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Welfare Assessment Based on Metabolic and Endocrine Aspects in Primiparous Cows Milked in a Parlor or with an Automatic Milking System*

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ABSTRACT

An automatic milking system (AMS) was compared with a traditional milking parlor (MP) to evaluate metabolic and psycho-physiological aspects of animal welfare. Twenty Italian Friesian heifers were allocated to 2 groups of 10 cows each after calving and maintained in the same free-stall barn. The first group was milked twice daily in a MP; the second group was milked in a single box AMS. Feed and diet characteristics were analyzed. Health status and body condition score (BCS) were evaluated in each cow. Blood samples were obtained from −14 to 154 d in milk (DIM) to determine metabolic profile and basal concentrations of cortisol in plasma. Data collected from 10 cows per group were processed. No significant difference was detected in milk yield, BCS, and energy-related metabolites (glucose, nonesterified fatty acids, β-hydroxybutyrate, and triglycerides) from cows in MP or in AMS during the first 22 wk of lactation. These results, jointly with the absence of significant differences in plasma metabolites related to protein metabolism, mineral metabolism, and liver function during the first 22 wk of lactation, indicates that cows in AMS did not suffer metabolically. Greater basal concentrations of plasma cortisol in AMS cows, even if absolute values were considered to be in an acceptable range, might indicate chronic stress in these primiparous cows. Further research is necessary to confirm this hypothesis.
(**Key words:** automatic milking, blood metabolite, cortisol, welfare)

Abbreviation key: AMS = automatic milking system, **AP** = alkaline phosphatase, **AST** = aspartate aminotransferase, **ECM** = energy-corrected milk yield, **GGT** = γ-glutamyltransferase, **LDH** = L-lactate dehydrogenase, **MP** = milking parlor, **PCV** = packed cell volume.

INTRODUCTION

The automatic milking system (**AMS**) relieves dairy producers of labor-intensive routines of the traditional milking parlor (**MP**; Mathijs, 2004). A growing concern about animal welfare, however, requires an evaluation of the impact of this new technology on cow health, physiology, and behavior (Hillerton et al., 2004). Both negative and positive animal welfare consequences arising from AMS introduction may be hypothesized. Two kinds of factors should be considered in the evaluation of cow welfare under AMS conditions: 1) psycho-physiological aspects related to disruption of social behavior rather than problems caused by the interaction between animal and machine and 2) metabolic aspects related to a possible increase in nutrient demand rather than a different feeding behavior in comparison with a MP system. For example, disruption of the cow's social behavior when milking becomes an individual rather than a social activity could have a negative outcome (Wiktorsson and Sørensen, 2004). Conversely, one positive effect could be the cow's free choice to enter the milking unit when it needs to eat concentrate and the fact that it can then be milked (Wiktorsson and Sørensen, 2004).

Furthermore, rolling herd average milk production is almost 15% greater for herds milking 3×/d than for herds milking 2×/d (Smith et al., 2002). The AMS allows a voluntary increase in milking frequency, which could increase milk yield from 3 to 11% over the common twice-daily milking strategy (Baines, 2002; de Koning et al., 2002; Wade et al., 2004). Increase in milk yield from increased milking frequency is essentially caused by local control of milk secretion. More milk is secreted because chemical and physical inhibitory mechanisms are less invoked (Knight et al., 1998). One matter of concern is whether cow metabolism is able to support related increases in nutrient requirement by means of mobilized body reserves.

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Wiktorsson et al. (2003), investigating some physiologic and metabolic aspects of the cow in an AMS throughout the first 19 wk of lactation, showed that primiparous cows may experience a severely negative energy balance in early lactation, with a greater body tissue mobilization than that in older cows, when a high milking frequency occurs in the AMS. Recently, Wenzel and Nitzschke (2004) studied the incidence of ketosis and reported no differences in serum glucose, β-hydroxybutyrate, urea, and aspartate aminotransferase (**AST**) for cows milked in a MP vs. an AMS.

