EFFICIENCY OF MACHINE MILKING AS INFLUENCED BY THE RESPONSE OF INDIVIDUAL QUARTERS OF THE UDDER WHEN SUBJECTED TO PRESCRIBED VARIATIONS IN MILKING PRACTICES

by

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INTRODUCTION

Much attention has been paid in recent years to the practices and problems of machine milking. The problems encountered under machine milking may be grouped under three headings: (a) Speed of milking; (b) Completeness of milking; and (c) The effect of the operation of the machine on the health of the udder.

While the rate of milk flow from the udder as a whole has been studied, little attention has been paid to the rate of flow from the individual quarters of the udder. The possibility exists that individual characteristics of one or more quarters may have sufficient effect on the overall rate of milk flow to influence standard milk practices. It seemed to justify further study.

The problem of how completely a cow can be milked by machine is still controversial. Some investigators (36) maintain that the milk can be completely drained from the udder if the machine is properly used, while others maintain that some hand stripping should be practiced. Also, it is possible that milk left in the udder through the practice of no stripping might have an effect on the health of the udder. Since this is still a controversial question, additional experimental study of machine and hand stripping is appropriate.

REVIEW OF LITERATURE

It is now commonly accepted that the physiological phenomenon of milk let-down is associated with the action of a hormone or hormones from the posterior lobe of the pituitary gland (51, 8, 9).

While Ely and Petersen (8, 9) were the first to present conclusive evidence as to the nature of this phenomenon, it has been known for many years that pituitary hormones affect the discharge of milk from a mammary gland. In 1910, Ott and Scott (30) discovered that the intravenous injection of an extract of the posterior lobe of the pituitary into a lactating goat caused the contraction of the glands and the discharge of milk. Hammond (15), working with cows in 1913, found that when an extract of the posterior pituitary was injected intravenously after milking, 20 per cent more milk was obtained than normally. Maxwell and Rothera (23) reported in 1915 that pituitrin injections caused a gradual rise of milk pressure in the udder, and since this pressure held for some time they believed that it was more than just a spasmodic muscular contraction. In 1930, Turner and Slaughter (51) found that by injecting extracts of the posterior pituitary milk which was not otherwise available was obtained. They believed that pituitrin does not cause a secretion of milk but rather a discharge of the milk, and that injections of extracts of the posterior pituitary permitted the removal of milk which was not otherwise available.

The most comprehensive study which has been made pertaining to the phenomenon of milk let-down is that reported by Ely and Petersen (8, 9) in 1940, on the extent of the nervous mechanism in the control of milk ejection and secretion. They denervated one-half the udder of several dry cows, and after the cows freshened observations of milk yields per half udder were made. In every case the action of fright stopped milk "ejection" in both halves of the udder. This indicated that milk "ejection" is not under the direct control of the central nervous system. The milk left in the udder was subsequently removed by injections of pituitrin or pitocin which indicates that it is under the influence of hormones from the pituitary gland. Their explanation of the ejection process is that stimulus of the teats and udder by massage or action of the hands causes a sensory nerve action which upon reaching the brain transmits to the anterior pituitary a nerve impulse which causes a discharge of pituitrin into the blood stream. Upon reaching the udder it is believed that this pituitrin causes a contraction of muscle fibers around the alveoli and ducts which forces the milk into the larger collecting spaces and gland cisterns. This explanation of the milk let-down process has been adopted by many others (51, 34, 36, 44, 7, 14).

Swanson and Turner (50) examined a dissected udder and found that smooth muscle appearing cells form incomplete bands around the alveoli. Upon contraction these smooth muscles aid in the expulsion of the milk. This corroborates Petersen's (8, 9) theory

of the presence of smooth muscle in the udder.

Petersen (35) has recommended that massage of the teats and udder precede the milking act. He claims that this stimulation will increase the rate of flow and decrease the time required for the milking process. He recommends (36) that a warm water wash (110° F. or warmer) be used in massaging the teats and udder. Fountaine (16) and others (4, 40, 52, 41) agree with this method of stimulation, emphasizing the need for high temperature water.

The need for heat as a stimulus in milk production has been questioned by Dodd and Foot (7). They conducted a nine week experiment using both hot and cold water, alternating these treatments on the cows. While hot water had no pronounced effect, as compared with cold water, on either the yield or the quality of the milk, one cow had to be stripped by hand following the change back to the cold water treatments. Similar results with hot and cold water have been reported by Roark (41), while Hamb and associates (14) found no different results between hot and wet, or hot and dry stimulations.

The length of the stimulation period has received little experimental attention, but has generally been set at 10-30 seconds (4, 7, 18, 35, 44, 45, 56). Roark (41), however, points out that while the rate of milk flow is significantly faster following 60 seconds stimulation, rather than 10 seconds stimulation, it is doubtful if the saving in machine time justifies the lengthening of the stimulation period.

Another point of much practical interest in connection with

milk let-down is the length of time of effective hormonal action. Miller and Petersen (26) found a progressive decrease in amounts of milk and fat from successively milked quarters of the same udder. They reasoned that the difference in yield obtained was not due to lowered secretion of milk, but rather to a dissipation of the oxytocic principle in the blood. They confirmed their belief by recovering all of the milk, through injections of obstetric pituitrin into the blood stream, causing an immediate let-down of all the milk left in the udder. They obtained similar results by delaying milking until 20 minutes after stimulation of the cow. Petersen (34, 36) later found in short-time experiments that milking must be completed by seven to eight minutes after stimulation if complete removal of milk in the udder is to be obtained. Ward and Smith (55, 56) conducted delayed milking trials over a five-day period, milking at 4-8-12-16-20 minute intervals respectively. They milked one-half of the udder of each cow normally as a control, and the other half was milked experimentally at the delayed intervals. Milking was always started at exactly two minutes after stimulation in the control half of the udder. The udder halves were alternated during the trial. They found that cows milked after 12, 16, and 20 minute waiting periods showed considerably less production in the experimental udder halves as compared to the control udder halves. Hamb and associates (14) found in milking 15 minutes after stimulation that milk yield decreased and milking time increased. Roark (41) states that no waiting period between massage and the start of

milking was better than an eight minute wait. All of these trials have been conducted on a short time basis.

