Influence of whole milk in diet of growing fattening Belgian Blue bulls on animal performances and on fatty acid composition in subcutaneous, intermuscular and intramuscular fats.

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Abstract: Hornick, J.L., Clinquart, A, Van Eenaeme, C., Gauthier S. and Istasse, L. Influence of milk in diet of growing fattening Belgian Blue bulls on animal performances and on fatty acid composition in subcutaneous, intermuscular and intramuscular fats.

The use of milk as component of a fattening diet for bulls was studied in an experiment carried-out over 2 years with Belgian Blue bulls. The animals weighted 305 kg at the beginning of the experiment. In all, 15 bulls were given a control concentrate fattening diet (control group, CG), while 11 others were fed concentrate plus 6.5 to 11 l whole milk per day according to weight or age (milk group, MG). The fattening period lasted for 174 and 181 d respectively in groups CG and MG. The MG-group had a higher killing-out percentage ($P<0.01$) and the meat was characterized by a lower b* value and a lower dry matter content ($P<0.1$). Whole milk in the diet increased the proportion of shorter chain and saturated fatty acid in fat ($P<0.001$) and reduced the proportion of mono- and polyunsaturated acids ($P< 0.1$). The extent of the changes were larger in subcutaneous and intermuscular fats than in intramuscular fat.

Keywords: fattening bulls - milk diet - fatty acids.

1. INTRODUCTION

In Belgium, diets for growing fattening cattle are based mainly on sugar beet pulp or on maize silage. Animal performances of Belgian Blue bulls weighting from about 300 to 600 kg are characterized by an average daily gain close to 1.47 kg/d and a feed conversion ratio of about 6.13 kg/kg (Minet et al., 1996). Various factors such as age, sex, use of growth promotors and slaughter conditions affect meat production but the diet is also of importance (see review by Monin, 1991). The scarce published data relative to use of milk by-products in diets for fattening cattle concern whey (Lehmann and Jans, 1993; Lehmann et al., 1993) but whole milk could also be used for such purpose, for example, in farms in which milk production is largely over the milk quota. The aim of the present experiment was to compare animal performances and meat quality in 2 groups of fattening bulls offered either concentrate diet or concentrate plus whole milk.

2. MATERIAL AND METHODS

2.1. Animals and management

A fattening experiment was repeated over 2 years with Belgian Blue bulls, double muscled type, maintained in a free stanchion barn with part bedded floors. Before the experiment, young animals were previously offered a growing diet based on maize and grass silage and a blend of cereals, dried sugar beet pulp and dried lucerne. The animals were then randomly allotted in groups and progressively adapted to their fattening diet, during a 7 d transition period. The first year, ten bulls were used. One group of 7 (control group, CG) was given a concentrate diet based on sugar beet pulp and supplemented with cereals, soya-bean meal and linseed meal (table 1). The second group of 3 (milk fed group, MG) were fed 6.5 to 11 l whole milk per day according to weight or age plus concentrate based on sugar beet pulp but with a lower proportion of soyabean meal, so that the theorical nitrogen intake on a metabolic weight basis, was equal in control and in milk fed groups. Milk was offered). The animals used in the present trial were offered milk in bucket, one time a day at 0800h , during the whole fattening period. Milk was offered restrictively so that animals were always able to drink the given amounts. The second year, 8 bulls received the control fattening diet and 8 bulls the diet with whole milk. Barley straw was fed in a hay rack and feed was always offered by group on an ad libitum basis. At the end of the experiment, the bulls were slaughtered in a commercial abattoir, according to the degree of fatness of the animals, estimated by palpation of the tail head, the loin and the rib area.

