Influence of Dairy Cows Race and Diet on Milk Composition in Algeria

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Abstract: The purpose of this study was to investigate the influence of race and feeding dairy cows on milk production and composition.Forty-eight Holstein cows of Holstein and Montbeliarde race were put at experiment in real farming conditions for a period of 3 months. Cows were fed in addition to hay and straw, a concentrated corn and soybean meal diet or a diet enriched with concentrated distillers grains with solubles (32%) in partial substitution of corn and soybean meal. Introduction of distillers grains involved an improvement of milk production with an average of 2.46 l / day (P<0.05), especially in Holstein race which showed the highest levels of production. It involved, also, a significant increase (P<0.01) in fat content, in particular unsaturated fatty acids (+1.85 %), compared with saturated fatty acids (-1.87%). In addition, Holstein milk is higher in fat content and less rich in proteins than Montbeliarde milk.

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1. Introduction

Milk constitutes a basic food in its model of consumption In Algeria (Abbas and Madani, 2005), and ensures essential nutritional role, since it is used as an alternative to more expensive foods such as meat. Thus, it can provide animal protein to urban population in full demographic expansion and whose nutritional habits tend towards advantage of products of quality, and where their domestic demand is in continuous rise since independence (Sraïri *et al,* 2007). This situation calls for immediate reversing trends to improve food security, by means of increasing domestic production of raw milk and its level of integration in supply circuit of dairy industry and consumer market, setting up structured means of necessary accompaniment. However, it must be able to provide professional, reliable tools to know and master the fine characteristics of milk according to breeding factors. The work undertaken in this study remain virtually no existent in Algeria. The objective of this study was to analyze the effects of diet (type of concentrate) and race (Holstein and Montbeliarde) on milk production and milk composition, in particular its fatty acid profile. It was conducted under real conditions of bovine breeding in Algeria (Area of Bejaïa).

2.Material and Methods

1- Food and animals Characteristics:

Forty-eight dairy cows, 24 of Holstein race and 24 of Montbeliarde race, were studied for an experimental period of 3 months preceded by an adaptation period of 15 days.

During the study, cows were divided into two groups (12 cows of each race as control group and 12 cows of each race as experimental group). The two groups of cows were fed the same diet based on hay and straw during adaptation period. 10 kg / day / cow of hay were distributed in two equal doses in the morning and the evening. However, 6 kg / day / cow of straw were distributed as a single dose in the evening. This diet is supplemented with12 kg /day /cow of concentrate feed based on corn and soybean meal and distributed to control group two times a day (5 kg in the morningand7 kg in the evening) during all the experimental period. Moreover, cows of experimental group received concentrate feed enriched by distillers grains with soluble (32%) at a dose of 7 kg / day / cow administered in two equal proportions in the morning and the evening during the first 5 days. Thereafter, in order to calculate refused amount by dairy cows, we increased to 10 kg / day / cow with two identical amounts in the morning and the evening during 5 days. Finally, to maintain milk production at an acceptable and consistent level with breeder commitments, we set from the 11th day, the amount of distributed concentrate to 12 kg / day / cow (5 kg in the morning and 7 kg in the evening). This amount was maintained until the end of the experiment. Both formulations of concentrated feed used during the test are presented in table 1.

Table 1. Composition of experimental concentrated food (g/100g of food)

	Type of concentrate	
Concentrates constituents	**Control concentrate**	**Experimental concentrate**
Corn/grains	47	33
Soybeanmeal	25	7
Wheat bran	25	25
Mineral and vitamin supplement for dairy cows	1	1
dicalcium phosphate	1	1
Salt	1	1
DDGS (distillers dried grains with soluble)	0	32
Total	100	100

2- Follow-up of dairy production evolution

Daily milk production after morning and evening milking for all cows was recorded in order to establish a curve of its evolution according to diet and race.

3- Sampling and analysis

Physico-chemical measurements (total solids, pH, protein, fat content and fatty acid profile) were made on individual milk collected at the morning milking, from two control and experimental groups. The samples were immediately stored at 4 ° C.

Total dry extract (TDE) was determined by drying using infrared moisture analyzer. Protein content (PC) was obtained by measuring total nitrogen using Kjeldahl method (AFNOR 1986, standard NF V04-211**)** and fat content (FC) by using acid-butyrometric Gerber method (AFNOR 1986, standard NF 04-210). Conversion factor (0.945) was used to calculate fatty acid content of milk fat (Paul and Southgate, 1978). Fatty acid profile was quantified by gas chromatography (Thermo-Finnigan chromatograph) in following operating conditions: N_2 flow of 6 psi and F.F.A.P. column.

