogut, J., Dijkstra, J., France, J., Kebreab, E., Van Vuuren, A. M., Tamminga, S. (2006): Estimation of the stoichiometry of volatile fatty acid production in the rumen of lactating cows. *Journal of Theoretical Biology* 238 (1), 36-51.
<https://doi.org/10.1016/j.jtbi.2005.05.026>
3. Baumgard, L.H., Corl, B.A., Dwyer, D.A., Saebo, A., Bauman, D.E. (2000): Identification of the conjugated linoleic acid isomer that inhibits milk fat synthesis. *Am. J. Physiol.* 278, 179-184.
<https://doi.org/10.1152/ajpregu.2000.278.1.R179>
4. Ben Salem, H., Moujahed, N., Beji, F. (1998): Les systèmes d'élevage bovin laitier intensifs hors-sols: rentabilité et reproductibilité? Cas de la région de Sfax. *New Medit* 9 (4), 22-26.
5. Ben Salem, M., Djemali, M., Kayouli, C., Majdoub, A. (2006): A review of environmental and management factors affecting the reproductive performance of Holstein-Friesian dairy herds in Tunisia. *Livestock Research for Rural Development* 18 (4).
6. Bernabucci, U., Lacetera, N., Ronchi, B., Nardone, A. (2002): Effects of the hot season on milk protein fractions in Holstein cows. *Animal Research* 51, 25-33.
<https://doi.org/10.1051/animres:2002006>
7. Bernabucci, U., Basiricò, L., Morera, P., Dipasquale, D., Vitali, A., Cappelli, F. P., Calamari, L. (2015): Effect of summer season on milk protein fractions in Holstein cows. *Journal of dairy science* 98 (3), 1815-1827.
<https://doi.org/10.3168/jds.2014-8788>
8. Broderick, G. (2003): Effects of varying dietary protein and energy levels on the production of lactating dairy cows. *Journal of dairy science* 86 (4), 1370-1381.
[https://doi.org/10.3168/jds.S0022-0302\(03\)73721-7](https://doi.org/10.3168/jds.S0022-0302(03)73721-7)

9. Cadomiga, C., Satter, L. (1993): Protein versus energy supplementation of high alfalfa silage diets for early lactation cows. *Journal of dairy science* 76 (7), 1972-1977. [https://doi.org/10.3168/jds.S0022-0302\(93\)77530-X](https://doi.org/10.3168/jds.S0022-0302(93)77530-X)
10. Cappa, V. (1998): Dairy cows milk yield and quality in hot climate conditions. *Zootecnica e Nutrizione Animale (Italy)* 24, 233-238.
11. Černý, T., Večeřa, M., Falta, D., Chládek, G. (2016): The Effect of the Season on the Behavior and Milk Yield of the Czech Fleckvieh Cows. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* 64 (4), 1125-1130. <https://doi.org/10.11118/actaun201664041125>
12. Colmenero, J.O., Broderick, G. (2006): Effect of dietary crude protein concentration on milk production and nitrogen utilization in lactating dairy cows. *Journal of Dairy Science* 89 (5), 1704-1712. [https://doi.org/10.3168/jds.S0022-0302\(06\)72238-X](https://doi.org/10.3168/jds.S0022-0302(06)72238-X)
13. Csiszter, L. T., Acatincăi, S., Neciu, F.C., Neamț, R.I., Ilie, D.E., Costin, L.I., Gavojdian, D., Tripon, I. (2012): The influence of season on the cow milk quantity, quality and hygiene. *Scientific Papers Animal Science and Biotechnologies* 45 (2), 305-312.
14. Darej, C., Moujahed, N., Kayouli, C. (2010): Effets des systèmes d'alimentation sur les performances des bovins dans les fermes laitières du secteur organisé dans le nord de la Tunisie: 1. Effets sur la production laitière. *Livestock Research for Rural Development* 22 (5).