2.2. Measurements

Daily feed intake of the groups was recorded each day and live weight once a month. Feed was sampled four times for chemical analysis. At slaughter, the carcass weight was recorded. pH was measured in the Longissimus thoracis muscle of both sides (7th, 8th, 9th ribs) 1, 2 and 4h post mortem, using a Portamess 751 knick pH-meter (Knick GmbH & Co, Berlin, Germany) with an Ingold

"penetration" pH-electrode (Ingold AG, Urdorf, Zwitzerland). Two days after slaughter, the 7th, 8th and 9th ribs were removed from the carcass. They were dissected in order to separate lean meat, fat and bones and to assess the composition of the carcass (Martin and Torreele, 1962). Meat quality was determined from a 2.5 cm thick cut of the Longissimus thoracis. The final pH was measured on freshly cut surfaces, using the technique described above. The HunterLab Labscan II device was used for objectively measuring CIE Lab brightness (L*) and colour (a* and b*) 48h *post mortem*. The cuts were weighed and stored during 5 days in a plastic bag at 4°c. The pourcentage weight loss was calculated in order to estimate drip loss. The cuts were then used for cooking loss determination; they were heated in open plastic bags in a waterbath during 50 minutes at 75°C. After heating they were cooled in cold tap water to room temperature, bags were drained and cuts were mopped gently dry with paper tissue. The difference between raw and heated weights was recorded as cooking loss, and expressed as a percentage of the raw weight. Warner Bratzler shear force was determined with a Lloyd LR5K perpendicular to the fibre direction on 1.25 cm diameter cores obtained from the heated cuts.

2.3. Chemical analysis

Dry matter (DM), ether extract, crude protein, acid-detergent fiber, calcium (Ca) and phosphorus (P) concentration of the diets was determined according to official procedures (AOAC, 1975). Subcutaneous, intermuscular and intramuscular fat was sampled from 7th, 8th and 9th ribs and the lipids were extracted and saponified as described by Ter Meulen et al. (1975). The fatty acid (FA) composition of fat and milk samples was determined by gas chromatography (Van Eenaeme et al., 1965).

2.4. Statistical analysis

Data relative to animal performances, meat quality and meat composition were statistically analysed as a 2x2 factorial design (two diets, two years). Parameters were analysed using the following model:

Yij = $\mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijn}$ where μ = overall mean, α_i = fixed effect of diet, β_j = fixed effect of year, $\alpha\beta_{ij}$ = interaction between diet and year effect, and ε_{ijn} = random residual effects associated with the n observations (~N[0,σ]). Data relative to fatty acid composition of the fat were analysed as a 2x2x3 factorial design (two diets, two years, three fat location). Parameters were analysed using the model: Yij = $\mu + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \varepsilon_{ijkn}$ where μ = overall mean, α_i = fixed effect of diet, β_j = fixed effect of year, γ_k = fixed effect of fat location, $\alpha\beta_{ij}$, $\alpha\gamma_{ik}$ and $\beta\gamma_{jk}$ are corresponding interactions effects and ε_{ijn} = random residual effects associated with the n observations (~N[0,σ]) (Dagnelie, 1975).

3. RESULTS

Fatty acid composition of milk and concentrate fat has been measured only the first year of the experiment. The milk fat was rich in palmitic and oleic acids while high concentrations of linoleic, oleic and linolenic acids were found in the concentrate diets (table 2). The animal performance did not differed between MG and CG (table 3). The initial live weight and age was respectively close to 305 kg and 10 months in both groups, the length of the fattening period was 177 d and the total live weight gain was close to 255 kg. The average daily gain was similar in both groups at about 1.45 kg/d. Taking into account milk consumption, the total DM intake was 1340 kg/bull and feed conversion ratio about 5.3 kg DM/kg. On the basis on a DM content of 150 g/kg and a protein content of 265.6 g/kg DM in whole milk, the average daily protein intake was 1.26 and 1.19 kg/d/bull in CG and MG. Corresponding data for fat ingestion were respectively close to 182 and 502 g/d. In such conditions, fat concentration in diet corresponded respectively to 2.4 and 6.8% of total dry matter.

The slaughter and carcass characteristics are given in Table 4. There were no significant differences between the 2 groups except that the killing-out percentage was significantly higher in MG than in CG ($P<0.01$).

Table 5 shows meat characteristics in the control and milk fed groups. The only difference between the groups was a lower b* value in meat from MG ($P<0.1$). The DM content of meat in CG was significantly higher ($P<0.1$) at 24.1% than in MG (23.3%) (Table 6). There were no differences between the other chemical components of meat, expressed on DM basis (4.8% for ash, 81.6% for crude protein, 4.1% for ether extract and 0.16% for cholesterol).

