SOME MECHANICAL FACTORS AFFECTING MACHINE MILKING CHARACTERISTICS UNDER SEMI-ARID CONDITION

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Summary

The effect of mechanical factors and season of the year on milking characteristics (milk yield, time of milking, rate of milk flow, stripping time and stripping milk) were studied on 26 Holstein Friesian cows, raised under Saudi Arabia environmental conditions. Cows were in the third and fourth lactation and reached the peak. Cows milked twice a day with equal intervals. Three vacuum levels (34, 38 and 42 cfm) and two pulsation ratios were used to form six vacuum-pulsation combinations. The study was carried during two seasons Autumn-Winter (S1) and Spring-Summer (S2). After absorbing the cow equations least square analysis was used to analyze the data. Vacuum level 38 cfm and pulsation ratio 70:30 was the best among all combinations of vacuum level-pulsation ratio. No significant effect ($p < .01$) for season, up to the seventh half minute, on the rate of milk flow. However, season of the year has a significant effect on total milk yield, stripping time and stripping milk.

(**Key Words**: Machine Milking, Vacuum Level, Pulsation Ratio, Rate of Milk Flow)

Introduction

Changing the characteristics of a milking machine (pulsation ratio, pulsation rate and vacuum level) can affect milking performance. The correct level of these three factors will remove as much milk as possible from the cows udder in minimal time and will reduce the risk of injury to the udder. Increasing pulsation rate increased milk flow rate and decreased milking time (Caruolo et al., 1955; Collier et al., 1981; Clough, 1959; Clough and Dodd, 1956; Clough et al., 1953; Goff and Schmidt, 1967; Gregoire et al., 1953; Griffin and Grindal, 1981; Jorgenson and Caruolo, 1963; Moore, 1965). Increasing pulsation ratio (expansion phase: message phase) increased milking rate and decreased milking time (Allison, 1959; Caruolo et al., 1955; Collier et al., 1981; Clough, 1959; Clough and Dodd, 1956; Gregoire et al., 1953; Griffin and Grindal, 1981), although some studies showed no improvement on milking pereformance (Goff and Schmidt, 1967; Gregoire et al., 1953; Griffin and Grindal, 1981).

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The machine factor that causes the greatest change in milk flow rate is vacuum level, increasing vacuum level increased maximum and average rate of milk flow (Griffin and Grindal, 1981; Grindal, 1981). Milking time decreased significantly with increasing vacuum level (Griffin and Grindal, 1981; Grindal, 1981). Whittlestone and Olney (1962) defined vacuum-decrease time, as the period starting with decreasing vacuum in the pulsation chamber and ending when ambient preasure was reached. The authors found that, slowing vacuum-decreased time increased peak milking rate.

Mein (1977), compared vacuum decrease times of .1 and .25 second and found no difference of peak milking rate. Increasing vacuum level has tendency to cause the teat cups to crawl up on the udder and to increase machine stripping time and milk yield (Gregoire et al., 1953). Widenning pulsation ratio from 1 : 1 to 2 : 1 reduced stripping milk Environmental temperature is the climatic factor that affect milk production. Heat has a direct effect on milk production. Heat has a direct effect on milk secretion through its alteration of the neural and endocrine mechanism that control the mammary gland activity, Johonson (1965) and Schmidt (1971). Therefore the objectives of study are:

First; to investigate the effect of mechanical factors mainly pulsation ratio, and vacuum level on milking characteristics, that include;

1. Milk yield.
2. Milk flow rate, measured as the yield in first, second ········ etc half- minute of milking.
3. Time of milking.
4. Stripping milk.
5. Stripping time.

Second; Study the effect of season of the year on milk yield.

Materials and Methods

The study included 18 Holstein Friesian cows, milked twice a day, calved in October and November. Eight other cows calved in march and April. All 26 cows were under the same management conditions at college of agriculture farm, King Saud University in Riyadh. The cows were chosen to be in the third and fourth lactation and reached the peak. Cows milked twice a day *with equal interval. The duration of the experi*ment was six weeks in winter (Dec.-Feb.) and six weeks in summer (June-Aug.). Six combinations of three vacuum levels; 34, 38 and 42 cm; and two pulsation ratio; 60:40 and 70:30; were used for milking each cow. To minimize the effect of stage of lactation on milking characteristices, each cow has each treatment for one day and each treatment follows every other treatments six times.

After absorbing the cow equations, least square analysis was carried out on the data of half-minute milk yield, machine time and stripping milk according to the following models:

$$Y_{ijkl} = \mu + T_i + S_j + R_k + (TS)_{ij} + (TR)_{ik} + (SR)_{jk} + \epsilon_{ijkl}$$

where:

Y_{ijkl} = half-minute milk yield, machine time, stripping time and stripping milk.

μ = common mean, ϵ_{ijkl} = error~N $(0, \sigma^2)$

T_i = i^{th} effect of time of milking (i = 1, 2).

S_j = j^{th} effect of season (j = 1, 2).

R_k = k^{th} effect of vacuum-pulsation ratio combination (k = 1, 2, ······, 6).

R_1 = 34 cm and 70 : 30.