15. Darej, C., M'Hamdi, N., Attia, K., Hamzaoui, S., M'Hamdi, H., Mrabet, K., Bouraoui, R. (2019): Effects of livestock practices on animal wellbeing and milk quality in the holstein cow in tunisia. Effets des pratiques d'élevage sur le bien-être animal et la qualité du lait chez la vache Holstein en Tunisie. *Journal of new sciences, Agriculture and Biotechnology* 65 (2), 4066-4076.
16. Dixon, L.B., Ernst, N. D. (2001): Choose a diet that is low in saturated fat and cholesterol and moderate in total fat: subtle changes to a familiar message. *The Journal of nutrition* 131 (2), 510S-526S. <https://doi.org/10.1093/jn/131.2.510S>
17. Doska, M.C., Silva, D.F.F.D., Horst, J.A., Valloto, A.A., Rossi Junior, P., Almeida, R.D. (2012): Sources of variation in milk urea nitrogen in Paraná dairy cows. *Revista Brasileira de Zootecnia* 41 (3), 692-697. <https://doi.org/10.1590/S1516-35982012000300032>
18. Gargouri, A., Hamed, H., Ben Ali, B., Elfeki, A., Gdoura, R. (2014): Evaluation of T unisian milk quality in dairy herds: Inter-relationship between chemical, physical and hygienic criteria. *Animal Science Journal* 85 (6), 714-721. <https://doi.org/10.1111/asj.12180>
19. GDSAD, General Directorate for Studies and Agricultural Development. Survey on the Structures of Agricultural exploitations (2004-2005). 2005, Tunis, Tunisia.
20. Hammami, M., Elmi Soltani, E., Bouraoui, R. (2011): L'élevage laitier hors-sol en Tunisie: Difficultés actuelles et incertitudes pour l'avenir (cas de Boumerdes-le Sahel tunisien). *New Medit* 10 (1), 58-64.
21. Hammami, M., Bouraoui, R., Selmi, H. (2017): Characterization and typology of dairy cattle farms in the Tunisian semi-arid (Zaghouan region). *Journal of New Sciences* 42, 2290-2298.
22. Heck, J., Van Valenberg, H., Dijkstra, J., Van Hooijdonk, A. (2009): Seasonal variation in the Dutch bovine raw milk composition. *Journal of dairy science* 92 (10), 4745-4755. <https://doi.org/10.3168/jds.2009-2146>
23. IGRMM, Interprofessional Group of Red Meats and Milk. Annual activity report of the Interprofessional Group of Red Meats and Milk. 2018, Tunis, Tunisia.
24. Jenkins, T.C., McGuire, M.A. (2006): Major advances in nutrition: Impact on milk composition. *Journal of Dairy Science* 89 (4), 1302-1310. [https://doi.org/10.3168/jds.S0022-0302\(06\)72198-1](https://doi.org/10.3168/jds.S0022-0302(06)72198-1)
25. Kadzere, C. T., Murphy, M., Silanikove, N., Maltz, E. (2002): Heat stress in lactating dairy cows: a review. *Livestock production science* 77(1), 59-91. [https://doi.org/10.1016/S0301-6226\(01\)00330-X](https://doi.org/10.1016/S0301-6226(01)00330-X)

26. Kamoun, M., S.H., Najahi, R., Jemmali, B., Tayachi, L., Ben Lassoued, S., Hachaichi L., Kaouech, B., Ferjani, A., Zouari, K. (2011): Relations entre pratiques d'élevage et qualité du lait dans le Nord Tunisien. *2ème Congrès Maghrébin : Toxiinfections Alimentaires*. 14-15 décembre 2011, Hammamet, Tunisie.
27. Malossini, F., Bovolenta, S., Piras, C., Dalla Rosa, M., Ventura, W. (1996): Effect of diet and breed on milk composition and rennet coagulation properties. *Annales de Zootechnie* 45, 29-40.