The FA composition of subcutaneous, intermuscular and intramuscular fat samples are given in table 7. The most prevalent FA in beef fat were oleic, palmitic and stearic acids, with values respectively close to 37, 29 and 19%. The total saturated fatty acid (SFA) content was significantly lower at 46.57% in intramuscular fat and higher in intermuscular fat (55.59%, $P<0.001$). Furthermore, intramuscular fat was generally richer in polyunsaturated fatty acids (PUFA) at 18.07% and poorer in monounsaturated (MUFA) ($P<0.001$). The overall effect of whole milk in a fattening diet was an increase of the proportions of myristic, palmitic and palmitoleic acids (4.19 vs 3.00%, $P<0.001$; 29.66

vs 26.97%, P<0.001; 2.87 vs 2.26%, P<0.001). By contrast, stearic, oleic, linoleic and linolenic acids were decreased (P<0.1 for stearic and oleic acids; P<0.001 for linolenic acid). The SFA proportion increased by more than 2 % (P<0.001) and MUFA and PUFA decreased by about 1% (P<0.1). The effect of milk was mainly found in subcutaneous and intermuscular fat while the differences were weak and generally not significant in intramuscular fat although the linolenic acid content was significantly lower in MG.

4. DISCUSSION

The performances of the bulls in the CG were in line with the performances observed with Belgian Blue double muscle bulls offered a corresponding fattening diet based on sugar beet pulp (Clinquart *et al.* 1991; Minet et al., 1966).

Milk powder is occasionnally used with a high efficiency in diets for growing and fattening pigs (Fevrier and Mourot, 1989; Morgan et al., 1989) and, of course, widely used for veal calves. The efficiency may be reduced in ruminants since milk directed into the rumen is fermented by microflora with increased productions of volatile fatty acids, mainly butyrate, and ammonia (Mayombo et al., 1994). Apparently, milk feeding had no negative effects on animal performances in this experiment. It must be noted that a partial closure of the oesophageal groove might occured in the animal of milk-group, since the reflex could remain in mature ruminants for a long time when it is maintained (Ø rskov, 1982; Mayombo et al., 1994). The animals used in the present trial were offered milk in their early age in bucket. They still displayed signs of juvenile excitement when drinking during the fattening period nearly until the end of the period. It is thus possible that milk transited at least partially by the oesophageal groove in abomasum. However, the feed conversion ratio expressed as net energy per kg ADG was worse for the milk-group compared to concentrate group ($P<0.001$), indicating a lower efficiency of energy utilisation for growth. Dietary fat supplementation for fattening bulls is known to improve the average daily gain and feed conversion ratio, when fat incorporation does not exceed 5% of dry matter (Clinquart et al., 1995). In this experiment, the enrichment of fat in whole milk fed animals reached 6.6%. This may explain the lack of beneficial effect on animal performance.

There were interesting effects of the incorporation of milk on the the killing-out percentage. According to Geay (1978), a concentrate diet induce a greater killing-out percentage than diet based in large percentage of roughage, the changes being associated with a larger digestibility of the concentrated diet. Milk may be considered as a highly concentrated feedstuff when expressed in DM and thus, its high digestibility may have modified the gut content of the animals. Milk supplementation

had no effects on the carcass composition, although dietary fats are reported to increase body fat deposition in growing cattle (Chilliard, 1993; Clinquart et al., 1995).

The difference of meat yellow color (b* value) between the two groups may be possibly ascribed to the numerically lower ether extract content of the meat from milk-group.

The most interesting effects of the treatement were observed on fatty acid composition in the carcass. The prevalence of oleic, stearic and palmitic acids which accounted for about 85% of the total fatty acids was in aggreement with values commonly accepted for ruminant fats (Clinquart et al., 1991; Duckett et al., 1993). The larger concentration of PUFA in intramuscular fat at 18.07% was probably due to the extraction of phospholipids from the structural components of muscle cells, rich in linoleic acid (Duckett et al., 1993). Further support for this hypothesis is provided by the low ether extract content of Longissimus thoracis of Belgian Blue bulls which was less than 5% in DM in this trial (Table 6). Clinquart et al (1992) reported values closed to 3.0% with similar animals and 17.2% in Holsteins. According to Scott and Ashes (1993) the composition of membrane phospholipids may be changed by dietary manipulations. In the present experiment, milk lipids had weak effects on composition of intramuscular fat although significant effects on subcutaneous and intermuscular fats were found.