In direct contrast to these findings is the work reported by Knodt and associates (18). They divided their cows into groups, attaching the milking machines at 2-4-6-8 and 10 minutes after stimulation was started. No significant differences in yields over a 35 day period were found. In a later trial the cows were milked at 2-5-10 and 20 minute intervals, and again no significant differences were found. Work done by Beck (3) has indicated that on short time experiments there is a decrease in yield and an increase in milking time when milking is started eight minutes or more after stimulation is started. He further showed, however, that when cows milked in this manner were allowed a long enough period of time to adjust themselves to this practice differences in milk yields were insignificant, but that they continued to milk out at a slower rate. It is recommended by many that the milking machine be attached about one minute after proper stimulation (35, 12, 38, 44, 41, 39).

It is now generally agreed that fast milking is a desirable practice (32, 37, 7). Babcock (1) in 1889, reported that successively milked quarters of the same udder gave progressively less milk. Dahlberg (6) reports that the length of the milking period has a direct effect upon the persistency of milk production. He found that production started to decline earlier in the case of long time machine milking as compared to short time milking, and that there is a lower yield for the total lactation

under long milking time practices. Favorable results were obtained through the practice of regularly timed milking periods. Petersen (32) also showed that cows must be milked fast if high milk production is to be maintained.

Another advantage of fast milking is the danger of damaging udder tissue through leaving the milking machine on too long. Petersen (37) has demonstrated this possibility exists through an experiment conducted on an excised udder. This udder was hung in a normal position in the laboratory, and injections of either skim milk or saline solution were made to keep up the normal pressure. After the udder was filled the teat cups were attached, and their action both internally and externally was observed. He discovered that the teat cups began to crawl upward with each vacuum stroke. It was found that as the crawl became faster the decline of milk flow also became more pronounced. In nearly every case the milk flow stopped before the gland was emptied due to the closing of the gland sinus by the crawling teat cups. Most workers advocate that milking machines be removed as quickly as milk flow ceases, because of the danger of injury to the teat sinus which might lead to mastitis (12, 36, 37, 38, 44, 47, 7, 64, 65).

Because of the importance of fast milking the question arises as to the rate at which a cow can be expected to milk out under standard milking conditions. Matthews (21) pointed out that there are differences in time required to milk cows regardless of their yields. Foot (11) demonstrated that each cow has a

characteristic milk flow curve when milked with a mechanical milker. Petersen (36) believes that cows can be trained to milk fast. He found that when proper milking machine methods were employed many cows were milked in two minutes and that most are milked in 3½ minutes. Parkin (31) confirmed Petersen's report with over 900 cows milked at fast milking demonstrations in which most of these cows were milked in 3 to 3½ minutes.

Since there are differences between cows in their rate of milking there is also a possibility that differences exist between individual quarters of the same udder in milking response. Wide variations are known to occur between individual quarters as to milk yields (2, 10, 4, 19). As early as 1904, Beach and Clark (2) reported that under normal milking practices the average cow gave roughly 40 per cent of her milk from the fore quarters and 60 per cent from the rear quarters, with about 50 per cent of the total yield from the right and 50 per cent from the left halves of the udder. Since that time numerous workers have reported similar findings (10, 4, 19, 52, 22).

Although differences in yields of milk between quarters of the udder have been well established (52, 22) the milking rates of individual quarters have received comparatively little attention. Since there are differences between cows in their rate of milking, there is a possibility that differences may also exist between individual quarters in milking response. Matthews et al. (22) measured these individual rates using a specially designed quarter machine on 94 cows. Readings were taken at 2.5, 5.0, and

7.5 minutes showing the pounds of milk given during each interval, and the total amount given for the entire milking period. These readings included the 1.5 minute period during which the most milk was obtained.

A definite difference is shown between the milking rates of the high producing rear quarters and the lower producing front quarters. The milking rates obtained for both front quarters averaged 49.9, 81.1, and 92.8 per cent of their total yield for each succeeding 2.5 minute milking period, while the two rear quarters milked out at an average rate of 43.1, 76.2, and 91.2 per cent of their total yield. After 2.5 minutes of milking 48.9 per cent of the udders had differences of 20 per cent or more between the quarter with the highest percentage of its total yield obtained and the quarter in the same udder with the lowest percentage. After 5.0 minutes of milking only 35.1 per cent of the udders had differences of 20 per cent or more. The two front quarters had the highest milking rates during the first 2.5 minutes in 35.6 per cent of the udders. Despite these variations within the same udders, variations between cows generally were greater than variations between separate quarters of the same udder.

The 1.5 minute period during which peak flow was obtained came after an average of 1.64 minutes of milking for the front quarters and 1.87 minutes for the rear quarters had occurred. It was found that 6.9 per cent of all front and 18.1 per cent of all rear quarters had rates of 1.5 pounds per minute or above during

the 1.5 minute peak flow.

