77

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Determining Optimum Performance for Milking Equipment, Procedure and Systems

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TABLE OF CONTENTS

	<u>Page</u>
A. COVER PAGE	1
B. TABLE OF CONTENTS	2
C. ABSTRACT	3
D. INTRODUCTION.	4
E. RESULTS	5
1. Stimulation Experiments	5
2. Evaluation of Pipeline Size and Liner Stiffness. . .	6
3. Teatcups with New Liner Designs	7
4. Basic Liner Characteristics	9
5. Organism Transport Through Teat Canal.	10
F. EVALUATION OF ACHIEVEMENTS	12
G. COOPERATION	13
H. BENEFIT TO AGRICULTURE.	14
I. LIST OF PUBLICATIONS RESULTING FROM THIS PROJECT.	14
APPENDIX 1	17

C. ABSTRACT

Achieving and maintaining a high level of milk production, labor efficiency, and milk quality depends on many aspects of dairy management. One of the most important is the milking process. Milking represents the most consuming activity on the dairy farm and modern machine milking systems are increasingly complex and automated. The major objective of the research reported was to quantify interrelationships between the physiology of the cow, the characteristics of the machine milking process, and the milking routine utilized by the operator. In particular, the research activity was directed to the following sub-projects:

- 1) Evaluation and analysis of routines and procedures aimed to promote milk ejection in cows and the effects on milking efficiency (labor), and persistency (yield).
- 2) Evaluation of the existing conventional machine milking process, including a consideration of pipeline size.
- 3) Development and evaluation of several new machine designs aimed to improve milk removal and to reduce risk of mastitis.
- 4) Analyze teat/liner interactions to provide an objective basis for liner design.
- 5) Quantify mechanisms for transport of mastitis-causing pathogens through the teat canal.

Results from this research have led to redesign of existing equipment and the development of new concepts of machine milking based on a more complete knowledge of the physiology of the teat and the machine as a potential factor in mastitis. Results of the research have also led to an understanding of factors contributing to mastitis which are not machine related.

D. INTRODUCTION

Dairy farming is an important agricultural enterprise in the United States, Israel, and many other developed countries. The monetary value of milk and animals as produced on the farm is multiplied many times in terms of total economics of goods and services supporting dairy production and in the processing, distribution and sale of milk and dairy products. The efficiency of the dairy cow as a producer of high quality, nutritious, human foods is well-documented.

Research which would show only modest benefits in terms of milk yield or udder health, or increased efficiency of milk production, or reduced losses in production will have great significance. U.S. and Israel dairy cow populations are approximately 10 million and 120,000 respectively. Mastitis is the most costly single disease on the dairy farm. Losses due to decreased production, treatment costs, discarded milk, and culled cows are estimated to be as much as \$200/cow/year. The estimated total loss due to mastitis is thus \$2 billion and \$2.4 million for U.S. and Israel respectively. Under such circumstances, improvement even by small percentages will have great economic impact.

E. RESULTS

1. Premilking Stimulation Routines

Large dairy herds put an increasing demand and emphasis on labor efficiency. The additional time and effort of premilking manual stimulation (in addition to ensuring clean teats and normal milk) can affect milking efficiency, especially in milking parlors. Yet, many "academic" recommendations for practical milking routines emphasize the traditional rule for "massage" prior to attachment of units, in spite of results from many short-term experiments and "farmer observations" to the contrary. No published research results, based on measurements of milk yield, milk fat yield, milk composition, milk flow rate, milking time, residual milk, and hormone release (oxytocin, prolactin, and cortisol) were available to answer the question of whether premilking stimulation effectively increases production in Holstein cows over a complete lactation.