28. M'hamdi, N., Bouallegue, M., Frouja, S., Ressaissi, Y., Brar, S.K., Hamouda, M.B. (2012): *Effects of environmental factors on milk yield, lactation length and dry period in Tunisian Holstein cows*. In Milk Production-An Up-to-Date Overview of Animal Nutrition, Management and Health. <https://doi.org/10.5772/50803>
29. NT 14.141. 2004. Norme Tunisienne relative au "LAIT CRU DESTINÉ À LA TRANSFORMATION". INNORPI Tunisie.
30. Okine, E., Khorasani, G., Kennelly, J. (1997): Effects of source of forage and level of concentrate on chewing activity and milk production response in late lactation cows. *Canadian Journal of Animal Science* 77, 253-258. <https://doi.org/10.4141/A96-091>
31. OLP, Office of Livestock and Pasture (2018): Annual activity report of the Office of Livestock and Pasture. Tunis, Tunisia.
32. RCAD, Regional Commissary for Agriculture Development (2018): Annual activity report of the Regional Commissary for Agriculture Development. Bizerte, Tunisia.
33. Rejeb Gharbi, F., Lahsoui, R., Gouhis, F., Rached, Z. (2007): Rentabilité économique de l'élevage laitier en Tunisie: cas des gouvernorats de l'Ariana et de Mahdia. *Biotechnol. Agron. Soc. Environ.* 11 (3), 211-223.
34. Sahu, J., Bhonsle, D., Mishra, S., Khune, V., Dutta, G., Chaturvedani, A. (2018): Effect of Season on Milk Composition Traits and Test Day Milk Yield of Kosali Cows. *Bulletin of Environment, Pharmacology and Life Sciences* 7 (10), 143-145.
35. Sharma, V., Murdia, P. (1974): Utilization of berseem hay by ruminants. *The Journal of Agricultural Science* 83 (2), 289-293. <https://doi.org/10.1017/S0021859600051972>
36. Singh, V.P., Dubey, M., Chaubey, A.K. (2015): Seasonal influence on milk production performance in different breeds of dairy cows. *Environment and Ecology* 33 (1A), 371-374.
37. Sraïri, M.T., Hasni Alaoui, I., Hamama, A., Faye, B. (2005): Relations entre pratiques d'élevage et qualité globale du lait de vache en étables suburbaines au Maroc. *Revue De Medecine Veterinaire* 156 (3), 155-162.
38. Sucak, M.G., Serbester, U., Görgülü, M. (2017): Effects of Dietary Starch and Crude Protein Levels on Milk Production and Composition of Dairy Cows Fed High Concentrate Diet. *Turkish Journal of Agriculture-Food Science and Technology* 5 (6), 563-567. <https://doi.org/10.24925/turjaf.v5i6.563-567.718>
39. Tyasi, T.L., Gxasheka, M., Tlabela, C.P. (2015): Assessing the effect of nutrition on milk composition of dairy cows: A review. *Int. J. Curr. Sci.* 17, 56-63.
40. Wangdi, J., Zangmo, T., Karma, M., Bhujel, P. (2016): Compositional quality of cow's milk and its seasonal variations in Bhutan. *Livestock Research for Rural Development*, 28 (1).
41. West, J.W. (2003): Effects of heat-stress on production in dairy cattle. *Journal of dairy science* 86, 2131-2144. [https://doi.org/10.3168/jds.S0022-0302\(03\)73803-X](https://doi.org/10.3168/jds.S0022-0302(03)73803-X)
42. Wolter, R., Ponter, A. (2012): Alimentation de la vache laitière. *5eme édition, Editions France agricole*, Paris, 273p.
43. Yoon, J., Lee, J., Kim, C., Chung, Y., Kim, C.-H. (2004): Effects of milk production, season, parity and lactation period on variations of milk urea nitrogen concentration and milk components of Holstein dairy cows. *Asian-australasian journal of animal sciences* 17(4), 479-484. <https://doi.org/10.5713/ajas.2004.479>