The major characteristics of fat samples in MG bulls were an increase in short chain acids (myristic, palmitic and palmitoleic acids), a decrease in long chain acids (stearic, oleic, linoleic and linolenic acids) and a global increase in SFA. Diets supplemented with fat from animal origin, containing high levels of SFA, are generally known to increase the proportion of SFA in animal tissues (Clinquart et al, 1995). Furthermore, the major changes of dietary fat occuring in the rumen are hydrolysis and saturation (Palmquist and Jenkins, 1980; Zinn, 1989; Ferlay et al., 1992) so that PUFA are mainly transformed in SFA and longer FA are shortened. Since milk fat composition was very similar to that of fat tissue, it was thus not surprising that fat in milk fed animals was enriched in SFA and shorter fatty acids. One could also expect a larger proportionnal increase in stearic acid associated with the ruminal saturation of oleic acid from the milk. Since this was not observed, one has to hypothetize that milk did not fall entirely into the rumen, avoiding thus the saturation. However, this would not aggree with shortening of FA. But stearic acid absorbed in the intestine is also partly desaturated to oleic acid

(Grummer, 1991; Enjalbert, 1995), reflecting a correcting mechanism allowing ruminants to deposite a FA spectrum fairly constant in most circumstances. The reason why weak differences in FA composition in intramuscular fat was observed was probably that membran lipids, major constituents of meat ether extract, are derived from the own anabolic process of the muscular cell, as opposed to FA from fat depots, partly derived from dietary fat.

5. CONCLUSION

It can be concluded from the present trial that milk in fattening diet for cattle did not modify significantly animal performances, carcass quality and meat characteristics. The enrichment of the diet with milk fat changed the FA composition in the carcass by increasing the proportion of shorter chain acids to the detriment of longer chain, and by reducing the unsaturation of fatty acids. These effects were expressed to a larger extent in subcutaneous and intermuscular fats than in intramuscular fats.

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RESUME

Hornick, J.L., Clinquart, A, Van Eenaeme, C., Gauthier S., Istasse, L. Influence du lait dans un régime d'engraissement sur les performances zootechniques et la composition chimique de la graisse sous-cutanée, intermusculaire et intramusculaire chez des taurillons Bleu Blanc belge de type culard: L'utilisation de lait comme aliment complémentaire d'engraissement a été étudiée chez des taurillons d'engraissement de race Bleu Blanc belge dans une expérience qui s'est déroulée sur une période de deux ans. En année 1, 7 animaux ont reçu un concentré d'engraissement témoin (groupe témoin, CG). Sept autres ont reçu un autre concentré et de 6.5 à 11 l de lait par jour (groupe lait, MG) suivant le poids et l'âge, trois d'entre eux ayant reçu du lait entier et quatre autres du lait écrémé. En année 2, l'expérience a été répétée avec 8 témoins et 8 animaux recevant du lait entier exclusivement. La période d'engraissement moyenne a duré 174 et 181 jours respectivement dans les groupes CG et MG. Il n'y a pas eu de différences significatives entre les groupes concernant les performances zootechniques, les caractéristiques à l'abattoir, les caractéristiques de la carcasse et de la viande, à l'exception d'un plus grand rendement d'abattage dans le groupe MG ($P<0.01$), d'une plus faible valeur b* et d'une plus grande teneur en matière sèche dans le groupe CG ($P< 0.1$). L'incorporation de lait a augmenté les teneurs en acides gras saturés et en acides gras à plus courtes chaîne ($P<0.001$), l'ampleur des changements étant plus grande dans les graisses sous cutanées et intermusculaires que dans les graisses intramusculaires.

KURZFASSUNG

Hornick, J.L., Clinquart, A, Van Eenaeme, C., Gauthier S., Istasse, L. Milch im Jungbullenmast : Effekte auf Tierleistung und subkutane, intra- und extramuskulare Fettzusammensetzueng.