4- Statistical Analysis

Data were presented as mean ± standard deviation and were initially analysed by ANOVA. Comparison between two means was performed by Student "T" test and between several means analysis of variance (ANOVA). A probability value of $P<0.05$ was considered significant. All statistical calculations were performed using Statistica version 6.1 software (Statistica Entreprise Wide SPC System "SEWS", Statsoft France, 31 cours des Julliottes F-94700, MaisonAlfort- France.

3. Results and Discussion

Adaptation period

Race effect is not taken into consideration during this adaptation period. This experiment was conducted to evaluate milk production allowed by introduction of distillers grains in concentrate food for all races combined. Furthermore, race effect was studied during experimental period.

Careful observation of the evolution of average milk production per day during adaptation period (Figure 1) provides interesting results. There is significant difference between control group and experimental group. Indeed, the average production permitted by control feeding was estimated at 12.34 ± 1.33 l / day / cow, compared to experimental feeding which was 20.52 ± 2.15 l / day / cow with a variation of production of 8.18 l /day.

On the other hand, there is an identical increasing evolution for both groups (control and experimental) but at different levels of production, which is shown by two perfectly parallel curves.

Experimental period

Effect of e race on milk production

There is very highly significant difference between the two races in terms of milk production ($P<0.01$). Indeed, race has a very highly significant effect on milk production which is higher in Holstein cows (28.97 ± 2.30 l / day) compared with Montbeliarde cows (21.81 ± 1.78 l / day)(Figure 2). The average deviation of dairy production between the two races, with confused food, is of 7,16 l/day in favour of the Holstein race.

Effect of diet on milk production

Food factor seems to influence milk production level. Indeed, results show significant difference ($P<0.05$) between control (27.02 ± 5.89 l / day) and experimental (29.48 ± 7.41 l / day) groups (Figure 3).

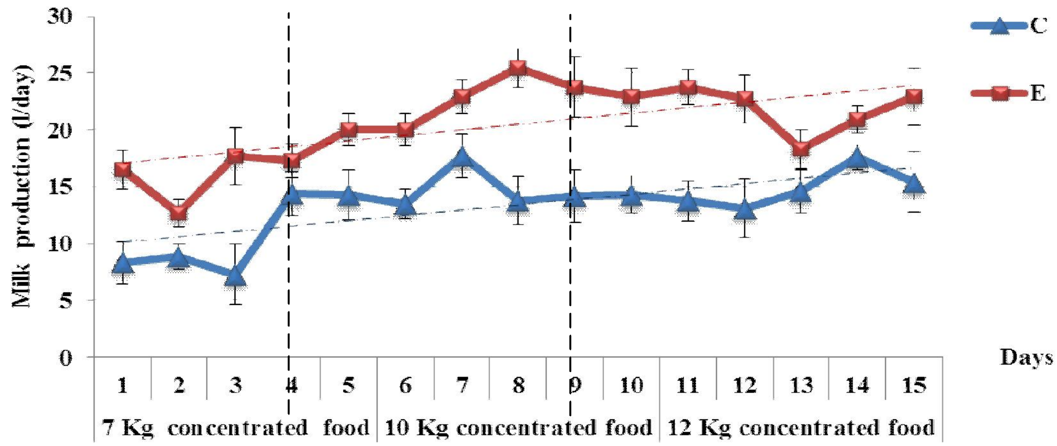

Figure 1. Evolution of average milk production per cow of control and experimental groups during adaptation period (C: Controls, E: Experimental).

