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Is selecting dairy cows for fat and protein contents an opportunity to maintain yearly compact-calving systems?

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Abstract

This study aimed to explore the effect of alternative selection strategies based on milk fat and protein contents instead of milk yield on reproduction of dairy cows. About 500 lactations were recorded, equally distributed among breeds (Holstein: HO or Normande: NO) and genetic groups with similar genetic merit for fat and protein yields and either high breeding values for milk yield (MILK) or fat and protein contents (CONT). Milk progesterone monitoring enabled the study of the reproductive performance. In both breeds, cows in CONT produced less milk (-763 kg in HO, -649 kg in NO), with higher fat content (+4.1 g kg⁻¹ in HO and +3.9 g kg⁻¹ in NO) and higher protein content (+1.6 g kg⁻¹ in HO, +2.0 g kg⁻¹ in NO) than cows in MILK. Cows in CONT had an earlier resumption of luteal activity than cows in MILK (-6 d in HO, -4 d in NO). There was no difference in ovulation detection rates between genetic groups. No difference in fertility performance was observed between genetic groups in NO. However, HO in CONT had a lower re-calving rate than in MILK (48 vs 55%). Selecting dairy cows for fat and protein contents may not be a good opportunity to improve reproduction.

Keywords: dairy cow, genetic merit, cyclicity, oestrus, fertility

Introduction

The consensus in the literature is that reproduction is impaired because dairy cows are investing most of their resources in milk production (Friggens *et al.*, 2010). The fat fraction of milk represents about 50% of the energy exported in milk, the protein fraction about 25% and the lactose fraction about 25%. Producing the same fat and protein yields (milk solids) through high contents would result in lower milk yield and lower lactose yield and thus result in less total energy exported in milk. Consequently, glucose would be more bioavailable for other functions such as reproduction, blood flow would diminish resulting in less hormones exported in milk and higher hepatic clearance (Wiltbank *et al.*, 2006). There is a lack of information concerning the reproductive performance of dairy cows selected on fat and protein contents compared to cows selected on milk yield, at comparable milk solids yield. The present study aimed to explore the effect of genetic merit for milk fat and protein contents compared to milk yield on reproduction of dairy cows.

Materials and methods

Between 2006 and 2015, about 30 Holstein cows (HO) and 30 Normande cows (NO) were involved in a trial conducted at the INRA experimental farm of Le Pin-au-Haras (Normandy, France). Within breed, cows were classified according to their estimated breeding values into two genetic groups with similar estimated breeding values (EBV) for fat and protein yields (see details in Delaby *et al.*, 2010). Cows with high EBV for milk yield and low EBV for fat and protein contents were assigned to the milk group (MILK); those with low EBV for milk yield and high EBV for fat and protein contents were assigned to the content group (CONT). The EBV were expressed as a deviation from the reference population. The EBV for milk yields were +308 in MILK and -303 in CONT for HO and +290 in MILK and -264 in CONT for NO. For HO in MILK, EBV were -1.7 for fat content and -0.5 for protein content, compared

to +1.9 and +0.5 respectively for HO in CONT. For NO in MILK, EBV were -1.9 for fat content and -0.9 for protein content, compared to +1.5 and +0.8 respectively for NO in CONT.

All cows were managed under a three-month compact calving pasture-based system. Oestrus behaviour were recorded five times a day using the standardized recording procedure of Kerbrat and Disenhaus (2004). The voluntary waiting period was set to 42 days *postpartum*. Cows were inseminated on spontaneous oestrus only. Pregnancy was diagnosed through ultrasonography examination.

Cows were milked twice a day, milk yield was recorded each time, fat and protein contents were estimated three times a week over two milkings. Morning milk samples were taken thrice a week to determine milk progesterone concentration for the monitoring of ovarian activity. Thresholds were estimated to distinguish ovulatory and luteal phases using the methodology of Cutullic *et al.* (2011). Commencement of luteal activity (CLA) was set as the time from calving to the first luteal phase. Based on CLA and cycle length, cyclicity profiles could be classified as normal or abnormal (CLA lower than 50d with regular cycles ranging from 20 to 25 days). Body condition score (BCS) was assessed once a month (0-5 scale, Bazin *et al.*, 1984).

