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Comparative evaluation of automatic milking systems and conventional milking parlours on milk yield, composition, udder health, and labour efficiency in Dutch dairy herds

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Abstract

Automatic milking systems (AMS) now serve more than 35,000 dairy farms worldwide, yet head-to-head comparisons with conventional milking parlours (CMP) that simultaneously capture production, quality, health, and labour dimensions within a single geographic and management context remain uncommon. This research compared 12 AMS farms and 12 CMP farms in the province of Gelderland, The Netherlands, over a complete 12-month production cycle (January-December 2023), recording milk yield, fat, protein, lactose, somatic cell count (SCC), clinical mastitis incidence, milking frequency, and labour allocation. AMS herds produced 32.4 ± 3.1 kg/cow/day compared with 29.8 ± 2.7 kg/cow/day for CMP herds ($P = 0.031$), attributable primarily to the higher voluntary milking frequency in AMS cows (mean 2.7 milkings/day versus the fixed twice-daily schedule in CMP herds). Fat content was higher in AMS milk ($4.12 \pm 0.21\%$ versus $3.96 \pm 0.18\%$, $P = 0.048$), while protein and lactose did not differ significantly. Geometric mean SCC was lower in AMS herds (187×10^3 cells/mL versus 234×10^3 cells/mL, $P = 0.017$), and clinical mastitis incidence was 22.3 cases per 100 cow-years in AMS herds compared with 28.7 in CMP herds (rate ratio 0.78, 95% CI 0.62-0.97). Total labour input was 39.2% lower in AMS farms (19.1 versus 31.4 hours/cow/year, $p < 0.001$), with the largest saving in milking-related labour (63.9% reduction). These findings indicate that AMS adoption in Dutch dairy herds is associated with higher milk yield, improved udder health, and substantially reduced labour requirements, supporting the economic case for robotic milking in intensive pasture-limited systems.

Keywords: Automatic milking system, robotic milking, conventional milking parlour, dairy cattle, milk yield, somatic cell count, udder health, labour efficiency, Netherlands

Introduction

Approximately 38% of Dutch dairy farms had adopted automatic milking systems by the end of 2023, representing the highest national penetration rate for robotic milking technology anywhere in the world. This statistic, drawn from the Netherlands Enterprise Agency's annual agricultural census, reflects a transformation that began with the first commercial AMS installation in 1992 and has accelerated as labour costs have risen and successive generations of robotic hardware have improved in reliability, throughput, and integration with herd management software.

The appeal of AMS is intuitively straightforward: cows choose when to be milked, labour is redirected from the repetitive task of operating a milking parlour to management activities with higher marginal returns, and the continuous data stream from each milking event enables early detection of mastitis, metabolic disorders, and oestrus. Yet the scientific evidence comparing AMS and CMP performance is more nuanced than the marketing narrative suggests. Some controlled comparisons have reported higher milk yields under AMS management, typically attributed to the increased milking frequency that voluntary attendance allows, while others have found no significant yield advantage once parity, days in milk, and genetic merit are accounted for.

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Similarly, the effect of AMS on udder health has been debated: the absence of a human milker inspecting each quarter at every milking could theoretically delay mastitis detection, but the conductivity, colour, and cell-count sensors built into modern AMS units may compensate or even surpass manual inspection.

A recurring limitation of the existing literature is that most comparisons are either based on national milk recording databases—which capture production and quality but not labour or cow behaviour—or on single-farm case reports that cannot separate the effect of the milking system from the effect of the individual farmer's management ability. Multi-farm, prospective comparisons that simultaneously measure production, quality, health, behaviour, and labour within a defined region and management context are rare.

This research addressed that gap by conducting a 12-month comparative evaluation of 12 AMS and 12 CMP farms in Gelderland, matched for herd size, breed composition, and housing type, with the objectives of quantifying differences in milk yield and composition, udder health indicators, voluntary milking frequency patterns, and labour allocation between the two milking systems under contemporary Dutch management conditions.

