

2x Compared to 3x Milking Frequency in a California Dairy Herd

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## Abstract

Increased milking frequency has been a method used by dairymen for decades in an attempt to increase production. When considering a switch to more frequent daily milking other areas should be also considered such as milk quality, reproduction and herd health. Through this study I looked at the differences between animals being milked 2x daily and 3x daily and how their levels of production and health were differentiated throughout an entire lactation. This was done to better understand the consequences likely to materialize when a herd is switched from a conventional 2x milking protocol to a 3x daily milking procedure. These findings will be valuable to any dairy producer contemplating such a switch in order to improve their efficiency and profitability. The literature obtained for this review did help to pull together valuable statistics to any producer worried about losses in production, reproduction or herd health. These studies looked at all different stages of lactation and how these differences in milking frequencies materialize from week 1 to week 14 of a cow's lactation. A local dairy herd of 1100 Holsteins which transitioned their herd from 2x to 3x was also evaluated to determine significant changes in all important areas mentioned above. It was concluded that obvious improvement in fluid production and milk quality materialized after the switch to 3x milking. Differences in reproduction and milk components were found insignificant in all literature reviewed and in the local dairy herd. The producer should evaluate their own economics and facilities when contemplating such a switch but the switch can be easily justified for production improvements in a herd of lactating dairy cattle.

## Introduction

The effects of milking frequencies on herd production and health are factors a commercial dairy producer would ultimately take into consideration when deciding on their own management plan. This study in particular will look at the differences in production and health of lactating animals being milked 2x daily vs. 3x daily. The main purpose is to identify any important economic benefits which may materialize if a producer did decide to switch from 2x to 3x. In order to better understand what economic benefits or problems may occur it will be important to analyze each aspect of the dairy operation that impacts efficiency and the monthly milk check. To achieve this goal, past studies will be dissected to determine how fluid milk production, components of milk, reproduction and milk quality will most likely be affected when switching from a milking frequency of 2x daily to 3x daily for all stages of lactation. In addition to this a commercial dairy herd located in Tulare California milking approximately 2,000 cows which in recent years made the switch from 2x to 3x will be studied and evaluated through records and managerial experiences. This will provide the study with a contemporary California dairy that should better justify the findings in the literature review process. The objective is to determine if switching to milking 3x a day is economically responsible and justifiable for a commercial dairy operation in California.

## **Materials and methods**

Data was collected from a California dairy farm using monthly test data and oral references from management as the main source of information. The dairy had switched from 2x a day milking to 3x a day milking about 12 months prior to the start of my project and allowed me to access their records to help improve my milking frequency results. Dairy Comp was used for graphs, plots and list which were included within the literature review and results sections of the study. Literature from the Journal of Dairy Science was extensively used in order to develop a well rounded and informative literature review. The articles spanned from the years 1979 to around 2010 all dealing with the relationship between milking frequency and production, reproduction and nutrition.

## Literature Review

### *Fluid Milk Production*

Dairy producers are now more than ever looking for ways to improve their herd's efficiency in regards to milk production, animal reproduction and nutrition (DMI). I looked at this as an opportunity to review a number of scientific research articles and determine if findings over the past 30 years justify an average California dairy producer's decision to switch from 2x daily milking to 3x daily milking. Overwhelmingly, a majority of the studies concluded that switching to more frequent milking directly resulted in an increased level of fluid milk production.

A study conducted by Campos and coworkers reviewed DHI records of 4293 Holsteins from 14 different herds spanning over the years 1984 through 1992 found that 3x daily milking for a 305 day (d) period resulted in increased of 17.3%, 12.3% and 8.8.% on milk, fat and protein respectively (Campos, Wilcox etc.). Other studies conducted on milking frequencies and production levels have found substantial differences between primiparous and multiparous animals. Allen et al. used 14 groups of high yielding cows during their first four lactations and found that cows milked 3x daily vs. 2x daily yielded an increase of 19, 13, 11 and 13% respectively in their first four lactations (Allen et al.). This is one study that suggests the use of 3x daily milking may have a more significant economic impact on first lactation animals than it does on animals in their second, third or fourth lactations. Dairy producers looking to gradually transition their herd to 3x daily milking would be more comfortable doing so knowing their first lactation animals have the potential of producing 25.2% more milk than an animal only milked 2x daily. The same study found that reproduction efficiency was not negatively affected by the

increase in milking frequency but this can be further analyzed in other studies with a greater emphasis on the relationship between milking frequency and reproduction. (Allen et al.)