Milch in der Bullenmast wurde experimentiert in zwei nachfolgende Jahre in Belgische Blau-Weisze Jungbullen. Am erstes Jahr wurde an sieben Tiere eine Kontrollekraftfuttermastration gegeben (Kontrollegruppe, KG). Die anderen erhalteten ein anderes Kraftfutter und, nach Körpergewicht 6.5 bis 11 L Milch pro Tag (Milchgruppe, MG); drei Tiere bekommten Volmilch (VMG) und die übrige vier entsahnte Milch (EMG). Das zweite Jahr war eine Wiederholung mit bzw 8 Tiere im Kontrolle- und 8 im Volmichgruppe. Der gesammte Mastdauer war 174 und 181 Tage bzw. fur KG und MG. Die Tiere des Milchgruppes hätten eine höhere Slachtausbeute ($p<0,01$). Das Fleisch dieser Gruppe hätte fast wesentlich niedrigere b*-Werte und niedriger Trocknenmassgehalt. ($p<0,1$).

Volmilchzugabe erhöhte signifikant das Anteil der gesattigten Kuzketten Fettsäuren im Fett (52.65 vs 50.13%, P<0,001). Die Aenderung war groben im Subkutanes und intermuskulares Fett dann im Intramuskulares Fett.

Table 1
Ingredients and chemical composition (with standard errors) of concentrate fed to control group and of concentrate fed to the milk-fed group (g/kg)

Item	Control	Milk supplement	Whole milk
Feed ingredients (g/kg)			
sugar beet pulp	420.25	462	
barley	105	115	
maize	90	99	
spelt	65	71.5	
middlings	95	104.5	
soya bean meal	107.5	49.5	
linseed meal	65	47	
molasses	38	40.5	
mineral mixture	14.25	11	
Chemical composition (g/kg DM)			
organic matter	927.6±5.8	930.5±6.1	973.6±1.5
crude protein	164.2±13.5	141.5±10.6	265.6±10.9
ether extract	23.7±3.5	23.5±2.0	315.6±13.1
acid detergent fiber	204.1±37.0	215.7±24.2	0
Ca	10.5±1.6	10.4±0.2	10.7±0.6
P	4.7±0.7	4.0±0.6	7.8±0.4

Table 2
Fatty acid composition of the ether extract fraction in concentrate fed to control group, in concentrate fed to milk-fed group and in milk (molar %)

Item	Control	Milk-fed	Whole milk
C12:0	-	-	3.27
C14:0	0.6	0.53	11.8
C14:1	-	-	0.94
C16:0	17.09	17.37	30.21
C16:1	0.67	0.56	1.62
C18:0	5.84	4.32	14.94
C18:1	22.14	22.29	34.57
C18:2	36.32	39.01	1.44
C18:3	17.35	15.92	1.22

Table 3
Animal performances with standard errors of control group (CG) and milk-fed group (MG)

Item	Treatment		Level of significance
	CG	MG	
n	15	15	
Initial age (months)	10	10	
Initial live weight (kg)	309.4 ± 12.1	298.7 ± 14.1	NS
Final live weight (kg)	563.3 ± 11.3	556.3 ± 15.1	NS
Total gain (kg)	253.9 ± 10.5	257.5 ± 12.3	NS
Fattening period (d)	173.7 ± 7.2	181.3 ± 8.3	NS
Average daily gain (kg/d)	1.47 ± 0.05	1.43 ± 0.06	NS
Feed intake/bull			
concentrate (kg)	1516.3 ± 53.6	1300.1 ± 62.6	0.01
milk (l)	0	1356.0 ± 36.4	
dry matter (kg)	1334.3	1347.5	NS
Feed conversion ratio (kg DM/kg)	5.33 ± 0.20	5.30 ± 0.23	
Feed conversion ratio (Mcal/kg)	8.05 ± 0.32	9.81 ± 0.32	0.001

Table 4
Slaughter and carcass characteristics with standard errors of control group (CG) and milk-fed group (MG)