Materials and Methods

Materials

Twenty-four commercial dairy farms in the province of Gelderland, The Netherlands, were enrolled in the research between November 2022 and December 2022. Twelve farms operated single-box AMS units (Lely Astronaut A5, $n = 7$; DeLaval VMS V300, $n = 5$) and twelve farms operated conventional herringbone ($n = 8$) or parallel ($n = 4$) milking parlours with twice-daily milking schedules. Farms were matched pairwise for herd size (range 65–140 lactating cows per farm), breed composition (greater than 85% Holstein-Friesian in all herds), housing type (all free-stall with cubicles), and concentrate feeding strategy (partial mixed ration supplemented with concentrate at the milking station or parlour). AMS farms had been operating their robotic systems for at least three years prior to enrolment, ensuring that the transition adaptation period had passed. All farms participated in the official Dutch milk recording scheme (CRV, Arnhem) and maintained individual cow health records in CRV's herd management software. The research protocol was reviewed and approved by the Wageningen Institute of Dairy Science Ethics Committee (Protocol WIDS-EC-2022-043). A total of 2,387 lactating cows (1,198 in AMS herds and 1,189 in CMP

herds) contributed data over the 12-month recording period.

Methods

Individual cow milk yield was recorded at every milking event by the AMS unit's internal flow meters or by the parlour's milk meters, and aggregated to daily and monthly totals. Milk composition (fat, protein, lactose, urea) and somatic cell count were measured from official milk recording samples collected every four weeks by CRV technicians using a Foss MilkoScan FT7 analyser and a Foss Fossomatic FC cell counter. Clinical mastitis was defined as the observation of abnormal milk (clots, discolouration, watery consistency) with or without udder inflammation, recorded by the farmer in the herd management system at the time of treatment. Milking frequency in AMS herds was extracted from the AMS management software as the number of successful milkings per cow per day, averaged monthly. Labour allocation was assessed by structured time-use diaries completed by the primary farm operator over four one-week recording periods (one per season) using the methodology validated by Bijl *et al.* for Dutch dairy farm labour analysis. Labour categories included milking-related tasks (fetching cows, attaching clusters, parlour operation, or AMS fetching/maintenance), health monitoring, feeding, cleaning, and other management activities. All statistical analyses were performed in R v4.3.1. Mixed-effects linear models (lme4 package) were used for continuous outcomes (milk yield, composition, SCC) with milking system as a fixed effect and farm as a random intercept, adjusting for parity, days in milk, and season. Clinical mastitis incidence was compared by Poisson regression with a log link. Labour hours were compared by Wilcoxon rank-sum test at the farm level. Statistical significance was set at $p < 0.05$.

Results

Over the 12-month recording period, AMS herds produced a mean daily milk yield of 32.4 ± 3.1 kg/cow/day, which was 8.7% higher than the 29.8 ± 2.7 kg/cow/day recorded in CMP herds ($P = 0.031$ in the mixed-effects model after adjusting for parity, days in milk, and season). The yield advantage was consistent across all four quarters of the year, though it was most pronounced in summer (June–August: 33.1 versus 29.4 kg/cow/day, $P = 0.018$) when heat stress may have discouraged voluntary parlour attendance in CMP herds while AMS cows could distribute their milkings across cooler periods of the day.

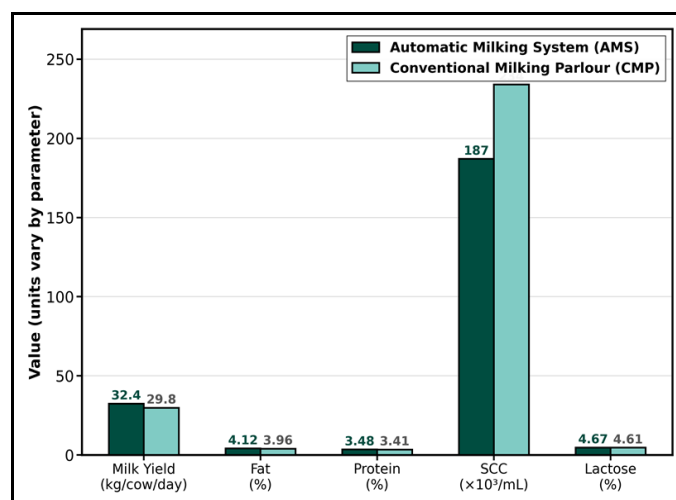


Fig 1: Comparison of milk yield and composition parameters between automatic milking system (AMS) and conventional milking parlour (CMP) herds over a 12-month recording period