R_2 = 34 cm and 60 : 40.

R_3 = 38 cm and 70 : 30.

R_4 = 38 cm and 60 : 40.

R_5 = 42 cm and 70 : 30.

R_6 = 42 cm and 60 : 40.

TS, TR and SR are the interactions among the main effects. Least square means were estimated using GLM (SAS, 1984). Preplaned comparison method was used to test the hypo-

TABLE 1. EFFECT OF TIME OF MILKING ON MILK FLOW RATE, MACHINE TIME, STRIPPING TIME AND STRIPPING MILK

Time (half minute)	Morning milking		Evening milking	
	Means (kg)	SE	Means (kg)	SE
1st	1.575[a]	.021	1.523[a]	.021
2nd	1.559[a]	.022	1.459[b]	.022
3rd	1.549[a]	.015	1.306[b]	.015
4th	1.456[a]	.020	1.129[b]	.020
5th	1.413[a]	.025	.929[b]	.025
6th	1.150[a]	.014	.623[b]	.014
7th	.877[a]	.019	.450[b]	.020
8th	.648[a]	.020	.284[b]	.024
9th	.487[a]	.012	.203[b]	.017
10th	.379[a]	.027	.162[b]	.040
11th	.281[a]	.032	.169[b]	.053
MT (min)	4.342[a]	.031	3.317[b]	.031
ST (min)	.605[a]	.021	.524[b]	.021
SM (kg)	.581[a]	.029	.577[a]	.028

Different letters in the same row refer to highly significantly different means ($p < .05$).

thesis H:

LSM(i) = LSm(j).

Results and Discussion

Table 1 shows that there is a significant effect of time of milking on half minute milk yield, machine time, stripping time, and stripping milk. The rate of milk flow was the highest in the first half minute and remained high for three minute, then decreased gradually to about .2 kg at 5.5 minutes of milking. These results are in agreement with Clarence (1970) who reported that "the highest rate of milk flow was in the first half minute, where oxytocin level is high at the beginning of milking". Total milk yield was 11.374 kg for morning milking. However total milk yield was 8.237 for evening milking, the difference can be attributed at least in part to the direct effect of high environmental temperature, the environmental temperature prevailing in Saud Arabia remains above the thermoneutral temperature of lactating Holstein (21c) for at least 8 months of the year, on milk syntheses. This phenomenon can be explained by the observed change in animal's activity and feeding behavor which increased during night time. Hafez (1980) reported that high environmental temperature alter feeding and activity of the animals to increase during night. Generally, milk production of exotic temperate-evolved Holstein cows transferred to hot regions is known to decline, this decline have been ascribed to heat-induced suppression of thyroid activity along with many other physiological changes (including alteration of thermal, other hormonal, energy and water balances) necessary to minimize the rise in body temperature (Collier et al., 1981; Johnson, 1987).

Rate of milk flow for first, up to the seventh half minute were not significantly different in cooler seasons (autumn-winter) compared with hotter ones (spring-summer). The significant difference was observed in the eighth to eleventh half minute might due to the decline in the oxytocin level at the end of milking. Moreover, no statistical difference was observed between the two seasons (table 2) in machine time. The increase in stripping milk in spring-summer (S2) might due to the increase in stripping time by about 60% in S2. Table 3, shows a significant affect for vacuum-pulsation ratio combination on half-minute milk yield for 1, 2, 3, 6. 7, 8 and 9 half-minutes. For fixed pulsation ratio increasing vacuum level from 32 to 42 cfm increased milk flow i.c. the increase in negative pressure resulted in an increased rate of milk withdrawal. The rate

TABLE 2. LEAST SQUARE MEANS AND STANDARD ERRORS OF HALF MINUTE MILK YIELD, MACHINE TIME, STRIPPING TIME AND STRIPPING MILK BY SEASONS

Time (half minute)	Autumn-Winter		Spring-Summer	
	Means (kg)	SE	Means (kg)	SE
1st	1.431ª	.026	1.466ª	.033
2nd	1.527ª	.029	1.491ª	.036
3rd	1.454ª	.018	1.401ª	.023
4th	1.365ª	.024	1.380ª	.031
5th	1.169ª	.031	1.183ª	.039
6th	1.025ª	.018	1.018ª	.022
7th	.754ª	.024	.763ª	.030
8th	.400ª	.027	.532ᵇ	.032
9th	.303ª	.018	.388ᵇ	.021
10th	.256ª	.042	.286ᵇ	.044
11th	.202ª	.052	.248ª	.051
MT (min)	3.837ª	.039	3.822ª	.049
ST (min)	.455ª	.026	.685ᵇ	.033
SM (kg)	.446ª	.036	.713ᵇ	.045

Different letters in the same refer to a highly significant different means ($p < .05$).