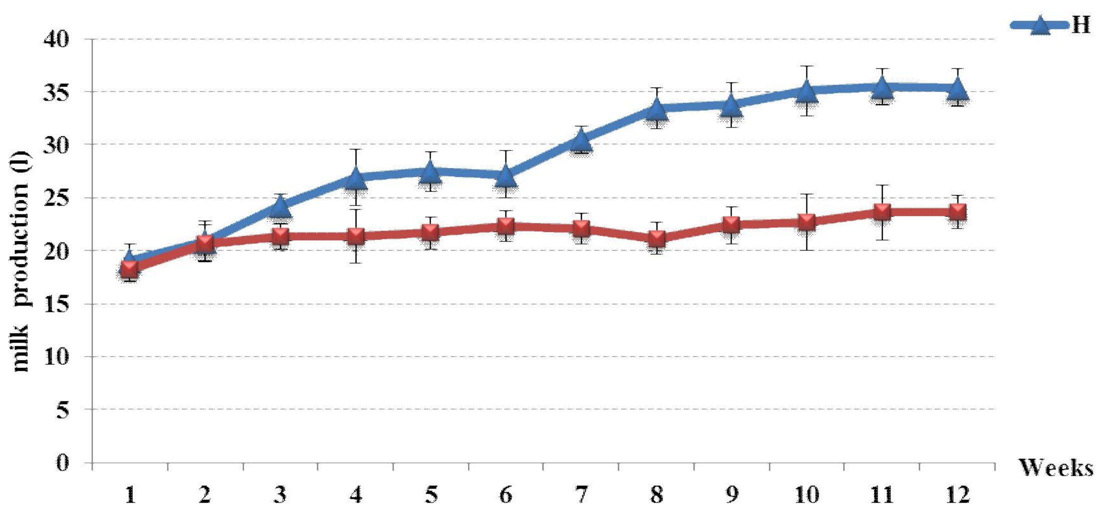

Figure2.Evolution of average milk productionaccording toraceduringexperimental period (H: Holstein, M: Montbeliarde)

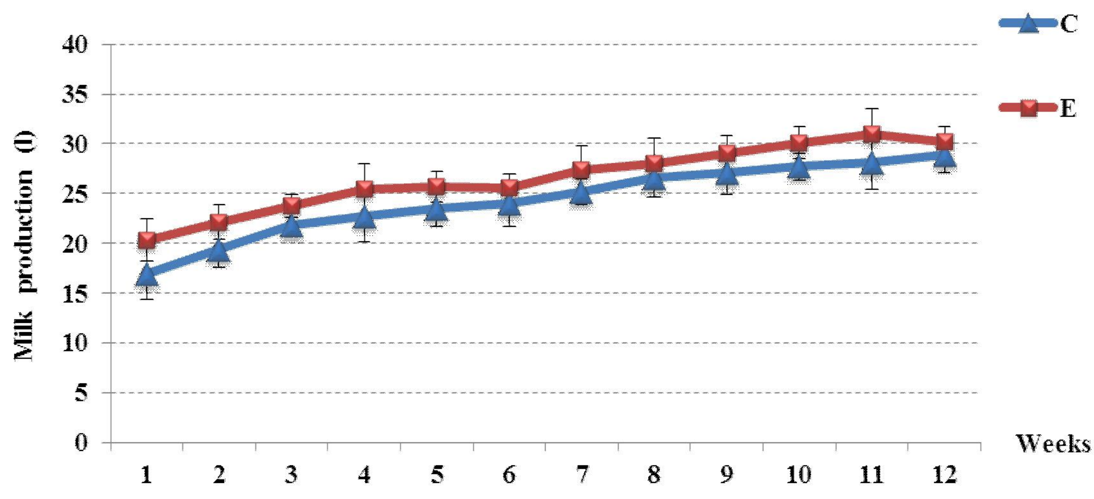

Figure 2. Evolution of average milk production according to diet during experimental period (C: Controls, E: Experimental)

Consequently, the introduction of distillers grains during 12-week experiment, involved an improvement of significant dairy production inexperimental group compared with controls (more than 2.46 l / day) independently of the genetic factor. According to Fournier (2008), distillers grains can replace a significant portion of corn and protein supplement used in cows feed, which reduces starch and sugars level. These two factors, in addition to high-fiber distillers grains content, help to decrease incidence of rumen acidosis.

Effect of race on milk physicochemical characteristics

Results concerning physico-chemical characteristics of milk according to race are presented in table 2.

Tableau 2. Effect of race on milk physico-chemical characteristics

	Holstein	Montbeliarde	Significancelevel
pH	6.75 ± 0.27	6.67 ± 0.08	NS
Total dry extract (g/l)	117.49 ± 5.57	119.94 ± 9.13	NS
Fat content (g/l)	36.51 ± 5.18	35.87 ± 5.01	NS
Total fatty acids (g/l)	34.50 ± 4.89	33.89 ± 4.73	NS
Proteins (g/l)	31.68 ± 0.65	31.84 ± 1.90	NS

NS: not significant

Total dry extract and pH

At the end of the first experimental period, milk pH of both races (Table 2) is in conformity with standards cited by Alais (1984): 6.6 to 6.8. Total solids content represents whole milk component excluding water. Measurement of this parameter permitted us in general to appreciate the richness of milk (Alais, 1984). Total solids content ranges between 125 to 135 g/l (Vierling, 1999; Alais, 2003).