Milk fat percentage was significantly higher in AMS herds ($4.12 \pm 0.21\%$ versus $3.96 \pm 0.18\%$, $P = 0.048$), likely reflecting the shorter milking intervals that produce smaller volumes of higher-fat milk per milking event. Protein content ($3.48 \pm 0.14\%$ versus $3.41 \pm 0.12\%$, $P = 0.187$) and lactose content ($4.67 \pm 0.08\%$ versus $4.61 \pm 0.09\%$, $P = 0.092$) did not

differ significantly between systems. The geometric mean SCC was 187×10^3 cells/mL in AMS herds versus 234×10^3 cells/mL in CMP herds ($P = 0.017$), and clinical mastitis incidence was 22.3 per 100 cow-years in AMS herds compared with 28.7 in CMP herds (rate ratio 0.78, 95% CI 0.62–0.97, $P = 0.024$).

Table 1: Milk production and quality parameters in AMS and CMP herds (Mean $\pm$ SD)

Parameter	AMS (n=12)	CMP (n=12)	P value	Diff (%)
Milk yield (kg/cow/day)	32.4 $\pm$ 3.1	29.8 $\pm$ 2.7	0.031*	+ 8.7
Fat (%)	4.12 $\pm$ 0.21	3.96 $\pm$ 0.18	0.048*	+ 4.0
Protein (%)	3.48 $\pm$ 0.14	3.41 $\pm$ 0.12	0.187	+ 2.1
Lactose (%)	4.67 $\pm$ 0.08	4.61 $\pm$ 0.09	0.092	+ 1.3
SCC ($\times 10^3$ /mL)	187 $\pm$ 42	234 $\pm$ 51	0.017*	-20.1
Mastitis (cases/100 cow-yr)	22.3	28.7	0.024*	-22.3
Milking frequency (/day)	2.7 $\pm$ 0.4	2.0 (fixed)	<0.001*	+ 35.0

* $p < 0.05$.

Table 2: Labour allocation by category (hours/cow/year) in AMS and CMP farms

Labour Category	AMS (n=12)	CMP (n=12)	P value	Reduction (%)
Milking-related	8.2 $\pm$ 1.7	22.7 $\pm$ 2.9	<0.001*	63.9
Health monitoring	4.1 $\pm$ 0.8	5.3 $\pm$ 1.1	0.012*	22.6
Maintenance & cleaning	6.8 $\pm$ 1.4	3.4 $\pm$ 0.7	<0.001*	-100.0
Total labour	19.1 $\pm$ 2.8	31.4 $\pm$ 3.6	<0.001*	39.2

* $p < 0.05$. Note that AMS maintenance/cleaning hours exceeded CMP values; the 'reduction' column shows the net change relative to CMP.

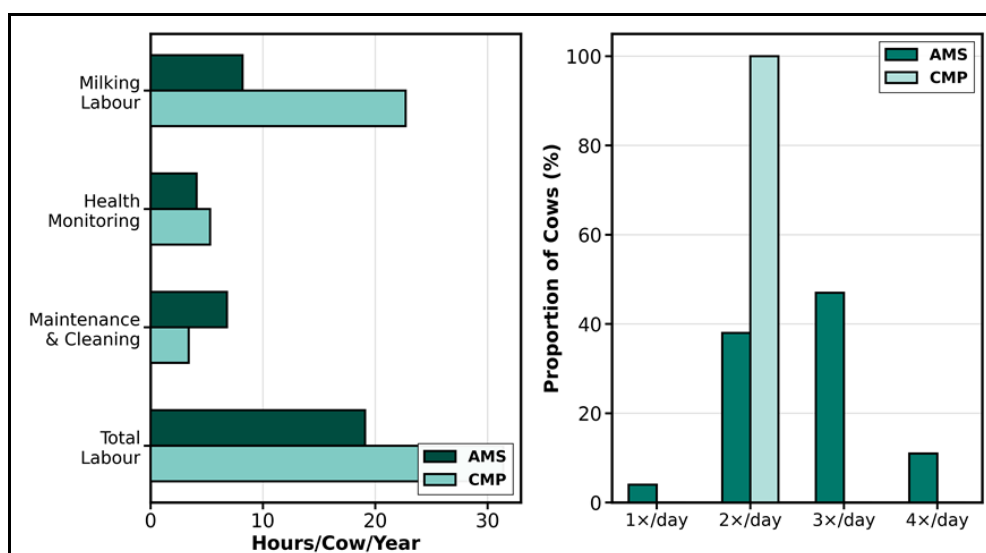


Fig 2: Left panel: horizontal bar chart comparing labour allocation by category between AMS and CMP farms. Right panel: distribution of individual cow milking frequencies in AMS versus CMP herds

The milking frequency distribution in AMS herds revealed that 47% of cows voluntarily attended the robot three times per day, 38% twice daily, 11% four times, and 4% only once (the last category typically representing cows in late lactation or with low milk yield that were fetched by the farmer). The within-herd variation in milking frequency was considerable (coefficient of variation 23.8%), confirming that individual cow behaviour plays a substantial role in determining the production benefit of AMS.