The following experiments related to lactation were conducted:

- a. A study aimed to determine the persistency of Holstein cow's response to premilking stimulation was conducted and reported as a part of this project by Zinn et al, 1982. It was concluded that the response of cows to premilking manual stimulation (in terms of milking characteristics) was consistent over the experimental period (100-280 days in lactation). Differences between milking variables were significant at each stage of the experiment.
- b. The effect of premilking stimulation on lactation persistency of Holstein cows was studied. Thirty-three Holstein cows were milked in a stall barn to measure effects throughout complete lactations of:
 - i) Full stimulation premilking preparation, i.e. forestripping one to two streams of milk, washing teats with individual paper towels wetted in a 200 ppm iodine udder wash solution, drying with individual paper towels plus massage to complete a total of 40s from beginning of preparation, then a 20s delay before attaching the milking unit, or

- ii) A minimum stimulation, premilking preparation, i.e. forestripping one to two streams of milk, plus wiping teats with individual paper towels wetted in 200 ppm iodine udder wash solution, then drying with individual paper towels, all events not exceeding an average 15s total followed by immediate attachment of the milking unit.

For the full manual stimulation and minimum premilking stimulation treatments, 17 and 16 cows respectively, the total lactation and average milk yields were 8042 kg, 8484 kg, and 26.1 k, 27.6 kg. These differences were not statistically significant nor were any differences in persistency or slopes of the lactation curves. Milk accumulation curves were recorded twice weekly for each cow at 8, 16, 24, 32, and 40 weeks. Significant treatment differences occurred for peak flow rate and time to start of peak flow during the last three periods, for machine on-time and average flow during the last two periods, and for time to obtain the last kg of milk during the last period only. Stipping yields and percent residual milk yields were not different between treatments.

This study as in a series of previous short-term trials (Sagi et al, 1980) indicates no advantages in milk yields or persistency beyond minimum milking preparation for high producing Holstein cows. There were differences in flow rates and milking times during the last one-third to one-half of lactation, however, these differences do not offset the time required for the full manual stimulation.

2. Evaluation of Pipeline Size and Liner Stiffness

- a. A theoretical study (Gates et al, 1981) augmented by laboratory experiments (Gates et al, 1982) was conducted as a part of the BARD project. The main conclusions of these studies are:
 - i) Milk pipeline configurations determine the system sensitivity to slug formation as a function of fill depth,
 - ii) The formation of slugs will result in vacuum fluctuations and impaired milk quality, and
 - iii) Current recommendations which limit the number of units to milking pipeline diameter (in inches) raised by the power of two may result in oversized pipeline diameters.

b. Liner Stiffness

To determine the effects of liner stiffness on milking performance, two experiments were conducted. Liners of the same geometry (DeLaval 01) but with three different inflection points (25.0, 35.5, 49.0 kPa) were provided by the DeLaval Rubber Plant for study.

Experiment 1 - Nine cows were subjected to a treatment sequence of three 3x3 Latin squares. Each treatment period lasted 6 days and data were collected during the a.m. milking of Days 5 and 6.

Experiment 2 - Twelve cows divided into two groups of first lactation and second or third lactation were used. Each group of cows was subjected to the same treatment sequence according to the design of two 3x3 Latin squares, providing a double-changeover experiment. Each treatment period lasted 7 days and data were collected during the a.m. milking of Days 5 & 7.

Cows were milked twice a day at equal intervals. Milking was completed when the milk flow rate dropped below 200 ml/minute. Least square means of milking performance from these two experiments are given in Table 1. Differences in production variables (milk yield, strip yield, and residual yield) were not significant in either experiment. Similar trends with respect to milking variables were recorded in both experiments. The stiff liner was significantly different from both the control and flexible liners for milking time, peak flow, and average flow. Milking time was less and peak flow greater for the stiff liner. Average milk flow was significantly greater in Experiment 2 (almost true in Experiment 1). There were no significant differences between the control and flexible liners.

3. Teatcups With New Liner Designs

The conventional milking machine utilizing a double-chambered teatcup is considered to be both efficient and reliable. However, investigations of the role of the pulsating liner have revealed that liner wall movement may result in cyclic vacuum fluctuations under the teat end. Furthermore, certain combinations of these cyclic fluctuations, with irregular fluctuations, contribute to increased risk of mastitis. A temporary reverse pressure gradient across the short milk tube may develop as a result of a combination between cyclic and irregular fluctuations. This in turn may result in a transfer of bacteria and cross-contamination. Reducing the

TABLE 1

Least Square Means of Milking Performance for
Experiment 1 (9 cows) and Experiment 2 (12 cows)