TABLE 3. LEAST SQUARE MEANS OF HALF MINUTE-MILK YIELD, MACHINE TIME, STRIPPING TIME AND STRIPPING MILK, BY VACCUM-PULSATION RATIO, R_1-R_6

Time (half-min)	R_1	SE	R_2	SE	R_3	SE	R_4	SE	R_5	SE	R_6	SE
1st	1.460^{a}	.036	1.358^{c}	.036	1.607^{bda}	.034	1.493^{dfg}	.038	1.776^{befhik}	.035	1.614^{bdfhl}	.036
2nd	1.441^{a}	.039	1.299^{bc}	.039	1.596^{bda}	.038	1.477^{bdfg}	.040	1.686^{bdfhi}	.038	1.555^{bdj}	.038
3rd	1.427^{a}	.025	1.359^{bc}	.025	1.454^{da}	.024	1.354^{bf}	.026	1.540^{bdfhi}	.025	1.431^{dhk}	.025
4th	1.323^{a}	.034	1.260^{a}	.034	1.313^{a}	.033	1.275^{a}	.035	1.280^{a}	.034	1.304^{a}	.034
5th	1.208^{a}	.043	1.144^{a}	.034	1.410^{a}	.042	1.161^{a}	.045	1.191^{a}	.042	1.181^{a}	.042
6th	$.975^{a}$	.024	.949	.024	$.824^{ada}$	.024	$.898^{bdm}$	.025	$.797^{acfe}$	.024	$.879^{acfe}$	.024
7th	$.724^{a}$	.032	$.776^{a}$	.032	$.529^{abc}$	.032	$.666^{ab}$	.034	$.605^{b}$	.034	$.681^{ac}$	.033
8th	$.530^{a}$	.036	$.574^{c}$	.035	$.329^{bd}$	.037	$.499^{a}$	.037	$.389^{bd}$	.410	$.476^{a}$	.036
9th	$.371^{a}$	.023	$.431^{bc}$	.021	$.287^{bd}$	.024	$.383^{a}$	.022	$.279^{bd}$	.027	$.320^{d}$	.023
10th	$.263^{a}$	$.049^{a}$	.354	.042	$.253^{a}$	.049	$.305^{a}$	.051	$.217^{a}$	.060	$.234^{a}$	.052
11th	$.204^{a}$	.054	$.324^{a}$	.045	$.207^{a}$	.060	$.257^{a}$	.055	$.154^{a}$	.092	$.203^{a}$	.060
MT (min)	4.031^{a}	.053	4.331^{a}	.053	3.630^{a}	.051	3.874^{bdfg}	.055	3.361^{bdfhj}	.052	3.749^{bdfj}	.052
ST (min)	$.508^{a}$	.035	$.587^{a}$	$.036^{a}$	.536	.035	$.564^{a}$	.038	$.599^{a}$	.035	$.594^{a}$	.035
SM (kg)	$.499^{a}$	.048	$.573^{a}$	.049	$.545^{a}$	.047	$.544^{a}$	.051	$.568^{a}$	.048	$.740^{a}$	.048
MY (kg)	11.714^{a}	1.075	11.643^{a}	.803	12.013^{a}	.356	12.570^{a}	.676	12.343^{a}	.864	12.109^{a}	1.081

Different letters in the same row refer to highly significant different means ($p < .01$).

Note: R_1: 34 cfm, 70:30; R_2: 34 cfm, 60:40; R_3: 38 cfm, 70:30; R_4: 38 cfm, 60:40; R_5: 42 cfm, 70:30; R_6: 42 cfm, 60:30

of withdrawal varied for different levels of pulsation ratio and for different cows. The negative force affects the speed of milk removal in two ways, one is the effect upon the openning of the teat meatus, and the other is the effect upon the rate of milk flow through the meatus.

With every increase in negative pressure there is a proportional increase in the rate of flow through the meatus. The difference in the opening of the meatus can account for great variation in the rates of increase in milk flow with increased negative pressure, both within and between cows, (Smith and Petterson, 1946). The amount of negative force to open the meatus, maximally, will depend upon the tension of the sphincter muscles surrounding it. Other factors, such as stenosis of the passageways for the milk, are often contributing causes for restriction of milk flow. Other factors like age, inheritance and breed differences play an important role in determinning the rate of milk flow (Schmidt, 1971).

Increasing vacuum level reduced machine time but has no significant effect on stripping time or stripping milk, these results are in agreement with Caruolo et al. (1955). However, Stewart and Schultz (1958) found that stripping time decreased from 67 to 53 sec, as the vacuum increased from 10 to 12.5 in. and the amount of milk from machine-stripping was not significantly affected. For fixed vacuum level, widening the pulsation ratio from 60:40 to 70:30 increased the rate of milk flow and decreased machine time. However, no significant effect of pulsation ratio on stripping time or stripping milk, similar results were reported previously by Smith and Petterson (1946) and Moore (1971).

In conclusion as in previous studies, increasing vacuum level and widening the pulsation ratio increased the rate of milk withdrawl. Instead of using vacuum level 40 cfm and pulsation ratio 50:50, we recommend using vacuum level 38 cfm and pulsation ratio 70:30. The later combination improved all milking characteristics and have not cause any mastitic infection. In Saudi Arabia, where the air temperature of 35℃ and above is common during summer and fall seasons, evaporative cooling may be one of the most reasonable means to alleviate the adverse effect of hot summer on milk production.

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