Finally, 102 records on HO in MILK, 115 records on HO in CONT, 130 records on NO in MILK and 153 records for NO in CONT were analysed. Continuous variables (e.g. milk yield) were analysed through linear mixed models and dichotomous variables (e.g. ovulation detection) through generalised mixed models, with a random effect of the cow.

Results and discussion

To our knowledge, this is the first study comparing such genetic groups. In both breeds, cows in CONT produced less milk (-763 kg in HO, -649 kg in NO; Table 1), with higher fat content (+4.1 g kg⁻¹ in HO and +3.9 g kg⁻¹ in NO) and higher protein content (+1.6 g kg⁻¹ in HO, +2.0 g kg⁻¹ in NO) than cows in MILK. Milk solids production was similar in both genetic groups within breeds (+15 kg for cows in MILK compared to cows in CONT in both breeds). This was expected according to their genetic merit for production traits. Within each breed, there was no difference in BCS at calving between genetic groups. NO in the CONT mobilised less body reserves than those in the MILK (+0.25 BCS), this was not observed in HO. Cows in CONT had an earlier CLA than cows in MILK (-6 d in HO, -4 d in NO). There was no difference in ovulation detection rates between genetic groups. No difference in fertility performance was observed between genetic groups in NO. However, HO in CONT had a lower re-calving rate than in MILK (48 vs 55%). This was mostly explained by more non-fertilisation or early embryo mortality (33 vs 25%) and more late embryo mortality (14 vs 9%). Results comparing NZ and US HO strains are in line with our results (Horan *et al.*, 2005) although they had different genetic merit for milk solids yield.

Conclusion

To conclude, this study showed that, at similar genetic merit for milk solids, cows with high genetic merit for fat and protein content had earlier resumption of luteal activity, identical ovulation detection rate and re-calving rates than cows with high genetic merit for milk yield. Normande cows resumed ovarian activity on time. Holstein cows with high genetic merit for fat and protein contents produced a substantial amount of milk and had a degraded re-calving rate compared to those with high genetic merit for milk yield. Further studies are needed on the metabolic costs of milk production. Selecting on fat and protein contents instead of milk yield would not appear as a good strategy to improve reproduction at identical milk solids production.

Table 1. Adjusted productive and reproductive performance for Holstein (HO) and Normande (NO) cows, in milk (MILK) or content (CONT) genetic group.

	HO		NO		Significance levels ¹	
	MILK	CONT	MILK	CONT	B	B:G
Number of lactations	102	115	130	153		
Number of ovulations	237	343	376	462		
Production						
Total milk yield (kg)	7,609 ^d	6,846 ^c	5,765 ^b	5,116 ^a	***	***
Total milk solids (kg)	500 ^b	484 ^b	409 ^a	393 ^a	***	**
Average fat content (g kg ⁻¹)	36.0 ^a	40.1 ^b	39.4 ^b	43.3 ^c	***	***
Average protein content (g kg ⁻¹)	30.6 ^a	32.2 ^b	33.1 ^c	35.1 ^d	***	***
BCS at calving	3.00 ^a	2.85 ^a	3.40 ^b	3.50 ^b	***	ns
BCS at nadir	1.70 ^a	1.70 ^a	2.50 ^b	2.75 ^c	***	**
Reproduction						
CLA (d)	38 ^c	32 ^b	32 ^b	28 ^a	**	**
Normal cyclicity (%)	40	53	66	71	***	ns
Ovulation detection rate (%)	73	69	71	67	ns	ns
Non-fertilisation/early embryo mortality (%) ²	25	33	22	25	*	ns
Late embryo mortality (%) ²	9	14	5	8	*	ns
Re-calving rate (%)	55	49	73	68	***	ns

¹ Effects of breed (B) and genetic group within breed (B:G). Significance levels: *** $P \leq 0.001$; ** $P \leq 0.01$; * $P \leq 0.05$; + $P \leq 0.10$; ns $P > 0.10$.

² Combined outcomes of 1st and 2nd service.

^{a,b,c,d} Distinguish adjusted means that are different between breeds and genetic groups.

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