It is clear from Figure 3 that there is a difference but not significant of total dry extract between milk of each race respectively 117.49 ± 5.57 g/l for Holstein and 119.94 ± 9.13 g/l for Montbeliarde, with a deviation of 2,45 g/l in favour of Montbeliarde race. However, this parameter is less than values reported in the literature (Vierling, 1999; Alais, 2003). However, Veisseyre (1979) reports that this content remains dependent of race, and variations can be considerables.

Proteins

Montbeliarde cows produced milk richer in protein (31.84 ± 1.90 g/l) compared to Holstein race (31.68 ± 0.65 g/l), although these differences were not significant statistically (Table 2). It was established that some races are more predisposed than others to produce protein-rich milk (Pissavy and Dezendre, 2006). Normande cows (34.9 g/l), Montbeliarde (32.9 g/l) or Brown (33.6 g/l) produce milk richer in protein and cheese better ability than

Holsteins (31.2 g/l) put at same conditions (Auldist et al, 2002; Mistry et al, 2002).

Fat content and fatty acids

Milk fat content of Holstein race is of 36.51 ± 5.18 g/ l, higher than Montbeliarde race (35.87 ± 5.01 g/l), with a deviation of 0.64 g/l in favour of Holstein race, which also produces milk rich in fatty acids.

Fatty acids profile

To facilitate reading of the results, fatty acids with number of carbon atoms less than 18 have been grouped under the term short and medium chain fatty acids (SMCFA); and under the term long chain fatty acids (LCFA) those which carbon atoms number was equal or higher than 18. Both groups were divided between saturated fatty acids (SFA) and unsaturated (UFA) (Table3).

Fatty acids profile in Table 3 shows that saturated fatty acids level was higher in Montbeliarde race (66.04%) with 54.51% of short and medium chain fatty acids against 11.53% of long-chain fatty acids, compared to Holstein race (65.68%) of short and medium fatty acids with less short and medium chains fatty acids (53,85 %) and more long chain fatty acids (11,83 %). Contrary to saturated fatty acids, unsaturated fatty acids content is higher in Holstein (34.17%) than Montbeliarde (33.82%) with a deviation of 0.38% for long-chain fatty acids in favour of Holstein. However, several authors showed that animal race is an important factor of variation in milk fatty acids composition (Jensen et al, 1999; Chilliard et al, 2000; Sollberger et al, 2004).

Table 3. Fatty acid composition of milk fat according to race

Fatty acids	Holstein (%)	Montbeliarde (%)	Deviation(%)
Short and medium chain saturated fatty acids (SMCSFA)	53.85	54.51	0.66
long chain saturated fatty acids (LCSFA)	11.83	11.53	0.30
saturated fatty acids (SFA)	**65.68**	**66.04**	**0.36**
Short and medium chain unsaturated fatty acids (SMCUFA)	3.47	3.50	0.04
long chain unsaturated fatty acids (LCUFA)	30.70	30.32	0.38
Unsaturated fatty acids (UFA)	**34.17**	**33.82**	**0.34**

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Food effect on milk physico-chemical characteristics

Apart from the effect of race of dairy cows, control of feeding can best explain the variations of milkchemical composition (Agabriel *et al*, 1995) (Table 4).

Table 4. Feeding effect on milk physico-chemical characteristics

Variable	Control	Experimental	significancelevel
pH	6.68±0.08	6.73±0.28	NS
Total dry extract (g/l)	112.35±1.47	125.08±4.30	***
Fat content (g/l)	31.55±0.49	40.82±0.55	***
Total fatty acids (g/l)	29.81±0.46	38.58±0.52	***
Proteins (g/l)	31.87±1.09	31.65±1.68	NS

***: P< 0,001; **: P< 0,01; *: P< 0,05; NS: not significant

Total dry extract and pH

Distillers grains intake does not have significant effect on milk pH (Table 4). It is always in agreement with standards (6.68 ± 0.08 for control group and 6.73 ± 0.28 for experimental group).