One question which may arise in a producers mind when thinking of the switch to 3x daily milking is its effect on lactation persistency for all lactation groups because it is the persistency of a cow that will increase yields and average production levels of a dairy farm. Studies have found that there is a persistence response which is triggered by early lactation increased milking frequency that can improve an animal's levels over a whole lactation period (Dahl et al.). There have been a number of researchers who have hypothesized that this increase in production may be a result of increased levels of prolactin (PRL) which increases the number of fully differentiated mammary cells, resulting in higher production levels. When milking frequency is increased the number of PRL releasing events will inevitably increase in the animal's mammary system resulting in increased milk yields over the course of an entire

lactation.

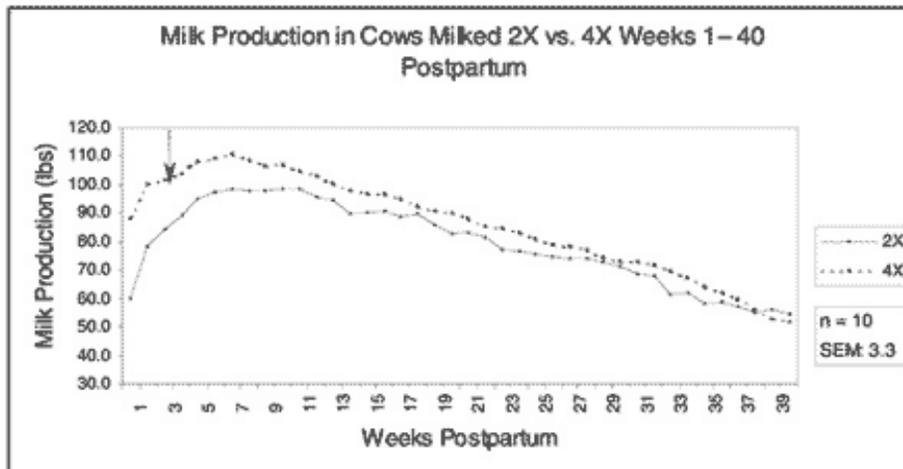


Figure 1. Hale et al. Fluid Production

Some studies have been conducted with the primary goal of evaluating the effect of Increased Milking Frequency (IMF) during different stages of lactation and its effect on persistency and production over a whole lactation. Hale et al. used three different treatments in their study to evaluate early lactation milking frequency and its effects on persistency. The different treatments were the normal 2x daily milking post partum, 4x milking at 1d PP until 21d PP (IMF 1) and 4x milking starting at 4d PP ending at 21d PP (IMF 2). The effects on milk production were then documented over a 44 week time span to see the lasting effects of the two different types of increased milking frequencies. This portion of the study concluded that the increased milking frequency in early lactation did result in an increase in milk production which persisted throughout the entirety of the lactation justifying the claim that persistency can be affected by IMF in early lactation animals. Through weeks 4-10 the study found a 5.25% increase in milk production in animals experiencing IMF and in weeks 7-44 a 7.6% increase in milk production.

Table 1. Hale et al. Fluid Milk Study

Milking frequencies by group			
X1	First 4 weeks 1x 2x daily remainder of lactation		
X2	2x entire lactation		
X3	First 4 weeks 3x 2x remainder		
Results:	X1 (kg)	X2 (kg)	X3 (kg)
Wk 1-4	24.1	31.9	31.4
Wk 10	30.9	33.9	33.7

There are a number of other studies that supported the notion that IMF in early lactation results in an increase in yield throughout a given lactation. A fixed yield response of 3.5 kg/d in cows milked 3x daily was reported in a study conducted by Erdman and Varner (1995). Other studies found that an increase of 3.0 kg/d and 4.0 kg/d respectively of added milk production was a result of IMF of 3x daily in early lactation. (Pearson et al.) (Pool)