Item	Treatment		Level of significance
	CG	MG	
n	15	15	
Slaughter characteristics			NS
Weight at slaughter (kg)	560.3 ± 11.73	547.0 ± 13.7	NS
Warm carcass weight (kg)	360.9 ± 8.3	360.0 ± 11.0	NS
Killing-out percent. (%)	64.4 ± 0.28	65.8 ± 0.35	0.008
Carcass characteristics			NS
muscles (%)	73.8 ± 0.59	74.7 ± 0.69	NS
adipose tissue (%)	13.7 ± 0.52	13.2 ± 0.51	NS
bone (%)	12.5 ± 0.19	12.1 ± 0.17	NS

Table 5
Meat characteristics with standard errors of control group (CG) and milk-fed group (MG)

Item		Teatment		Level of significance
	CG		MG	
n	15		15	
Meat quality				
pH after				
2 h	6.6	± 0.05	6.5 ± 0.05	NS
4 h	6.0	± 0.05	6.1 ± 0.05	NS
48 h	5.5	± 0.02	5.5 ± 0.02	NS
Color				
L*	42.9	± 0.71	42.8 ± 0.84	NS
a*	16.6	± 0.38	16.5 ± 0.45	NS
b*	16.9	± 0.19	16.8 ± 0.22	0.08
a*/b*	0.99	± 0.02	0.98 ± 0.03	NS
Drip loss (%)	5.1	± 0.22	5.1 ± 0.03	NS
Cooking loss (%)	25.5	± 0.59	26.7 ± 0.69	NS
Peak shear force (N)	37.1	± 2.7	41.9 ± 3.4	NS

Table 6.
Chemical composition with standard errors of meat from control group (CG) and milk-fed group (MG)

Item	Treatment		Level of significance
	CG	MG	
n	15	15	
DM (%)	24.1 ± 0.27	23.3 ± 0.34	0.08
Ash (% in DM)	4.7 ± 0.08	4.86 ± 0.09	NS
Crude protein (% in DM)	90.7 ± 0.79	92.5 ± 0.92	NS
Ether extract (% in DM)	4.5 ± 0.58	3.6 ± 0.35	NS
Cholesterol (g/kg DM)	1.76 ± 0.09	1.49 ± 0.22	NS

Table 7.
Fatty acids composition (molar %) of subcutaneous, intermuscular and intramuscular fat samples from control group (CG) and milk-fed group (MG).

Fatty acid.	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	Sat.	MUFA(1)	PUFA(2)
Main effects										
Location										
Subcutaneous	4.26a	30.28a	3.62a	16.81a	40.50a	3.69a	0.85a	51.38a	44.12a	4.53a
Intermuscular	3.69a	28.01ab	2.13b	23.75b	37.74ab	3.72a	0.85a	55.59b	39.87b	4.57a
Intramuscular	2.54b	25.99b	1.81b	18.14a	35.61b	14.68b	1.40b	46.57c	37.35b	18.07b
P>F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Group										
CG	3.00	26.97	2.26	20.21	38.75	7.75	1.18	50.13	40.96	9.51
MG	4.19	29.66	2.87	18.78	36.74	6.94	0.83	52.65	39.6	8.57
P>F	0.000	0.000	0.000	0.067	0.066	0.115	0.000	0.000	0.073	0.087
Interaction (P>F)	0.057	0.4	0.094	0.78	0.039	0.98	0.53	0.027	0.046	0.111
Individual groups										
Subcutaneous										
CG	3.66a	29.02a	3.19a	17.40	41.62	4.11	1.00a	50.10a	44.81	5.11
MG	5.17b	32.16b	4.26b	15.92	38.81	3.06	0.61b	53.29b	43.08	3.67
Intermuscular										
CG	2.95a	26.14a	1.84	24.7	39.09	4.25	1.025a	53.83a	40.94	5.27
MG	4.70b	30.72b	2.51	22.55	35.9	3.01	0.61b	57.99b	38.41	3.6
Intramuscular										
CG	2.35	25.75	1.7	18.52	35.55	14.88	1.51a	46.47	37.14	18.14
MG	2.78	26.31	1.96	17.61	35.69	14.40	1.24b	46.72	37.65	17.98
SED (3)	0.48	1.49	0.35	1.99	1.93	1.93	0.15	1.57	2.10	2.27

a,b,c: values in a column with different subscripts within a studied effect differ significantly.
(1) MUFA: monounsaturated fatty acid
(2) PUFA: polyunsaturated fatty acid
(3) SED: Standard error of the differences