In addition to the speed of mechanical milking the problem of completeness of milking has received some experimental attention. Some investigators claim that complete removal of the milk from the udder can be accomplished with the milking machine provided proper machine stripping methods are practiced (61, 12, 36, 41, 64). Petersen (36) definitely recommends machine stripping only and states that he has yet to see a cow which cannot be completely milked out by machine. He emphasizes the necessity of machine stripping by pointing out that when the pressure in the udder begins to decline, due to decreased milk flow, the teat cups begin to crawl up on the udder shutting off the teat sinus. The vacuum then extends into the teat with possible injurious action resulting. This is the time to start machine stripping by pulling down on the teat cups, thus leaving the teat canals open for the flow of milk from the milk glands. The machine should then be removed as quickly as milk flow stops. Hand stripping can be replaced almost entirely by machine stripping according to many investigators (60, 36, 26, 34, 35, 12, 62, 63, 44, 47, 48, 65).

Despite the opinion that hand stripping can be replaced by machine stripping there is still some evidence to the contrary. It is commonly known that the last drawn milk is higher in percentage of butterfat than that drawn during the early or middle part of the milking period (39, 43). There is still some question, however, as to whether the increased butterfat obtained in hand stripping warrants the necessary effort involved in obtaining it.

Wilson and Cannon (60) found that hand stripping after machine milking generally resulted in an average increased production of 0.03 pounds of butterfat per cow per day. When this butterfat was left in the udder it was found the 73 per cent of it was obtained in subsequent milkings. Woodward et al. (61) reported generally similar results, emphasizing that while some butterfat was left in the udder, too much time should not be spent in obtaining it.

The effect of complete milking on the yield of milk and persistency of production has been shown by Wilson and Cannon (60). They found that hand stripping after machine milking resulted in increased production of about 0.8 pounds of milk per cow per day. When this milk was left in the udder it was found that 46 per cent of it was obtained at the next milking. Petersen (36) and others (57, 60, 17, 33) emphasize that all milk must be removed from the udder at each milking. Since the udder will hold only so much milk, any milk left in the udder will replace some that might have otherwise been secreted and consequently will cause a decrease in milk flow.

Stocking (49) found an increase in the bacterial count of the milk when strippings were left in the udder at the previous milking. However, he observed no adverse effects from this action. Wayne and Macey (58) report a slightly higher bacterial count during the experimental period, but no detrimental effects were observed then or during subsequent lactations. The importance of increased bacterial counts through incomplete milking has been

discounted by several workers (54, 58, 61, 43).

There is some evidence that incomplete milking may cause damage to the udder. As long ago as 1898, Nelson (29) reported that incomplete withdrawal of milk from the udder had been suspected of contributing to the causes of mastitis. Munchen et al. (27) found that failure to hand strip 50 cows artificially infected with streptococci mastitis caused intense clinical symptoms of mastitis. However, those infected cows which were hand stripped soon returned to normal.

Schalm and Mead (43) report that leaving approximately two pounds of milk in the udder at each milking resulted in acute mastitis in two mastitis infected quarters and generally abnormal milk in the other infected quarters. The non-infected quarters, however, remained in a normal condition. Other workers (48, 24, 43) report detrimental effects from non-hand stripping only where the udder was in an unhealthy condition.

While the importance of complete milking has been universally recognized, the value of hand stripping as part of this operation has frequently been discounted. Woodward et al. (61) report that while slightly higher butterfat and milk yields may be obtained by hand stripping the labor involved does not warrant this operation. Petersen (38), in recommending only machine milking, reports that hand stripping introduces bacteria into the milk. Wilson and Cannon (60) found that cows being hand stripped do not tend to save milk for the stripper.

As things now stand, the danger of udder damage in leaving

the milking machine on individual quarters too long has not been too well answered. The question of stripping after machine milking is still a controversial subject. Some workers maintain that hand stripping is necessary to obtain maximum milk and butterfat yields, as well as to insure udder health (39, 43). Others insist that cows can be trained to milk out completely through proper machine milking and machine stripping practices (33, 12).

Much experimental attention is still needed to study the variations in rate of flow and total yield between individual quarters of the same udder. More work is also needed in the study of machine vs. hand stripping, both as to yield and udder health.

DEVELOPMENT OF TECHNIQUE TO MEASURE THE VARIATIONS IN THE RATE OF MILK FLOW BETWEEN QUARTERS OF THE UDDER

In order to make a study of the variations between quarters of the same udder, a specially designed quarter milking machine was necessary.

The machine adapted for this purpose consisted of a specially designed split-claw teat cup assembly (see Plate II) furnished by the De Laval Company. Separate hoses connect each teat cup with individual glass jars mounted in a wire basket (see Plate I). The pail was replaced by the inverted lid from a five gallon ice cream container which formed a vacuum seal for the head of the machine (see Plate I). The jars used were one gallon commercial glass skim milk jars (see Plate III). They were fitted with

EXPLANATION OF PLATE I

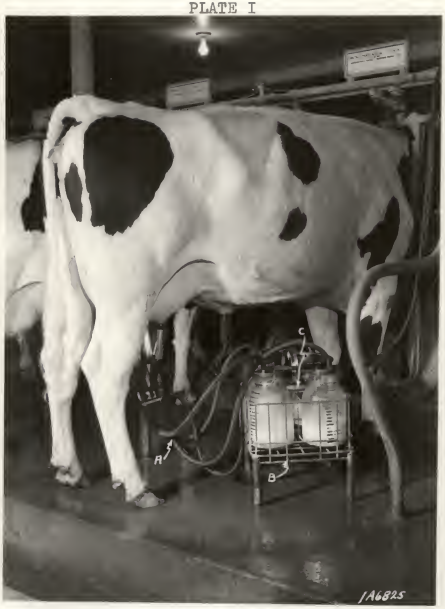
Photograph of apparatus adapted to measure the rate of milk flow from the individual quarters of the same udder.

A - Milk hoses connecting split-claw teat cup assembly with individual glass jars.

B - Wire basket which holds the glass jars and head of the machine.