Some studies have shown less of a difference in milk yield regarding 2x daily milking and 3x daily milking in early lactation. This particular research project (McNamara et al.) used three different types of milking frequencies. Group X1 was milked once daily for the first four weeks of lactation and 2x daily for the remainder of the lactation. X2 was milked 2x daily for the entire lactation and X3 was milked 3x daily for the first four weeks and 2x daily the rest of the lactation. Their findings concluded that milking 1x daily yielded significantly less fluid than X2 and X3. During this time span X1 averaged 24.1 kg/d and X2 and X3 averaged 31.9 and 31.4 kg/d respectively. Through week ten of the study X1 averaged 30.9 kg/d while X2 and X3 averaged 33.9 and 33.7 kg/d. This shows a 24.5% difference in milk yield in X1 and X2 during the first four weeks of the lactation a significant difference for any producer. The yields for X2 and X3 were consistent for the first four weeks and throughout the rest of their lactation. Group X1 did show residual effects of infrequent milking in early lactation as this group consistently produced less throughout the lactation until about week 20 when no significant difference in yields could be identified.

There are a number of different theories regarding the correlation between increased milking frequencies and yields throughout a given lactation. Some researchers argue that the IMF allows for more exposure to the blood supply and lactogenic hormones responsible for milk production (Soberon et al). Another theory is that the capacity of the udder is increased along with more frequent milking directly resulting in increased fluid yields (Wall and McFadden). These are important hypotheses in order to better understand what enables the animal to produce more when subjected to IMF.

Wall and Mcfadden concluded in their study that mechanisms within the mammary gland were indeed responsible for the increase in milk production. Bernier-Dodier et al. argued in their research for the correlation between IMF and the function of the number of mammary epithelial cells and their secretory activity. They concluded that secretory activity likely contributed to the sudden increase in milk production during 3x milking in mid-lactation dairy cattle.

An article published by Hilary M. Sullivan of New Mexico State University described the correlation between intramammary gland pressure and decreased milk production. These researchers argue that IMF will relieve the animal of this pressure and in response increase their fluid milk production. They went on to add that some research has concluded that switching a whole herd from 2x to 3x milking will yield approximately 7.7 lbs. more milk per cow per day (Hale et al). Interestingly, they went on to discuss how studies conducted have proven that 85% of this added production could be realized simply by increasing milking

frequency of fresh cows from 2x to 4x daily milking for 21 days beginning with day 4 PP (Hale et al., 2003).

### *Milk Components*

High producing commercial dairy producers in California understand the importance of component pricing and how it affects their monthly milk price. Responsible producers keep a close eye on their protein to fat ratio and should understand how small changes in nutrition or other daily routines of a cow's life like milking frequency can quickly alter this ratio both negatively or positively. I would like to discuss the different correlations between milk components and frequencies of milking in an average dairy herd. Many important studies have looked at this correlation and found some interesting results which may be helpful in a producer's decision on what milking protocol they would like to implement in their operation regarding frequencies.

Recent prices for butterfat and protein on a per pound basis for the month of January of 2012 were \$1.7395 and \$3.3558 respectively (USDA). These prices are an illustration of how important component pricing is for dairy producers and why they spend so much of their time developing management plans that aim to maximize component production in their dairy cattle.

A way in which this is easily monitored with dairy management software is by frequently checking the protein to fat ratio for the herd. If this ratio exceeds 1.0 or drops below .80 the dairy producer should automatically understand that either the fat or protein percentages are not where they need to be. Any ratio above 1.0 indicates a milk fat depression since the fat percentage should always be a couple points higher than the protein percentage. If the ratio drops below .80 this is a direct indication of milk protein depression. Once these conditions are

recognized the problem can be further dissected in order to find the underlying causes. More often than not a problem in the TMR rations is a direct cause of these depressed component percentages especially in regards to the transition pens. A meeting with the nutritionist should be scheduled so a plan of action can be designed and implemented to improve the component production in the herd.

Scientific studies aimed at gaining a better understanding of the correlation between milking frequency and component production in dairy cattle have been met with a wide range of success. For the most part studies found that in herds milked 3x daily vs. 2x daily milk fat percentages were often adversely affected. Szuchs et al. found in their study cows being milked 3x daily averaged 3.6% fat, whereas 2x daily milking yielded 3.8% fat, a significant decrease in percentages that should be noted for future consideration.