	EXPERIMENT 1			OVERALL SIGNIFICANCE	EXPERIMENT 2			OVERALL SIGNIFICANCE
	"FLEXIBLE"	CONTROL	"STIFF"		"FLEXIBLE"	CONTROL	"STIFF"	
Machine Yield Kg/milking	11.0	10.9	10.6	N.S.	12.64	12.66	12.66	N.S.
Machine Strip Kg/milking	.4	.5	.5	N.S.	.29	.33	.32	N.S.
Total Residual Kg/milking	1.1	.8	.9	N.S.	1.41	1.45	1.35	N.S.
Total Yield Kg/milking	12.5	12.2	12.0	N.S.	14.36	14.44	14.36	N.S.
+Milking Time min	5.6 ^a	5.6 ^a	5.2 ^b	*	5.9 ^a	5.9 ^a	5.5 ^b	*
Peak Flow Kg/min	3.12 ^b	3.25 ^{ab}	3.34 ^a	*	3.23 ^a	3.30 ^a	3.51 ^b	**
Average Flow Kg/min	2.09	2.06	2.20	N.S.	2.18 ^b	2.17 ^b	2.34 ^a	*

* Means with the same letters are not significantly different

* Pr > 0.05

** Pr > 0.01

magnitude of the cyclic fluctuation by means of reducing liner wall movement was an objective of this sub-project.

To evaluate effects of reduced liner wall movement on milking performance and pressure gradient across the short milk tube, we developed and compared two experimental teatcup assemblies to a conventional unit. These assemblies were:

- i) A partial liner assembly, and
- ii) A liner with restricted wall movement (Sagi et al, 1983)

In milking performance the restricted liner was almost identical to the conventional teatcup. Moreover, both cyclic vacuum fluctuations and the incidence of reverse gradient were less pronounced in the restricted liner assembly than the conventional unit and, thus, have the potential of reducing the risk of reverse flow and subsequent cross-contamination.

4. Basic Liner Characteristics

Liners of different physical properties are currently marketed and liner design remains primarily an empirical art with many conflicting opinions over the "best" liner. Our objective has been to quantify the action of the liner on the teat in terms of forces exerted, the load distribution on the teat surface, and the variation of liner loads with various liners. Specifically, we seek to determine what physical properties of the liner are important to reduce organism transport and whether liners which are significantly different in terms of loading may have any measurable effect on milking performance.

A combined mathematical and experimental approach has been pursued. Preliminary measurements of contact pressure and resulting forces have been obtained. Measurement of the contact pressure has been accomplished by implanting a miniature pressure transducer on the inside surface of the liner barrel. The transducer is fabricated in our laboratory and uses a pressure sensitive transducer (commercially available) immersed in a small fluid-filled chamber. An elastic diaphragm is affixed to one end of the chamber which seals the fluid and this diaphragm is mounted flush with the inner surface of the liner barrel. Changes in forces on the diaphragm cause a change in the liquid pressure within the chamber and these pressures are sensed and recorded. The quantification of forces exerted by liners has not been previously accomplished. In

addition to measuring forces between the teat and liner for comparison of effects of different liners, these forces serve as boundary conditions for a mathematical description of the deformations and stresses developed in teat tissue during machine milking.

The measurement of effective teat load with two liner designs has been accomplished to date. The effective loading for both a "stiff" and "flexible" liners illustrates little difference over a majority of the teat surface. The "flexible" liner does impart larger compressive loads during liner collapse near the teat end. The measurements of teat/liner forces are not sufficient to fully characterize teat loading for the many available designs. Further measurements need to be made.

The teat has been modeled as a non-linear elastic material subjected to finite deformations. Based on published pressure verses diameter data from unsupported teats and the measured forces between the teat and liner, tissue stresses have been predicted from a mathematical model. Very large tissue stresses are predicted for linerless milking and are greatest on the inner teat surface. The presence of a liner drastically reduces tissue stress levels relative to the linerless case. These results help explain why linerless milking has not proven to be an efficient method of milk removal. Milking with a conventional teatcup assembly relieves wall stresses depending on liner bore and the initial and expanded teat diameter. The effect of a wide-bore liner on tissue stresses is similar to that of linerless milking if teats do not expand to contact the liner. If a contact force is developed, tissue stress distributions are predicted to be similar for the wide-bore liner to that of the narrow-bore, but of a greater magnitude. Thus, the linerless milking case is one extreme and yields the largest teat tissue stresses, while the narrow-bore liner represents the other extreme and the smaller teat wall stresses. The wide-bore liner, depending on teat diameter, falls somewhere between the two cases.