C - Inverted lid from a five gallon ice cream container which forms a seal with the head of the machine.

PLATE I



EXPLANATION OF PLATE II

Photograph of the split-claw teat cup assembly used to milk each quarter separately.

A - Connection of teat cup with milk hose leading to glass container.

B - Air hose leading from machine head to pulsator.

PLATE II

EXPLANATION OF PLATE III

Photograph of the one-gallon glass jars which receive the milk from the individual quarters of the udder.

A - Connection for air hose between jars.

B - Connection for milk hose.

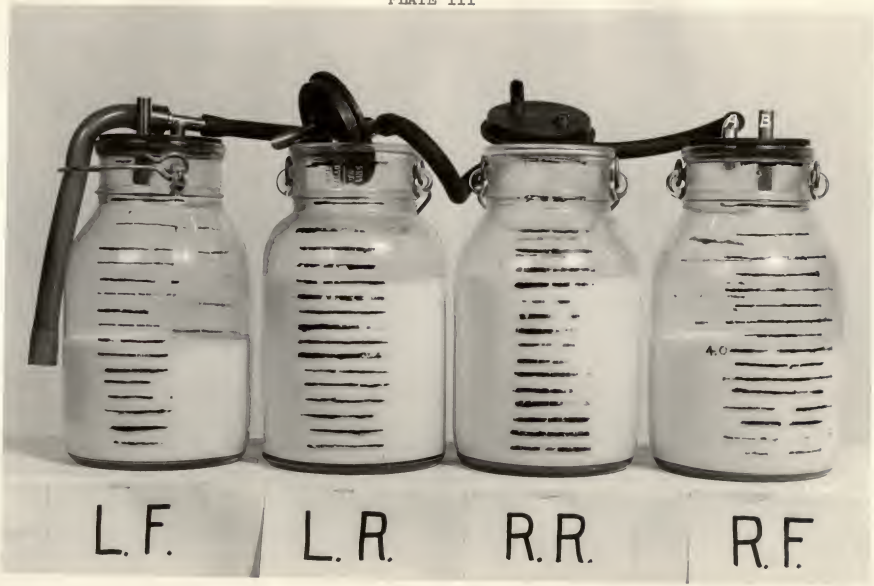
R.F. = Right front quarter of the udder.

R.R. = Right rear quarter of the udder.

L.R. = Left rear quarter of the udder.

L.F. = Left front quarter of the udder.

PLATE III



special hard rubber stoppers equipped with metal tubular outlets for milk and air hoses (see Plate III). The air hoses connect each jar to insure equal pressure in all four quarters of the udder. The jars were marked in 0.5 pound graduations with indelible ink (see Plate III), and were placed in the basket in such a manner as to be easily removed for emptying. The entire machine was assembled so that it could occupy a normal position at the side of the cow (see Plate I).

EXPERIMENTAL PROCEDURES

Response Of Individual Quarters Of The Udder To Machine Milking

Standard milking practices were followed throughout the milking trials. Cows were given a 15 to 20 second massage with a heavy cloth wrung out of chlorine water. No emphasis was placed on the temperature of the water. This was followed immediately by stripping two to three full hand squeezes of milk from each quarter into a strip cup. One minute elapsed between stimulation and application of the machine. Each cow was milked from the right side with the special quarter machine placed in as nearly a normal position as possible. Later, however, it was deemed advisable to milk a group of cows from the left side to determine if the response was different from that side.

Machine stripping was started as quickly as milk flow was sharply decreased. It was accomplished by merely pulling down on

the teat cup assembly. The weights of hand strippings were recorded separately for each quarter.

To determine the repeatability of measurements from day to day a group of 10 cows was selected and milked for 10 consecutive evening milkings. This group included 2 Guernseys, 4 Jerseys, 1 Ayrshire, and 3 Holstein cows. An analysis of the data revealed that a minimum of six milkings were necessary to show a reliable picture of each animal's response to the milking act.

A total of 71 cows numbering 25 Jerseys, 16 Ayrshires, 15 Holsteins and 15 Guernseys were then milked a minimum of six times. Only evening milkings were made and most of the cows were milked during six consecutive evening milkings. The cumulative yield of milk for each quarter was marked on each jar at 30 second intervals throughout the milking act. Machine stripping was limited to no more than 60 seconds. From these facts it was possible to obtain and record the following data as:

1. Cumulative yield per quarter at 30 second intervals.
2. Total milking time per quarter.
3. Total machine stripping time per quarter.
4. The amount of machine strippings per quarter.
5. The amount of hand strippings per quarter.
6. Milk obtained per quarter at any given 30 second period.

Machine And Hand Stripping Versus No Stripping In Opposite Halves Of The Same Udders

The purpose of this study is to compare the effect of no machine or hand stripping on one half of the udder, with normal machine milking and stripping on the other half of the same udder.

A group of 18 cows, including 7 Jerseys, 2 Holsteins, 5 Ayrshires and 4 Guernseys was used. These cows represented different ages and varied in stages of lactation. One Holstein and one Jersey were removed from the experiment before its completion, because of attacks of mastitis. Although both animals previously had shown the presence of long chain streptococci, only in the Jersey was there any evidence of streptococci organisms in the milk at the start of the trial. Each cow was milked according to the standard milking methods previously described.

The cows in this trial were divided into two groups of nine each. One group was milked normally on the left side of the udder, but was neither machine nor hand stripped on the right half. In the other group the cows were milked in the usual manner on the right half of the udder, while the left half was used for the outlined variation of milking procedure. Both halves of the udder were milked in a normal manner until machine stripping was started. At this point machine stripping of the control half was accomplished by pulling down on the individual teat cups. Due to the split-claw arrangement this had no effect whatsoever on the experimental half of the udder. The control half was then hand stripped with no stripping on the experimental half.