In a similar study conducted by Hale et al. two different groups of cows were compared with a 2x daily milking control group. The two test groups were labeled IMF 1 and IMF 4. Group IMF 1 was milked 4x daily from d1-d21PP and group IMF 4 was milked 2x daily from d1-d3PP and 4x daily from d4-d21PP. Results were quite similar with those found by the study mentioned earlier with slight negative effects on milk and protein percentages as well as lactose concentrations. Through the first three weeks of the experiment obvious depression in fat and protein yields were identified. For group 2x fat percentages averaged 4.95% while groups IMF 2 and IMF 4 averaged 3.95 and 4.17% respectively. This is a 20% decrease in group IMF 2 and a 16% decrease in IMF 4 compared with 2x. Protein was similarly affected in early lactation with yield of 3.04 and 3.14% in IMF 2 and IMF 4 respectively and 3.16% in the 2x

group, showing slightly less of a correlation between frequency of milking and component concentrations. As the lactations progressed to into week 44 the differences in fat and protein concentrations became less of an issue in the test groups subjected to IMF. Between weeks 4-44 IMF 2 and IMF 4 averaged 4.00 and 3.68% fat respectively while group 2x had an average of 4.20% fat. Protein averages from week 4-44 are as follows: group 2x was 3.10% with IMF 2 and IMF 4 averaging 3.03 and 2.92%. This study is an example of how increases in milking frequencies can have a direct negative correlation on component concentrations especially in early lactation periods. The difference became less significant as the lactations persisted and reached their later stages. This same study did however find IMF did not yield a negative response to Fat Corrected Milk (FCM) or protein. They could find no significant difference in FCM in group 2x and the two IMF groups. Once positive influence of the IMF groups compared with the 2x group were the lactose yields which tended to be higher in the 4x groups by about 3.61% (Hale et al.).

**Table 2. Hale et al. Milk Components Study**

Milking frequencies by group		Results	Control	IMF 1	IMF 2
		Fat %			
IMF 1	d1-21 4x	Wk 1-3	4.95	3.95	4.17
IMF 2	d1-3 2x	Wk 4-10	4.08	3.88	3.54
	d4-21 4x		4.2	4	3.68
		Protein %			
		Wk 1-3	3.16	3.04	3.14
		Wk 4-10	2.62	2.5	2.52
		Wk 10-44	3.1	3.03	2.92

An earlier study conducted in 1985 (E.J. DePeters et al.) directly compared milking frequencies of 2x and 3x and its effects on older cows and first lactation cows for the entirety of a lactation. This particular study is one which found mostly favorable outcomes when cows were switched to 3x daily milking frequency in regards to milk components. They reported that milk yield components in fact increased over an entire lactation but also explained its possible relation to the increased milk yield. They concluded that composition of fat, protein and solids-not-fat (SNF) did not change with the two different milking frequencies. There was also no important difference in milk protein numbers between the older cows and first lactation cows. One main difference they found between 2x and 3x was around week 15 where cows milking 2x recorded higher milk fat levels than the cows animals being milked 3x.

A study conducted by Sapru et al. out of Cornell University looked into the effects of milking frequencies on components and actual cheese yields. This group concluded that cows being milked 3x tended to have “lower actual, adjusted, and theoretical cheese yields” mostly due to the slight decrease in fat and casein concentrations found in the milk coming from 3x cows. They also went on to explain how cheese made from cows milked 3x decreased the cheese yield efficiency by around 0.5% due to the significant amount of protein loss in the whey used primarily in the cheese making process. Although they concluded that the difference in yield efficiency was not significant with the given experimental variation (Sapru et al.).

Overall, the majority of studies conducted regarding milk components and milk frequencies found no real evidence which should raise a red flag for a producer with a herd milking 3x. Most studies found no significant difference in the animals being milked 2x and 3x

regarding the components of the fluid milk. The dairy producer is ultimately held responsible to track their protein to fat ratio and determine if their nutritional values are at a high enough level to sustain a herd of dairy cows milking 3x.

## *Reproduction*

A major concern for any dairy producer looking to increase yields and maintain an efficient operation is reproduction. More than ever, dairy producers understand the great importance of having a consistent and reliable reproduction protocol. Pregnancy risk (PR), conception risk (CR), insemination risk (IR), services per conception (S/C) or average number of days open are just a few of the tools any responsible producer will look to in order to evaluate the efficiency of their current reproduction program. Any California commercial dairy producer thinking of switching from 2x to 3x should fully understand the direct effect this change in routine might have regarding reproductive performance of their herd.