5. Organism Transport Through Teat Canal

It is accepted that mastitis results from infection due to the penetration of pathogens through the teat canal into the teat sinus. However, methods by which bacteria are transported across the teat canal are not well established.

- a. Trials have been conducted to determine pressure gradients across the teat canal during milking and to determine whether conditions ever

11

exist for a reverse pressure to act as a possible mechanism for organism transport into the teat (Mahan, 1983). Techniques have been developed to measure the pressure gradient across the teat canal by implanting a miniature pressure transducer inside the teat near the proximal end of the teat canal and by placing a similar transducer inside the teatcup at the distal end of the teat canal.

When liner slips were induced during peak milk flow, the change in pressure outside the teat had no effect on pressures measured inside the teat. However, when liner slips were induced during periods of low milk flow and no milk flow, pressure change inside the teat closely followed the change induced at the outside of the teat. Reverse pressure gradients were measured under two conditions in the same cow on a rear teat. At low milk flow, five occurrences of reverse pressure gradients were recorded using a stiff liner and an equal number recorded using a flexible liner. Each occurrence of the reverse pressure gradient occurred as the liner opened. Milking parameters of vacuum level and pulsation rate and pulsation ratio had no effect on pressure gradients across the teat canal during low teat flow or no flow without liner slip.

Measurement of the pressure gradient across the teat canal illustrates that conditions may occur during low and no milk flow when a reverse directed gradient can exist. Whether this short lasting, relatively low amplitude pressure gradient can be a mechanism for transport of organisms through the teat canal requires further study.

- b. The keratin lining in the teat canal is postulated to function as a mechanical barrier to bacterial penetration, both by sealing the teat and by its milk "repellent" properties. As a result, the physical effect of keratin on the penetrability of externally applied endotoxin to the teat was tested. The results are:
- i) If the keratin lining is left intact in the streak canal, endotoxin is unable to penetrate into the teat cistern.
 - ii) Removal of the keratin lining causes the teat canal to become more susceptible to endotoxin penetration.
 - iii) Removal of the keratin lining causes a significant increase in somatic cell count.

Because removal of keratin leaves the teat more susceptible to bacterial invasion, a study was conducted to determine the rate of regeneration of keratin in the teat canal. If keratin is removed by erosion during milking, it is important to know how long it takes for this protective barrier to regenerate. Based on physical removal of the keratin from the teat canal, our measurements of regeneration of the keratin show that regeneration is complete in about 24 hours. Fluid shear stresses occur in the teat canal during milk flow and experiments are proposed to determine if shear stresses are sufficient to erode keratin during milking.

Processes of diffusion and bacterial growth exist as potential mechanisms for penetration of pathogens into and through the teat canal. These processes are being treated analytically and experimentally. A model for one-dimensional diffusion of bacteria through the teat canal has been developed to predict time required for given concentrations of bacteria to diffuse the length of the teat canal. The diffusion model has been modified also to include a bacterial growth model, although the model excludes death rate, substrate limitations, and keratin effects. It is likely that diffusion and bacterial growth would occur simultaneously and solutions to these models are being validated.

F. EVALUATION OF ACHIEVEMENTS

The research plan included five specific sub-projects. Important results and achievements were:

- 1) Studies confirmed that manual stimulation of Holstein cows prior to milking was of limited importance. Differences in lactational yield, milk flow rates, and milking times were not significantly improved to offset the time required for full manual stimulation.
- 2) Recommendations from a theoretical study augmented by laboratory experiments were developed for optimal sizing of milking pipelines. The formation of slugs resulting in vacuum fluctuations and impaired milk quality can be reduced.
- 3) Results from our partial liner studies indicate that a restrictive liner offers an alternative to conventional liner design. Restricting liner wall movement reduces the reverse pressure gradient across the short milk tube and this may have the potential of reducing the risk of reverse flow and subsequent cross-contamination between teatcups.