Individual milk weights for each quarter were kept throughout the 20 day experimental period. Three-day composite milk samples from each quarter were obtained during the first three and last three days of the experiment. These samples were tested for butterfat. Careful observations were made at each milking to

determine any evidence of milk or udder abnormalities.

These data on butterfat percentage, pounds of butterfat, and milk yields were analyzed carefully for each half of the udder. They were then compared to determine any significant differences between control and experimental halves of the udder.

Machine Stripping Plus Hand Stripping Versus Machine Stripping Only In Opposite Halves Of The Same Udders

This trial was conducted over a 30-day period using a group of 39 cows in the college herd. These animals were selected from three sections of the college barn and included 13 Jerseys, 7 Guernseys, 10 Holsteins, and 9 Ayrshires. They were then divided as evenly as possible into two groups. Standard milking practices, as previously described, were followed. Each animal was milked normally and completely, including hand stripping, in one half of the udder; while the other half of the udder was not hand stripped. In one group the right half of the udder was milked as the experimental half, while in the other group the left half was milked experimentally.

Composite milk samples from each quarter and the milk weights for each quarter were taken during the first six and last six milkings of the experiment. These milk samples were tested for butterfat, and a statistical analysis was made similar to that used in the machine stripping study.

EXPERIMENTAL RESULTS

Response Of Individual Quarters Of The Udder To Machine Milking

The average milk yields of individual quarters of the udder obtained from 464 milkings of 78 cows milked from the right side are presented in Table 1. Results show that an average of about 41 per cent of the total milk yield was obtained from the front quarters and about 59 percent from the rear quarter, or approximately a 40:60 ratio, which is in agreement with other investigations, as reviewed by Matthews (22). When this difference in yield was tested statistically by a T-test it was shown to be highly significant.

In grouping the quarter yields by udder halves it was found that the left half of the udder gave an average of slightly over one per cent more milk than the right half. This difference as tested by the T-test was found to be non-significant. In comparing yields between individual quarters of the udder, the front quarters averaged approximately the same, while the left rear gave an average of nearly three per cent more milk than the right rear quarter.

Interpretation of the rate of flow measurements from individual quarters was difficult since rate of flow in terms of pounds per minute is influenced by the yield of the cow. It has been found, however, that the per cent of total yield obtained during the first two minutes of milking is highly correlated with the

rate of milk flow from the udder (13). Therefore, the percentage yield from each quarter during the first two minutes of milking was used as a measurement of machine milking time. The results of such an analysis are shown in Table 1.

Despite the fact that the rear quarters yielded 41 per cent more milk than the front quarters the time required for machine milking was similar between the front and rear quarters. On the average, the front quarters were only 4.3 per cent more completely milked out after two minutes of milking than were the rear quarters; while this difference is statistically significant it does not appear to be important. This difference is shown in Table 1.

Greater differences were observed in the rate of milking out between the right and left halves of the udder. About 70 per cent of the total yield was obtained from the right half of the udder during the first two minutes of milking, while 78 per cent was obtained from the left half during the same period, as shown in Table 1. This difference was highly significant according to the T-test. Greater differences were observed in the rate of milking out between the front quarters of the udder than between the rear quarters.

At the time machine stripping was started the left half of the udder was, on the average, 78 per cent milked, whereas the right half was only 67 per cent milked out. At the same time the front quarters were about 73 per cent milked out, and the rear quarters were about 71 per cent milked out.

The average yields, per milking, of machine and hand

Table 1. The response of individual quarters of the udder to machine milking as measured by rate of flow, machine stripping, hand stripping and total milk yields of 464 milkings from 78 cows.

	Average yields per milking			
	Percentage of total yield obtained in two minutes	Machine stripping	Hand stripping	Total milk
	(Percent)	(Pounds)	(Pounds)	(Pounds)
Comparison between right and left halves of the udder				
Right halves	70.3*	1.8	0.4	6.7
Left halves	78.0	1.2	0.3	6.8
Difference	7.7	0.6	0.1	0.1
Comparison between front and rear halves of the udder				
Front halves	75.4*	1.2	0.3	5.6
Rear halves	72.3	1.8	0.5	7.9
Difference	3.1	0.6	0.2	2.3
Variations between quarters				
Right front quarter	70.1	0.8	0.1	2.8
Right rear quarter	70.4	1.0	0.2	3.8
Left rear quarter	75.4	0.8	0.2	3.9
Left front quarter	80.7	0.4	0.1	2.8

* Significant at the 1 percent level

strippings, per quarter and per udder halves, are shown in Table 1. From a percentage standpoint an average of approximately 50 per cent more machine strippings were obtained from the rear quarters than from the front, also an average of 50 per cent more machine stripping was obtained from the right halves than from the left halves of the udders. Similarly, an average of approximately 66 per cent more hand strippings after machine stripping were obtained from the rear quarters of the udders than from the front. Also, an average of 33 per cent more hand strippings were obtained from the right than from the left halves of the udders.

Although the difference in yields between the right and left halves was non-significant, there was a faster rate of flow and less strippings, on the average, from the left halves of the udders than from the right halves.

Since all of the above results were obtained by milking in a normal position on the right side of the cows, it was deemed advisable to milk some cows from the left side to determine whether the position of the machine had any effect on the milking response of either half of the udders. Results obtained in milking 63 cows from the left side indicate that the position of the machine does have some influence in milking response. Here, it was found that an average of approximately 56 per cent of the total milk yield was obtained from the rear quarters and an average of about 44 per cent from the front quarters. There was, however, no significant difference in the total yield between the right and left halves of the udders.