Many studies have directed their time and efforts to solve this question of IMF and its effects on reproduction efficiencies. Amos et al. found cows being milked 3x daily had a slightly longer interval to first estrus of about 5.7 day and on average were open 18.1 days longer than the cows being milked 2x daily (Amos et al.). The actual economic effect of average days open depends on what stage of lactation the cow actually is. It was reported by (de Vries et al.) that it costs a producer \$0.42/d for every day open past 100 days and \$4.95/d for every day open past 145 days. The fact that the cows experiencing IMF did average 18.1 more days open than the 2x cows should be taken into consideration and not taken lightly. The same study found that S/C averaged 1.9 for both 3x and 2x groups a descent S/C number when evaluating a herd although some studies have found that each .1 above 1.5 S/C will cost the producer about \$1.50 per cow (Smith and Becker).

In a related study conducted by McNamara et al. it found that many reproduction parameters were unaffected by the changes in milking frequency from 2x to 3x daily. Their study found the first indication of heat (luteal) activity averaged days 28.4 and 29.4 Post-partum (pp) for both 2x and 3x respectively. The same studies recorded conception rates to first service for 2x and 3x to be 74% (14/19) and 65% (13/20) respectively. One of the most important benchmarks for measuring reproductive efficiency, pregnancy risk, was not different between 2x and 3x, they recorded 84% (16/19) and 85% (17/20) for each group respectively. The number of actual service is low inflating the conception and pregnancy risks dramatically but they still give us a good indication of how the lactating cows reacted to the differences in MF (McNamara et al.)

Other studies have found some negative consequences of 3x milking on first lactation heifers (Allen et al.). This study found that the first lactation heifers milked 3x daily experienced more days to last breeding, greater services per conception and more days open than their counterparts being milked 2x daily. The same study found different results for later lactation animals being subjected to 3x milking frequency. For animals in their second lactation the research found no significant difference in days to last breeding although the services per conception were still higher for this lactation group versus animals being bred 2x. Allen and company discovered that third and fourth lactation animals experienced fewer days to last breeding or fewer days open and no difference in services per conception.

Overall the study conducted by Allen and company found that animals being milked 3x daily averaged fewer days open than their counterparts being milked 2x. This was true for

second, third and fourth lactation animals. However, when looking at only the first lactation animals they averaged 137.90 days open compared to 133.64 days open for the fresh heifers milked 2x. This should be taken into account by any producer since it is pivotal to get those heifers bred back in order to maintain adequate production levels of the entire herd while replacing later lactating animals who may be exiting the herd. All lactation groups except the fourth lactation animals averaged less than 2.5 services per conception for both 2x and 3x milking. Fourth lactation animals experienced an average of 2.78 services per conception for those being milked 2x and for animals milking 3x daily 2.63 a noticeable improvement. This study shows quite favorable results for lactation groups of two and up in regards to days open and services per conception important economic benchmarks for dairy producers and not so favorable results for first lactation animals. Although with good management practices 3x is a definite possibility for all stages of lactation with improvements in reproduction as a point of interest.

### *Milk Quality and Udder Health*

Udder health and milk quality are a few more examples of benchmarks and points of interest that any dairy producer must look at when evaluating herd efficiency and overall herd health. Producers have to understand the importance of maintaining low Somatic Cell Scores (SCC) and how these scores directly relate to their management practices especially in regards to milking procedures and facility maintenance. Not only do excellent SCC's illustrate how well a herd is actually performing, but they also give the producer an opportunity to receive a milk quality bonus at the end of the month. This bonus can really help when milk prices are unfavorable and is a great source of extra income at any time. Udder health and SCC are mostly affected by the presence of either environmental or contagious pathogens. These enter the animal's mammary gland and cause an increase in the proliferation of Somatic Cells which act as a defense mechanism in combating the foreign bacteria. It is my goal to better understand and illustrate the possible correlation between milking frequencies and SCC's along with udder health.