Bacterial transport in the partial liner and restricted liner designs is significantly reduced as measured by reduced incidence of contamination at the teat end. Removal of reverse pressure gradients across the short milk tube appears to reduce risk of bacterial transfer and cross-contamination which may in turn reduce the risk of new infections.

- 4) Measurements have indicated the potential for a reverse pressure gradient across the teat canal during periods of low and no milk flow during imposed liner slip. Reverse pressure gradients across the teat canal could conceivably promote retrograde flow of organisms into the teat cistern. Liner slips have been implicated as a cause of new infections by Irish researchers (O'Shea et al, 1983) but a quantitative explanation of how liner slips are interrelated with new infections has been lacking. Our measurements suggest the potential of reverse pressure gradients across the teat canal as a mechanism of transport linked to liner slips.
- 5) The processes of diffusion and bacterial growth are likely to occur simultaneously in the teat canal. Mathematical models for diffusion and bacterial growth suggest the potential of these mechanisms for organism transport in and through the teat canal.
- 6) Removal of the keratin layer at the innersurface of the teat canal leaves the teat more susceptible to bacterial invasion. Pathogens have been found in up to 50 percent of teats where keratin has been removed. As a result, factors causing keratin removal and the rate of keratin regeneration following removal have been studied.
- 7) Utilizing both experimental measurements of force exerted by the liner on the teat and a mathematical analysis, a better understanding of the teat/liner interaction has been accomplished. The presence of a liner drastically reduces teat tissue stress relative to the linerless case. Milking with a conventional teatcup assembly relieves stresses in the teat wall tissue depending on the diameter of the liner and teat diameter.

These achievements meet closely the objectives of the original project. Time and resources have limited the research to experimental and small herd size tests. Basic concepts have been developed which, in the future, can be applied to commercial herds.

G. COOPERATION

Cooperation between Cornell University and Technion Israel Institute of Technology has been excellent. Activities were initiated and conducted at both

Universities in accordance with availability of facilities and animals for the specific sub-projects. Experiments related to simulation were conducted at Cornell, while evaluation of conventional milking units was carried out both at the Technion and Cornell. Exchange of researchers occurred between the two institutions. Mr. Richard Gates spent six months in Israel during 1981 and Dr. Ram Sagi spent the summers of 1981 and 1982 at Cornell. Dr. Scott visited Israel for a short period to review research accomplishments during April 1982.

The collaboration between the researchers on this project has been excellent and has also resulted in the development of two additional projects related to machine milking. These projects were not supported by BARD but augmented the BARD project. Based on the encouraging results obtained from research supported by BARD, the research group has submitted a new proposal to BARD to pursue new and promising areas developed under BARD Project No. US-157-79.

H. BENEFIT TO AGRICULTURE

Two of the sub-projects have resulted in findings which are particularly applicable to dairy farming. These findings and recommendations are:

- 1) Research from stimulation studies has confirmed previous suggestions that thorough manual stimulation of Holstein cows prior to milking may be of limited importance. Because manual manipulation of the udder and teats can be limited to a minimum required for adequate hygienic conditions, efficiency of the milking process is increased. A significant reduction in milking time results from reduced cow preparation time.
- 2) Evaluation and analysis of existing machine milking configurations have yielded a practical recommendation for optimal sizing of milking pipelines. Following the recommendation will reduce the investment expense in a pipeline system and improve the efficiency associated with sanitation of the pipeline and, in addition, improve milk quality by reducing the potential of "slugs".

The other findings, as delineated in the section on EVALUATION OF ACHIEVEMENTS, especially those related to liner design, are also likely to result in practical application. Further validation of suggested concepts is proposed.

I. LIST OF PUBLICATIONS RESULTING FROM THIS PROJECT

1. Refereed Publications

Gates, R.S., R. Sagi, and N. R. Scott. 1981. Theoretical considerations in sizing milk pipelines. Trans. of ASAE. 24(6):1600-1604.