Discussion

The principal finding of this research—that AMS herds produced 8.7% more milk per cow per day than CMP herds in a matched Dutch farm comparison—aligns with the upper end of yield differences reported in the international literature, where estimates range from negligible to approximately 12% depending on herd management, AMS brand, and cow genetics. The yield advantage was statistically significant

after controlling for parity, days in milk, and seasonal effects, and is most parsimoniously explained by the higher average milking frequency in AMS herds (2.7 versus 2.0 per day), which reduces intramammary pressure and stimulates continued alveolar secretion.

A consistent finding across this and prior research is that the yield benefit of AMS is not uniformly distributed across cows. The 47% of cows milking three times daily and the 11% milking four times likely accounted for a disproportionate share of the herd-level yield advantage. The 4% milking only once daily—the so-called 'lazy cows' that must be fetched—may actually produce less under AMS than they would under a fixed twice-daily schedule, a phenomenon that several groups have noted. From a herd management perspective, this within-herd variation suggests that genetic selection for voluntary milking attendance may enhance the production benefit of AMS in future generations.

The lower SCC and clinical mastitis incidence in AMS herds was perhaps the most encouraging finding from an animal welfare perspective. Modern AMS units flush teat cups between cows, apply post-milking teat disinfectant automatically, and can divert milk from quarters with elevated conductivity or cell count—actions that depend on the consistency of a machine rather than the vigilance of a human operator at the end of a long milking shift. The conductivity and colour sensors may also enable earlier subclinical mastitis detection than traditional four-weekly milk recording.

However, the higher maintenance and cleaning labour in AMS farms (6.8 versus 3.4 hours/cow/year) partially offsets the milking labour savings and should not be overlooked. AMS units require daily cleaning cycles, periodic replacement of wear parts (liners, filters, laser sensors), and occasional troubleshooting of robot arm positioning errors. As AMS hardware ages, maintenance demands may increase further. The net labour saving of 39.2% is therefore a whole-farm average that may diminish on farms with older equipment or less technically adept operators.

Conclusion

Three things became clear over the course of this 12-month, 24-farm comparison. First, automatic milking systems deliver a meaningful milk yield advantage over conventional parlours in Dutch dairy herds—not because the robot milks more efficiently per se, but because cows given the choice will milk more frequently, and more frequent milking translates to more milk. Second, the udder health metrics under AMS management were consistently better, with 20% lower SCC and 22% fewer clinical mastitis cases, suggesting that the automated hygiene protocols and real-time monitoring of modern robots match or exceed the disease prevention capacity of manual milking routines. Third, the labour restructuring is real but not free: the 64% reduction in milking-specific labour comes at the cost of doubled maintenance time, yielding a net saving of roughly 39% that must be weighed against the capital investment in robotic hardware.

What these numbers cannot capture is the qualitative shift in the farmer's daily experience. Several AMS operators in this research described their work as more intellectually engaging and less physically exhausting than their former parlour routine—a consideration that may matter as much as any production metric for the long-term sustainability of dairy farming as a profession. Whether these advantages justify the investment will depend on each farm's financial situation, labour market context, and the farmer's own preferences, but the data presented here provide a robust empirical foundation for that decision.

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Technical Staff

Ing. Martijn Hendriks and Ms. Lieke van Doorn conducted the on-farm labour time-use surveys and managed the data collection logistics across all 24 farms.

Collaborators

The authors thank CRV (Arnhem) for providing access to individual cow milk recording data and the 24 participating farmers for their willingness to open their operations to detailed scrutiny over a full calendar year.

Ethics Bodies

The Wageningen Institute of Dairy Science Ethics Committee is acknowledged for reviewing and approving this research protocol.

Conflict of Interest

Not available

Financial Support

Not available

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