In contrast, results show highly significant difference of total dry extract (*P*<0.01) between control group (112.35 ± 1.47 g/l) and experimental group (125.08 ± 4.30 g/l) with however a deviation of 12.73 g/l.

The increase or decrease in total dry extract is directly related to particular variation of protein content and fat content (Croguennec *et al*, 2008), which are themselves function of feeding (Coulon *et al,* 1991).

Proteins:

We notes a reduction of 0.22 g/l of protein content in experimental group, with a value of 31.65 ± 1.68 g/l compared to control group (31.87 ± 1.09 g/l).

In whole, protein content is less influenced by feeding than fat content (Philipona et al, 2002). This is a relatively criterion variable from one day to other, because it is strongly related to milking, its level varying from 1 to 10 between the beginning and the end of the milking. However, it is, among solids of milk, the element which is most strongly and most quickly modifiable by the food (Hoden and Coulon, 1991).

According to Sutton (1989), protein content can vary greatly as a result of dietary factors. Indeed, this parameter increases linearly with energy intake (Rook and Balch, 1961; Wilson et al, 1967; Holter et al, 1972; Coulon and Remond, 1991, Huhtanen et al, 1993; Rulquin and Hurtaud 1994), except when the increase of energy intake is caused by fat content addition which, whatever their origin, have reducing effect (Remond, 1985; Doreau and Chilliard, 1992).

Moreover, protein content also depends on coverage needs of essential amino acids requirements, in particular lysine and methionine (Rulquin *et al.,*1993), especially of the nature of the nitrogenized complements distributed to animals. Finally, energy nature effect of protein content is subject to contradictory results, even if we admits that diet rich in starch induces generally an increase in protein content, at least in extreme cases (Coulon *et al.,*1989; Sutton, 1989). In other hand, addition of fat in the diet in order to increase energy intake, causes, according to Chillard and Doreau (1992) and Remond (1985), a decrease of protein content.

Fat content and fatty acids

According to the type of diet (Table 4), highly significant differences (P<0.01) were recorded in fat content between control group (31.55±0.49 g/l) and experimental group (40.82±0.55 g/l), and consequently in fatty acid content between the two groups, control (29.81 ±0.46g/l) and experimental (38.58±0.52 g/l).

According to Rulquin *et al* (2007), response of fat content to a supplement of glucose (digestible starch assimilable to glucose) are always negative and fat content decreased significantly. The role of glucose when the cereal of concentratedfood is corn is more significant (Sutton *et al,*1980).Then it could explain a decrease in fat content (Rulquin *et al*, 2007). But in against part in this study, the proportion of corn was partially substituted by distillers grains in experimental concentrated, which could be responsible for the considerable increase in fat content.

Fatty acids profile

Fatty acid profile of milk fat (Table 5) shows that saturated fatty acids level was higher in control group (66.04%) compared to experimental group (64.92%), with more fatty acids of short and medium chain (54.58%) for controls against (53.77%) for experimentals, and long-chain fatty acids (12.21%) for controls against(11.15%)for experimental. Contrary to saturated fatty acids, unsaturated fatty acids level is higher in experimental group (34.92%) than in control group (33.07%), with a deviation of 1.41% for fatty acids long chain in favour of experimental diet. We assists then in the experimental group, to decreased secretion of saturated fatty acids, compensated by an increased secretion of unsaturated fatty acids, especially those of oleic acid (0.4%), linoleic acid (0.84%) and linolenic acid (0.19%).

Table 5: Changes in fatty acid composition of milk fat according to type of diet

Fatty acids	**Controls (%)**	**Experimental (%)**	**Variation (%)**
Short and medium chain saturated fatty acids (SMCSFA)	54,58	53,77	-0,81
long chain saturated fatty acids (LCSFA)	12,21	11,15	-1,06
saturated fatty acids (SFA)	**66,79**	**64,92**	**-1,87**
Short and medium chain unsaturated fatty acids (SMCUFA)	3,27	3,70	0,44
C18: 1	25,90	26,30	0,40
C18: 2	2,70	3,54	0,84
C18: 3	0,95	1,14	0,19
C20: 1	0,26	0,24	-0,02
long chain unsaturated fatty acids (LCUFA) (LCUFA) (AGILC)	29,81	31,22	1,41
Unsaturated fatty acids (UFA)	**33,07**	**34,92**	**1,85**

Bugaud *et al* (2001) and Collomb *et al* (1999) observed some very interesting results, which are especially some changes in concentration of certain compounds synthesized by the animal according to nature of its diet what makes it possible to explain some of the observed differences. It is particularly fatty acids composition of milk fat (carbon chain length and degree of unsaturation) highly dependent on diet.