Gates, R.S., R. Sagi, and R.W. Guest. 1982. Criteria for optimizing size and configuration of milk pipeline. J. of Dairy Sci. 65:410-418.

Zinn, S.A., R.C. Gorewit, and R. Sagi. 1982. Milking responses of cows given premilking stimulation at four lactational stages. J. of Dairy Sci. 65:668-671.

Sagi, R., R.S. Gates, and N.R. Scott. 1983. Milking characteristics of teatcups with reduced liner wall movement. J. of Dairy Sci. 66:266-274.

Gorewit, R.C., R. Sagi, E. A. Wachs, and W.G. Merrill. 1983. Current concepts on the role of oxytocin and milk ejection. J. of Dairy Sci. 66:2236-2250.

Magee, C., R. Sagi, N.R. Scott, and R.S. Gates. 1984. Bacterial transport within and among various teatcup assemblies during milking. J. of Dairy Sci. (Accepted for Publication)

2. Theses

Mahan, S. T. Measurement of the pressure gradient across the streak canal of a dairy cow's teat during machine milking. M.S. Thesis. Cornell University, Ithaca, New York. 112 pp. 1983.

Gates, R. S. Biomechanics of teat/liner interaction during machine milking: a finite deformation approach. Ph.D Thesis (Draft Manuscript), Cornell University, Ithaca, New York. 169 pp. 1984.

3. Papers Presented at Meetings and Symposia

Sagi, R., N.R. Scott, and R. P. Natzke. 1980. Vacuum pump capacity, pipeline size, and modified cluster design: influence on vacuum stability and cross-contamination. Proc. 11th International Congress on Diseases of Cattle. Tel Aviv, Israel. p. 200-211.

Gorewit, R.C. and R. Sagi. 1981. Exogenous oxytocin in milk ejection in cows. J. of Dairy Sci. 64 (Supplement #1): 68.

Zinn, S.A., R.C. Gorewit, and R. Sagi. 1981. Comparisons of milking responses between cow's milked with or without premilking stimulation at four lactational stages. J. of Dairy Sci. 64 (Supplement #1):167.

Sagi, R., R.S. Gates, and N.R. Scott. 1982. Milking characteristics of teatcups with reduced liner wall movement. J. of Dairy Sci. 65 (Supplement #1):174.

Scott, N.R., M.J. Delwiche, J.A. Balthazer, R.S. Gates, C. Magee, M. Doane, R.P. Natzke, R.C. Gorewit, W.G. Merrill, and R.W. Guest. 1980. Computer assisted management and recent advances in machine milking research. Nat'l. Milking Center Design Conference, Rochester, New York. November 18-20. p. 168-198.

Sagi, R., R.S. Gates, and N.R. Scott. 1983. Bacterial transfer during milking within and between modified teatcups. J. of Dairy Sci. 66 (Supplement #1):213.

J. PATENTS

(none)

REFERENCES

- Gates, R. S., R. Sagi, and N. R. Scott. 1981. Theoretical considerations in Sizing Milk Pipeline. Trans. ASAE 24(6):1600-1604.
- Gates, R. S., R. Sagi, and R. W. Guest. 1982. Criteria for optimizing size and configuration of milk pipelines. J. of Dairy Sci. 65:410-418.
- Mahan, S. T. 1984. Measurement of the pressure gradient across the streak canal of a dairy cow's teat during machine milking. M.S. Thesis. Cornell University, Ithaca, New York. 112 p. 1983.
- Sagi, R., R. C. Gorewit, and S. A. Zinn. 1980. Milk ejection in cows given mechanical stimulation during late lactation. J. of Dairy Sci. 63:1957-1960 -
- Sagi, R., R. S. Gates, and N. R. Scott. 1983. Milking characteristics of teat-cups with reduced liner wall movement. J. of Dairy Sci. 66:266-274.
- Zinn, S. A., R. C. Gorewit, and R. Sagi. 1982. Milking responses of cows given premilking stimulation at four lactational stages. J. of Dairy Sci. 65:668-671.
- O'Shea, J., E. O'Callaghan and W. J. Meaney. 1983. Milking performance and Liner design and slips. Proc. of 1983 Annual Meeting, Nat'l. Mastitis Council. p. 4.