In comparing machine stripping yields the rear quarters were found to give an average of approximately 23 per cent more machine strippings than the front quarters, which is considerably less than that found when the cows were milked from the right side. Also, an average of approximately 15 per cent more machine strippings were obtained from the left halves of the udders than from the right halves. An average of approximately 80 per cent more hand strippings were obtained from the rear quarters than from the front quarters, while the left half of the udder yielded an average of 14 per cent more hand strippings than did the right half.

Machine Stripping Plus Hand Stripping Versus No Stripping In Opposite Halves Of The Same Udders

During a 24-day experimental period involving 16 cows, there was found to be a cumulative average increase in the difference between the daily milk and butterfat yields of the halves of the udders which were machine milked and hand stripped, and the halves that were machine milked but neither machine nor hand stripped. This difference in increased milk yield is shown in Figure 1. Comparisons showing the differences in milk and butterfat yields obtained when half the udders were completely stripped as compared with the halves which were not stripped are shown in Table 2. During the preliminary 3-day period of the experiment it was found that an average of approximately 6 per cent more milk and 11 per cent more butterfat were obtained from the half which

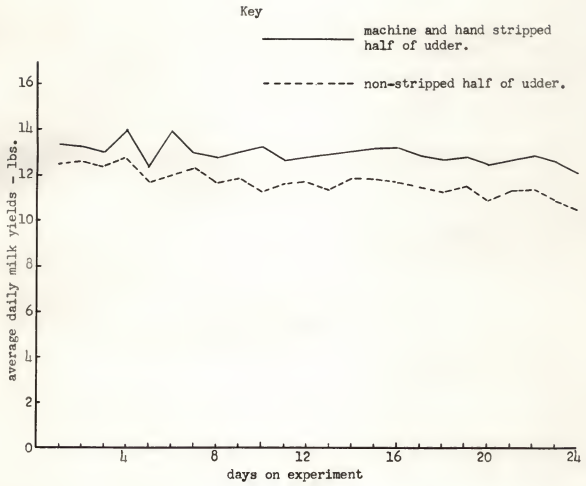


Figure 1. Comparative yields between stripped and non-stripped halves of the udder of 16 cows.

Table 2. Average yields in opposite halves of the udder when one half was machine and hand stripped and the other half was not stripped.

	Yields: First three days and final three days of a 24 day period.					
	Average daily milk yields		Average daily butterfat yields		Average daily butterfat test	
	First 3 days	Last 3 days	First 3 days	Last 3 days	First 3 days	Last 3 days
	(Pounds)		(Pounds)		(Percent)	
Group I 9 cows						
Right half stripped	14.3	13.5	0.64	0.61	4.1	4.5
Left half not stripped	13.5	12.1	0.51	0.55	3.8	4.5
Difference	0.8	1.4	0.13	0.06	0.3	0.0
Group II 7 cows						
Left half stripped	11.8	11.4	0.63	0.64	5.3	5.6
Right half not stripped	11.1	9.1	0.53	0.51	4.8	5.6
Difference	0.7	2.3	0.10	0.13	0.7	0.0
Group I and II combined 16 cows						
Udder half stripped	13.3	12.6	0.63	0.62	4.8	5.0
Udder half not stripped	12.5	11.0	0.57	0.53	4.6	4.8
Difference	0.8*	1.6*	0.06*	0.09*	0.2	0.2

*Significant at the 1 percent level with 15 degrees of freedom.

was completely stripped than from the half which was not stripped. During the final 3-day period of the experiment, however, the difference had increased until approximately 14 per cent more milk and 17 per cent more butterfat was obtained from the completely stripped halves of the udders, as compared with the non-stripped halves. This marked increase in difference occurred during the 18-day interval between the preliminary and final periods of the experiment. Statistical analysis of each days average milk yield differences between the completely stripped and non-stripped halves of the udder, by a T-test, were found to be highly significant. Significant T values were also obtained on the differences in butterfat yields between opposite udder halves during both the preliminary and final periods. They were not so decisive, however, as were those for milk yield differences.

Differences in butterfat tests between completely stripped and non-stripped halves of the udder are shown in Table 2. While there was a difference in butterfat tests favoring stripping during both the preliminary and final periods, the differences during the final period were not as decisive.

At the beginning of the experiment there were seven quarters from the cow's udders showing bacteriological symptoms of mastitis as indicated by the presence of long chain streptococci in three quarters and a high leucocyte count of 500 thousand or more in four quarters. One quarter exhibited both long chain streptococci and a high leucocyte count. Two infected quarters were from the completely stripped half of the udder and five were from

the non-stripped half. During the course of the experiment two cows were removed from the trial because of attacks of acute mastitis in the non-stripped quarters of the udder. One of these cows showed bacteriological symptoms of mastitis in both non-stripped quarters at the start of the experiment. Two more cows developed bacteriological symptoms of mastitis in one of their quarters from the non-stripped half of the udder during the experiment. Routine penicillin treatments were given all infected quarters, and at the completion of the experiment five quarters from the non-stripped udder halves and two quarters from the completely stripped halves still exhibited bacteriological symptoms of mastitis. Although some of the udders showed a definite heaviness in the non-stripped half during the early part of the experiment, no apparent physical change in the udders was noted among any of the cows at the end of the experimental period.

Machine Stripping Plus Hand Stripping Versus Machine Stripping Only In Opposite Halves Of The Same Udders

During a 36-day experimental period involving 39 cows a cumulative increase was found in the amount of milk obtained from the stripped half as compared with the non-stripped half of the same udders. Comparisons are shown in Table 3 and Figure 2 between the average milk and butterfat yields obtained from opposite halves of the udders at the beginning and at the end of the trial. During the preliminary 3 day period of the experiment an average of approximately six per cent more milk and eight per cent more

Table 3. Average yields in opposite halves of the udder when one half was hand stripped and the other was not hand stripped.