Chilliard *et al* (2008) also showed that milk fatty acids composition, which is an important component of its nutritional quality for humans is highly Influenceable in short-term by animals feeding. Always in this context, and according to several authors (Murphy and Cannilly, 1991; Palmquist et al 1993; Chilliard *et al* 2001), Animals diet can vary widely, and in many ways, the composition of milk fatty acids.

On another hand, a large number of epidemiological observations have shown positive association between cardiovascular disease incidence and the consumption of diet with high content of cholesterol and saturated fatty acids (Mann *et al*, 1997). Saturated fatty acids which represent 62% of total milk fat, are generally recognized as atherosclerosis risk factors, including increased cholesterolemia and LDL cholesterol. Monounsaturated fatty acids (oleic acid) and polyunsaturated fats could reduce the risk of atherosclerosis, in particular by increasing HDL level (Mensik and Katan, 1992).

Milk fatty acid with short to medium carbon ($C_4$to C_{16}) come from intra-mammary synthesis which, depends on acetate intakes (endogenous and from the ruminal acetate) and β-hydroxybutyrate (from endogenous and ruminal butyrate). All fatty acids whose carbon chain is greater than 18 carbon atoms come from fatty acids with long carbon chains transported by chylomicrons (exogenous), VLDL (endogenous) and albumin (endogenous) (Chilliard and Sauvant, 1987; Schmidely and Sauvant, 2001; Sauvant et al, 2006; Rulquin et al, 2007).

Long chain fatty acids (having at least 16 carbon atoms) are potent inhibitors of lipogenesis in mammary cells. This inhibitory effect is even more pronounced when fatty acids chain is more longerand more unsaturated (Chilliard *et al*, 2001). Moreover, and according to Gulati et al (1999), polyunsaturated fatty acids are not synthesized in ruminants, their concentration in milk depends primarily on food intake.

Among these polyunsaturated fatty acids, the most represented in our study is linoleic acid, its content is higher (Table 5) in experimental milks (3.54%) compared to control milk (2.70%). This is probably related to high content of distillers grains fat rich in polyunsaturated fatty acids, which contain according to Bachand (2007) about 15% of dry matter. Further researches are needed to confirm these trends.

Linoleic acid proportion in milk fatty acids is generally between 2 and 3%. When diets are enriched with seeds or oils rich in linoleic acid, this percentage does not exceed 3-4%, linoeic acid increase in our study in experimental compared to control diet is rarely greater than 1.5%. It is therefore clear that thrust hydrogenation of linoleic acid in the rumen limits strongly its incorporation into milk fatty acids (Chilliard *et al*, 2001).

Furthermore, the increase in the proportion of linoleic acid in dairy products is not an objective in itself, since the improvement of nutritional value of these products passes by an increase of linoleic/linolenic ratio (ω6/ω3) (Chilliard et al, 2001). This ratio has been modified in our study by distillers grains intake, then there is an increase of milk linoleic acid content in experimental group (3.10) compared to control group (2.84).

Conclusion

The objectives of this study were to demonstrate the effect of race and incorporation of distillers grains in the diet of dairy cows on milk production and composition.

In the range of actual conditions of intensive farming, this study showed that there are significant variations in milk production and physic-chemical composition. Milk production varies according to race and diet. It is significantly higher for Holsteins compared to Montbeliarde, and in experimental group compared to control group.

Similarly, differences in milk fat and protein content are due to both factors, race and diet. Holstein milk is on average richer in fat and lower in protein than Montbeliarde milk. These variations due to race are reduced compared to those due to diet. Thus, protein content slightly reduced, is less influenced by changing diet than fat content.

Furthermore, profile of milk fatty acids varies with feeding cows. When these consume experimental diet, milk is rich in unsaturated fatty acids and lower in saturated fatty acids. These results are explained essentially by the greatest richness of distillers grains in unsaturated fatty acids.

It thus appears, that the use of distillers grains in partial substitution of corn and soybean meal has a certain interest in dairy cows feeding.

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