Cows exposed to an AMS may have a possible decrease in nutrient balance during early lactation, but also a different pattern of some plasma metabolites from those milked in a MP as a consequence of the differences in feeding behavior between the 2 milking systems (Olofsson et al., 2000; Wagner-Storch and Palmer, 2003). In a behavioral study, feeding activity increased after milking and feed delivery for parlor cows, whereas milking and feeding activity in the AMS increased after human intervention (Wagner-Storch and Palmer, 2003). Olofsson et al. (2000) reported that feed intake was less during the night for cows in an AMS. Differences in feeding behavior (i.e., low night-time feeding activity in AMS) might lead to differences in the plasma metabolites (i.e., increased plasma NEFA in early morning as a consequence of long night-time feed withdrawal). In addition, socially low-ranked animals spent less time in the feeding area and made fewer visits to the feeding stations (Olofsson and Svennersten-Sjaunja, 2004), increasing their average interval between meals.

The hypothesis that milk yield increases because of AMS, together with insufficient information in AMS field trials, justifies specific research on these metabolic aspects. Blood metabolites considered in a metabolic profile may provide information on energy and protein metabolism, and together with BCS and milk yield, might show changes in lipid mobilization (Bertoni et al., 1999). Minerals, plasma proteins, and enzymes also could be useful to show whether inflammatory conditions occur or whether hepatic function and digestive processes are affected by husbandry (Bertoni et al., 1999).

With regard to the psycho-physiological aspects, the milking process represents a source of factors that may be stressful for naive primiparous cows, including novelty and interaction with a human (as in MP) or a mechanical robotic system (as in AMS), which might alter plasma cortisol, a glucocorticoid hormone related to stress response. Milking cows in an unfamiliar environment results in elevated concentrations of plasma cortisol, elevated heart rates, reduced oxytocin release, and less milk yields concomitant with an increase in the fraction of residual milk (Bruckmaier et al., 1993; Rushen et al., 2001). Cortisol itself does not seem to influence central inhibition of milk ejection (Wellnitz and Bruckmaier, 2001). In a previous study of primiparous cows, AMS produced baseline concentrations of plasma cortisol similar to those of cows milked in a MP (Hopster et al., 2002). Cortisol is widely considered to be a marker of stress in cattle. Baseline concentrations of plasma cortisol may be of interest to verify whether the milking system per se can affect the cow's susceptibility to suffer stress. Cortisol patterns in a chronic stress situation, however, are often controversial, especially when social hierarchy is taken into account (Wiktorsson et al., 2003).

The objective of this study using primiparous cows was to compare the effects of the milking system and related milking frequency on the susceptibility to metabolic stress and to psycho-physiological chronic stress in cows milked in a MP or by an AMS.

MATERIALS AND METHODS

Animals and Husbandry

Twenty healthy Italian Friesian first-lactation cows were chosen to study differences resulting from milking in a MP vs. an AMS. Two months before calving, heifers were allocated to 2 groups of 10 cows each that were comparable in terms of average breeding value, expected age at first calving, expected calving season, and BCS (Edmonson et al., 1989). At the beginning of lactation, the cows were introduced into 2 similar herds, each composed of a total of 50 cows, which were also comparable for average milk yield and parity. Ten first-lactation cows in each herd were selected from among those that had not experienced calving-related disorders, to study animal welfare mainly through metabolic and endocrine aspects during the first half of lactation.

Both herds were housed in the same free-stall barn. A double-8 herringbone MP was located at 1 end of the barn and at the other end was located a single box AMS (DeLaval VMS; DeLaval, Tumba, Sweden). Both groups of cows were fed a similar TMR distributed once daily (0800 h). The AMS cows also received a concentrate supply in the milking stall: 1 kg/d for every 10 kg of daily milk yield. Concentrate supplied in the milking stall had a chemical composition similar to that of the TMR (Table 1). The MP cows received additional concentrate supplied in the TMR ranging from 0.5 to 1.5 kg/d; the TMR was provided at the planned DMI level for the cows of the 2 groups, which allowed for a balance in average energy and protein intake between the 2 groups (Table 1). Routine milking times in the parlor started at 0530 and at 1630 h. Ingredients of the TMR in both groups are reported in Table 1.