Number of cows in group	Yields: First three days and final three days of a 36 day period					
	Average daily milk yields		Average daily butterfat yields		Average daily butterfat test	
	First 3 days	Last 3 days	First 3 days	Last 3 days	First 3 days	Last 3 days
	(Pounds)		(Pounds)		(Percent)	
Group I 18 cows						
Right half hand stripped	14.5	12.7	0.70	0.64	4.8	5.1
Left half not hand stripped	13.4	11.3	0.64	0.57	4.7	5.1
Difference	1.1	1.4	0.06	0.07	0.1	0.0
Group II 21 cows						
Left half hand stripped	14.7	13.1	0.64	0.59	4.3	4.5
Right half not hand stripped	14.1	11.7	0.60	0.51	4.0	4.3
Difference	0.6	1.4	0.04	0.08	0.3	0.1
Group I and II combined 39 cows						
Udder half hand stripped	14.6	12.9	0.67	0.61	4.6	4.7
Udder half not hand stripped	13.8	11.5	0.62	0.54	4.5	4.7
Difference	0.8*	1.4*	0.05*	0.07*	0.1	0.0

*Significant difference at the 1 percent level with 38 degrees of freedom.

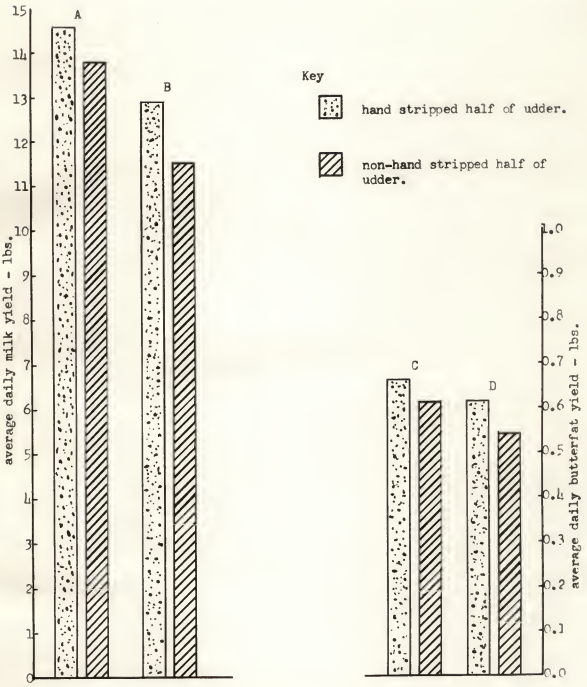


Figure 2. Comparative yields between the hand stripped and the non-hand stripped udder halves of 39 cows.

A. Milk yield - first 3 days of a 36 day period.
B. Milk yield - last 3 days of a 36 day period.
C. Butterfat yield - first 3 days of a 36 day period.
D. Butterfat yield - last 3 days of a 36 day period.

butterfat were obtained from the halves of the udders which were hand stripped than from the halves which were not stripped. During the final three day period of the experiment the average increase was approximately 12 per cent more milk and 13 per cent more butterfat from the hand stripped halves. The cumulative effect during the 24 days of the experiment is indicated by the difference between the first three days and the last three days. These differences in yields between udder halves were tested for significance by statistical analysis (46). A significant difference was found in both the average milk and average butterfat yields during both the preliminary and final three day periods, the significance being more decisive in the case of butterfat differences during the preliminary period, and conversely, more decisive in the case of the milk yield differences during the final period. In the case of both milk and butterfat production a more decisive T was obtained during the final three-day period than during the preliminary three-day period.

Average differences in butterfat tests between hand stripped and non-stripped halves of the udders are shown in Table 3. During both the preliminary and final three-day periods of the experiment there was a difference in favor of hand stripping. There was also an average increase in butterfat test from both halves of the udder during the course of the experimental period. The differences between the butterfat tests from the hand stripped halves compared with those from the non-stripped halves were less during the final three-day period than during the preliminary

three-day period.

At the beginning of this experiment there were 10 quarters from the cows udders showing bacteriological symptoms of mastitis as indicated by the presence of long chain streptococci in three of the quarters and a high leucocyte count of 500 thousand or more in four of the quarters. Three quarters exhibited both long chain streptococci and high leucocyte count. Three infected quarters were found in the hand-stripped udder halves and seven were in the non-stripped halves. During the course of the experiment five new quarters from the stripped udder halves and 12 from the non-stripped halves developed bacteriological symptoms of mastitis. Routine penicillin treatments were given, and at the completion of the experiment 13 quarters still exhibited bacteriological symptoms of mastitis. There were no cases of acute mastitis, as evidenced by abnormal milk or swollen and inflamed udders, observed during the course of the experiment.

DISCUSSION

In this investigation it was found that the front quarters averaged 41 per cent of the total milk produced and the rear quarters 59 per cent. These results are in close agreement with reports of other investigators (2, 22, 10, 4, 19, 52) in which the front quarters were reported to give approximately 40 per cent and the rear quarters 60 per cent. This would indicate that either the front quarters would milk slower or would be emptied

earlier during the milking process than the rear quarters. During the first two minutes of milking, an average of 4.2 pounds of milk were obtained from the front quarters, and 5.7 pounds were obtained from the rear quarters. In other words, 36 per cent more milk was obtained from the rear quarters than from the front quarters during the two-minute period, indicating more rapid flow from the rear quarters. However, the front quarters were 75 per cent emptied in the first two minutes while the rear quarters were 72 per cent emptied. Thus, the more rapid flow from the rear quarters tended to compensate for the greater quantity to be extracted. It does not appear that the end point in milking before stripping is indicated would result in much unnecessary pumping on the evacuated front quarters while the rear quarters were still being milked. Although this was not fully established as fact, it is of interest in considering the future design of milking machines.