One study used the California Mastitis Test (CMT) to evaluate the difference in milk quality in animals being milked 3x versus animals being milked 2x (Allen et al.). The CMT is a trace-3 scale based test in which a score of 1 indicates distinct thickening, 2 indicates instant thickening and gel formation and 3 indicates a formed gel with a surface elevation. The Allen study concluded that lactation groups 1-3 being milked 3x experienced higher CMT results than the same groups being milked 2x. They also found that lactation groups of four and higher milked 3x began to experience lower CMT numbers than frequencies of 2x.

There are a number of theories as to what causes these differences in CMT scores when milking frequencies are altered. One is that shorter incubation periods due to increased milking frequency results in a less severe infection. Another theory proposed that transmission of new infections within the herd to uninfected animals may be greater because of the obvious increase in exposure the lactating animals have to the milking machine (Logan et al.). These should all be taken into consideration when analyzing milking frequencies and its relationship with milk quality.

In another study aimed at determining the effect of milking frequency and its effect on overall milk quality, Klei and coworkers found some conflicting results with the study cited above. In their study they found that cows milked 2x daily experienced average SCC's of 122,000 in early lactation, 128,000 in early lactation and 149,000 in late lactation. On the other hand they found that the animals being milked 3x averaged SCC's of 93,000 in early lactation, 67,000 in mid-lactation and 120,000 in late lactation (Klei et al.). This study found an obvious increase in milk quality for all stages of lactation in those animals being milked 3x daily. These could be huge implications for dairy producers looking for ways to lower their SCC while increasing their milk quality bonus they receive from their processors at the end of the month.

Another study examined the relationship between milking frequencies and milk quality. This study used milking frequencies of 3x and 6x daily although, different than many of the studies previously mentioned, it can still be beneficial to our understanding of the animals immune physiological responses to different milking frequencies (Dahl et al.). Dahl and associates found that the group of animals milked 6x daily experienced lower Somatic Cell

Scores (SCS) in the first 21 d and led to a continued persistency of lowered SCS throughout the entire lactation. They reported SCS scores of 3.12 and 2.31 for milk frequency groups 3x and 6x respectively. The same study analyzed individual SCC's for 3x and 6x animals on 10 consecutive test days and determined the number of animals who scored <200,000 and >200,000.

Table 3. Dahl et al. Milk Quality Study

SCS	3x	6x
	3.12	2.31
SCC	3x	6x
>200,000	48	8
<200,000	122	82

The study concluded that udder health and more specifically milk quality was positively affected by the increase in MF. There was a significantly greater number animals which scored >200,000 in the 3x group than the 6x group and group 3x showed a 26% increase in SCS from the 6x group. The same study theorized that increases in prolactin receptor expression through IMF enhanced immune function both *in vitro* and *in vivo* explaining the greater ability of the animal to fight infection and subsequent differences in milk quality scores.

## Results

Results were based primarily through the review of extensive literature research. These findings were then strengthened by the use of records of a California dairy herd still in business today. This herd is known as Terra Linda Dairy and is located in Tulare, Ca. it is owned and operated by Mike Santos and his two sons Mike Jr. and Craig. The herd is composed of 1,300 milking Holstein cows. The Dairy was built in 1995 and has been family owned and operated ever since.

In 2004 management switched the 1<sup>st</sup> lactation fresh pen from 2x daily milking to 3x daily milking and in 2007 switched the mid to high producing cows from 2x to 3x as well. A more recent change made by the management team at Terra Linda Dairy was to switch their pen 5, a late lactation stripper pen, from 2x to 3x daily milking frequency on February 1, 2011. This gave me a more recent look at a group of animals that was subjected to an increase in milking frequency.

The stripper pen 5 of about 240 cows averaging about 275 DIM experienced an immediate jump in production from February to March. On February 15 Pen 5 tested at 72.4 lbs of daily milk production. In March of the same year they tested at 77.9 lbs of daily milk production. The next two test dates were April 12 and May 10 of 2011, pen 5 averaged 76.4 and 75.3 lbs of daily production respectively. This is a 5.7% average increase in production over the 3 months after switching from 2x to 3x daily milking. Management at Terra Linda also explained the obvious improvements in persistency throughout the lactation of the animals being subjected to 3x daily milking with a slight decrease (1/2 10<sup>th</sup>) in milk component numbers.