When the cows were milked with the receiving pail placed on the right side of the cow, there was practically no difference in the total pounds of milk obtained from the two halves of the udders. In studying the rate of flow, however, it was found that 70 per cent of the milk was obtained in the first two minutes from the right halves, on the average, whereas 78 per cent was obtained from the left halves during the same time. In other words, 11 per cent more of the milk was obtained in the first two minutes from the left halves than from the right, or stated in another way, 37 per cent more of the milk remained in the right

halves after two minutes of milking than in the left halves. This influence of the position of the receiving vessel was checked by switching the receiving vessel to the left side of the cow, where reverse results were obtained, but a sufficient number of trials were not conducted to justify presenting the data. These findings indicate that the position of the receiving vessel, being further removed from the half of the udder from the opposite side of the cow, results in sufficient difference in mechanical pull on the off side to cause more rapid and complete emptying of that side of the udder. Whether or not this is of importance in considering the future design of milking machines would need to be studied over a large number of cows for a long period of time. It is conceivable that repeated milking on the same side might cause the udder to become unbalanced. These facts do indicate the desirability of considering randomizing the milking of cows from a standpoint of the position of the receiving vessel.

A number of investigators have reported that hand stripping is unnecessary. In these investigations it was found that after the cows were machine stripped all of the milk had been obtained except 5 per cent, on the average. On a cow producing 30 pounds per day this would mean that only 1.5 pounds of milk would be left in the udder if hand stripping was not practiced. The depressing effect on milk flow and the hazard to the udder would both seem doubtful. Likewise it would seem questionable from an economic standpoint whether that amount of milk would pay for hand stripping. The data were not analyzed, however, to determine the

variation between high and low producers in the amount left in the udder. This could have a bearing on the conclusions.

In these trials 27 per cent of the milk was still left in the udder before any stripping started indicating without question the need for stripping. However, machine stripping resulted in about 22 per cent, or more than one-fifth, of the total milk.

Trials were conducted in connection with this investigation to answer these two primary questions with respect to strippings, both hand alone, and machine and hand combined: first, does the leaving of the strippings in the udder have a depressing effect on milk yield and any physiological disturbance in the udder, and second, whether the amount of milk and butterfat obtained was sufficient to pay for the labor of stripping? A temporary drop in milk yield through failure to completely milk out the udder is of little consequence. However, if there is evidence of a cumulative decrease, as was shown in this experiment, machine milking, plus machine and hand stripping, may be necessary. Also, since leaving machine and hand strippings in the udder apparently caused acute cases of mastitis in two udders during the experiment, continuation of this practice might not only result in a large number of abnormal quarters, and perhaps even an unusual number of replacements for the milking herd, but also a considerable loss in income.

When cows were machine milked and machine stripped, but not hand stripped, however, there seemed to be no injury or damage to

the health of the udder. The loss of milk and butterfat by not hand stripping, while statistically significant according to the T-test, is not enough to cause any appreciable decrease in the production of the individual cow. In a large herd, however, the increased production from hand stripping might be enough to more than compensate for the cost of the labor involved. If so, it would seem advisable to hand strip. Otherwise, it would seem that proper machine milking and machine stripping is sufficient for the average dairyman.

SUMMARY

The cows used in this experiment were milked from the right side with a specially designed individual quarter milker, enabling the rate of milk flow, total machine strippings, and total milk yield per quarter to be obtained.

1. An average of approximately 41 per cent of the total milk yield was obtained from the front quarters and an average of 59 per cent from the rear quarters of the udder.

2. The left half of the udder gave slightly over one per cent more milk than did the right half. The difference was non-significant according to the T-test.

3. The front quarters of the udders were, on the average, approximately 75 per cent milked out while the rear quarters were 72 per cent milked out after two minutes of milking. The right halves of the udders averaged about 70 per cent milked out after

two minutes of milking while the left halves were 78 per cent milked out, when milked from the right side.

4. At the time machine stripping was started the front quarters averaged about 73 per cent milked out and the rear quarters averaged about 71 per cent milked out. By udder halves the left halves averaged about 78 per cent milked out while the right halves were only 67 per cent milked out.

5. An average of approximately 50 per cent more machine strippings were obtained from the rear quarters than from the front quarters of the udder, while an average of 50 per cent more machine strippings were obtained from the right half than from the left half.

6. An average of about 66 per cent more hand strippings were obtained from the rear quarters of the udder than from the front. Also an average of 33 per cent more hand strippings were obtained from the right side than from the left half.

7. When milked from the left side the rate of flow was faster and there were less machine and hand strippings from the right side of the udder than from the left side.

8. When a group of cows were machine and hand stripped after machine milking in one half of the udder, and not stripped in the other half, there was found to be a cumulative average increase in the differences in daily milk and butterfat yields between the udder halves.

9. During the preliminary 3-day period of a 24 day trial, it was found that an average of approximately six per cent more

milk and eleven per cent more butterfat were obtained from the half of the udder which was machine and hand stripped than from the non-stripped half. During the final 3-day period of the experiment approximately 14 per cent more milk and 17 per cent more butterfat were obtained from the completely stripped halves than from the non-stripped halves.

10. Two cows developed acute cases of mastitis in the quarters not completely stripped.

11. An average of approximately six per cent more milk and eight per cent more butterfat were obtained from the halves of udders hand stripped after machine milking than from the halves not hand stripped, during the preliminary 3-day period of a 36 day trial. During the final 3-day period an average of 12 per cent more milk and 13 per cent more butterfat was obtained from the stripped halves than from the non-stripped halves.

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