The herd is currently averaging around 82 lbs of daily production and peaking at 95 lbs of milk production without the use of rBST for any lactation groups.

The management team also noted a considerable improvement with their milk quality numbers soon after switching most of their herd from 2x to 3x. They confirmed an improvement of about 20-40,000 regarding their SCC now averaging around 110,000 and receiving their milk quality end of the month bonus. They experienced obvious improvements in udder edema and udder health as well. They found no considerable differences in their reproductive efficiencies after they switched from 2x to 3x maintaining similar number after the switch. They are currently at a 19-20% annual pregnancy rate and a conception rate of 35% for first services on the entire herd all proficient numbers for a high producing Holstein herd.

## Discussion

Results of literature reviews and personal evaluations illustrate a favorable trend towards IMF. In terms of fluid milk production the results highly favored the 3x daily milking protocol compared to 2x. First lactation group animals performed especially well in terms of fluid milk production experiencing a higher yield early on in lactation and a stronger production persistency throughout the entire lactation. Allen and company recorded increased yields for first lactation animals as high as 19% versus the more conventional 2x daily milking. Most theories as to the cause of this increase in production aim at the increase in PRL releasing events and an increase in the number of mammary epithelial cells and their secretory activities which can be directly attributed to the increase in milking frequency from 2x to 3x.

Milk components and reproduction illustrated less of a correlation with IMF. Most studies have found little influence of milking frequencies on component production and reproduction efficiency. For the majority of studies evaluated the difference in milk components was not significant between milking frequencies of 2x and 3x. The studies showed a slight decrease in milk fat percent and protein percent when switching to 3x daily milking. These findings were mostly attributed to greater dilution of components in 3x milking due to the higher fluid milk yields.

Reproduction was another factor evaluated minimally affected by milking frequencies. It was concluded that early lactation animals milking 3x averaged more days open until first breeding than 2x daily milking. There was a positive correlation between pregnancy rates and increased milking frequencies found by (McNamara et al.) in which 3x animals experienced an 85% pregnancy rate in 20 cases. It was discovered that late lactation groups (four and up)

reacted more positively to IMF in regards to reproduction experiencing fewer days open to first breeding and fewer services per conception.

Milk quality was the final factor evaluated and met with mostly positive results. A study conducted by (Allen et al.) using the CMT found that animals experiencing 3x milking frequency scored slightly worse than their 2x counterparts in the lactation groups 1-3 but began to score lower than 2x groups for lactation groups 4 and above. It was also concluded that 3x milking frequency groups averaged more SCC's greater than 200,000 compared to a similar group being milked 6x daily. Although the 3x group did experience a greater number of animals that scored under 200,000 than the 6x group this difference was less significant.

## Conclusion

This study concluded switching from 2x daily milking frequency to 3x daily has the potential of dramatically increasing fluid production, improving milk quality, and affecting reproduction and milk components to a small degree. Results concluded an increase in fluid milk production in all herds switching from 2x to 3x and a greater persistency throughout lactation in the groups of animals milked 3x in early lactation stages. For a dairy with extra downtime between each milking it would be economically responsible to switch at least a portion if not all of the herd to 3x milking to increase production and efficiency in the milk barn.

These findings were better justified when looking at the records and attaining information from a current herd that made a similar switch. They quickly experienced increases in fluid production from fresh heifers to late lactation stripper cows. They were able to get more use out of their milk barn with less down time and more time allocated to cows being milked out. This dairy also saw positive results in the form of milk quality and SCC's after increasing the milking frequency within the herd. They noted an improvement of about 35,000 Somatic Cells from tests post-switch from 2x to 3x. This is vital for any dairy attempting to stay a-float when milk prices are at desired levels and milk quality bonuses are relied upon for extra added income. These findings help to justify the studies (Kei et al.) and (Dahl et al.) which both concluded an obvious increase in milk quality and udder health when increasing the milking frequencies within a herd.

A dairy producer with a large enough milk barn to handle 3x daily milking should strongly consider making the switch if currently milking only 2x daily with extra downtime. The positive effects of such a switch have proven to be present themselves in a timely fashion and

should be recognized within weeks. Since parlor efficiency and herd health are two huge concerns for any dairy producer 3x daily milking should be a definite option in order to greatly increase fluid production and decrease SCC's by improving udder edema and health.

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